COMPATIBILITY AMONG *Cucumis melo* VARIETIES

inodorus, conomon, flexuosus, momordica & *utilissimus*

BY

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THESIS

Submitted in partial fulfilment of the
requirement for the Degree of

Master of Science in Horticulture

Faculty of Agriculture
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Department of Olericulture
COLLEGE OF HORTICULTURE
Vellanikkara - Trichur

1984

DECLARATION

I hereby declare that the thesis entitled "Compatibility among *Cucumis melo* varieties *inodorus*, *conomon*, *flexuosus*, *momordica* and *utilissimus*" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Subha M. Mathew

SUBHA MARY MATHEW

Vellanikkara,

19-6-1984

CERTIFICATE

Certified that the thesis entitled "Compatibility among *Cucumis melo* varieties *inodorus*, *conomon*, *flexuosus*, *momordica* and *utilissimus*" is a record of research work done independently by Miss Subha Mary Mathew under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

P.K.Gopalakrishnan,
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Associate Dean,
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CERTIFICATE

We, the undersigned members of the Advisory Committee of Miss Subha Mary Mathew, a candidate for the Degree of Master of Science in Horticulture agree that the thesis entitled "Compatibility among *Cucumis melo* varieties *inodorus*, *conomon*, *flexuosus*, *momordica* and *utilissimus*" may be submitted by Miss Subha Mary Mathew, in partial fulfilment of the requirements for the degree.

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Introduction

INTRODUCTION

The melons are not as significant in man's economy as the cereals or legumes, but in the tropics, sub tropics and milder portions of the temperate zones, they are crops of more than ordinary importance. For the people of these areas, the cultivated members of the genus Cucumis have a place in their diet as desserts, salads, pickles or as ingredients of various vegetable dishes.

In India, the melons, particularly, snap melon, long melon and oriental pickling melon have received only scanty attention from breeders. Oriental pickling melon and snap melon are unique and have considerable variability in the Western Ghats. They are popular dessert and preserving melons cultivated especially in the warm humid tropical conditions of Kerala. The uniqueness of the above melons caused interest in us to study their relationship and affinity with common melons like long melon, musk melon and snake melon. The information regarding the compatibility among the different botanical varieties of *Cucumis melo* are also limited. In the present investigation affinity among oriental pickling melon (*Cucumis melo* var. *conomon* Mak.), musk melon (*Cucumis melo* var. *inodorus* Naud.), long melon (*Cucumis melo* var. *utilisimus* Duth. and Full.), snake melon (*Cucumis melo* var. *flexuosus* Naud.) and snap melon (*Cucumis melo* var. *momordica* Duth. and Full.) was studied through crossability index and seed set efficiency. It was also studied through manifestation of inter varietal heterosis and through genetic distance. The type of gene action governing quantitative characters was also estimated. The information on gene action is used to decide appropriate breeding methods. The crossability being a function of maternal parent, information on maternal effect would help in the choice of parents. The details of the investigation are presented here.

Review of Literature

REVIEW OF LITERATURE

Melons (*Cucumis melo*) are highly polymorphic species. India, being one of the secondary centres of origin of melons (Whitaker and Davis 1962), is rich in wild and cultivated forms which vary considerably from one another for many of the morphological characters. Only a few reports are available on the genetics of Indian melons (Nath and Dutta, 1971; Sambandam and Chellian, 1972).

As with similar species which included many diverse forms, investigators, attempted to divide *Cucumis melo* into botanical subspecies and distinct species. Naudin (1859) studied diverse forms in the melon group (*Cucumis melo*). He classified *Cucumis melo* into *Cucumis melo* var. *cantaloupensis* Naud., *Cucumis melo* var. *reticulatus* Naud., *Cucumis melo* var. *inodorus* Naud., *Cucumis melo* var. *flexuosus* Naud., *Cucumis melo* var. *conomon* Mak., *Cucumis melo* var. *chito* Naud., and *Cucumis melo* var. *dudaim* Naud., based on fruit and plant characteristics.

The snap melon (*Cucumis melo* var. *momordica*) and long melon (*Cucumis melo* var. *utilissimus*) were described by Kirtikar and Basu (1975) and were of typical Indian origin. Pangelo (1951) reported that all the seven forms reported by Naudin (1859) hybridized readily with one another and there was apparently very little sterility even among progenies from crosses involving variant types. Furthermore there were many intermediate forms.

Crossability studies in melons

Dutta and Nath (1969) undertook an investigation to determine the cross compatibility among musk melon, snap melon, long melon, water melon and round melon and the extent of fruit set and seed production of different melon species crossed with each other. Their investigation revealed that all musk melon, snap melon and long melon lines were cross compatible with each other. Crosses between musk melon and snap melon lines proved that wherever snap melon lines were used as female parent fruit set was quite high (60.00% - 70.00%). Similar results were obtained when musk melon lines were crossed with long melon lines. The fruit set was poor (20.00% - 33.30%), wherever musk melon lines were used as the female parent. In the reciprocal crosses, quite a high percentage of fruit set was observed (60.00% - 75.00%), except in one case where there was only 50.00% fruit set. These results clearly indicated that wherever musk melon lines were used as the female parent, poor fruit set was obtained. But when snap melon and long melon lines were used as female parents a high percentage of fruit set was obtained. The low fruit set in the crosses was probably due to the maternal influence of musk melon lines.

According to Dutta and Nath (1969) hand pollination was quite effective in long melon (64.29% - 85.00%) and snap melon (61.50% - 73.20%) but in musk melon lines it was less efficient (10.00% - 35.00%). Poor fruit set in musk melon was also reported by Whitaker and Davis (1962).

Experimental results on the seed set studies by Dutta and Nath (1969) revealed that in the crosses among musk melon, snap melon and long melon lines, average seeds/fruit was either almost equal or less than their better parent except in musk melon and snap melon crosses made reciprocally, where average seeds/fruit exceeded the better parent. The percentage of germination in almost all the hybrid seeds exceeded the better parent, thus showing heterosis.

Parthasarathy and Sambandam (1981) studied the compatibility of 'Dosakaya', a cultivated melon grown in Andhra Pradesh, with other *Cucumis* species like *Cucumis metuliferus* Naud., *Cucumis anguria* L., *Cucumis longipes* Hook;, *Cucumis zeyheri* Sond., *Cucumis dipsaceus* Ehrenb. and *Cucumis melo* L. The success of the cross was determined by the percentage of fruit set in crosses, developed seeds in crossed fruits, percentage of pollen fertility and viability in F_1. The crosses revealed that each 'Dosakaya' type was crossable with only *Cucumis melo*. Fruit set was nil in crosses with other species. The results clearly showed that the fruit set, mean seed number, seed germination and F_1 pollen fertility and viability of crosses between 'Dosakaya' types and

Cucumis melo were all comparable to that of selfing, thus indicating the free crossability of 'Dosakaya' types with *Cucumis melo*.

Studies on heterosis

Hayes and Jones (1916) were the first investigators to report heterosis in cucurbits. They reported 24.00% to 39.00% increase in yield in cucumber hybrids. Later on much breeding work for fruit quality were done in melons. (Sageret, 1826., Kubicki, 1962., Bains and Kang, 1963., and Spasov, 1963).

Qualitative characters

Fruit shape

Nath and Dutta (1971) reported that different inter varietal crosses among musk melon, snap melon and long melon lines produced fruits with almost intermediate shapes. Foster (1967) observed that fruit shape of the hybrid musk melons were intermediate between those of the parents.

Fruit colour

Chadha *et al* (1972) studied the skin colour in the crosses Hara Madhu x New Melon and Hara Madhu x Japanese Cantaloupe. The green colour of the F_1 fruits of Hara Madhu x New Melon and the phenotypic segregation of the F_2 into green and yellow types indicated monogenic inheritance of skin colour with dominance of green colour over yellow. In the other cross Hara Madhu x Japanese Cantaloupe, F_1 skin colour was yellow resembling Japanese Cantaloupe but in F and back cross generations distinct classes were not observed.

Nath and Dutta (1970) observed that the F_1 hybrids of long melon and snap melon possessed either dark green or green pericarp colour indicating that light green colour was recessive to both the green and dark green pericarp colours whereas green was recessive only to dark green. The F_1 hybrids showed that the mottled pericarp pattern of snap melon lines S_1 and striped pericarp pattern of S_2 were dominant over the whole colour pattern of long melon lines L_1, L_2 and L_3.

Sageret (1826) reported that white was recessive to yellow skin colour. Similarly Lumsden (1914) observed that F_1 musk melon hybrids were intermediate between the parents, and green colour of the skin was recessive to yellow.

Hughes (1948) published data indicating that white skin and green flesh of the cultivar 'Honey Dew' was recessive to the dark skin and salmon flesh of the cultivar 'Smith's Perfect'. The differences were due to single Mendalian dominant genes.

Flesh colour

Chadha et al (1972) reported that in the hybrid Hara Madhu x Japanese Cantaloupe, the flesh colour was white resembling Japanese Cantaloupe. The F_2 segregated in the ratio 3:1 indicating the monogenic inheritance of flesh colour with white dominant over green.

"Hagiwara and Kamimura (1936) reported dominance of white flesh colour over whitish orange. Hughes (1948) and Bains and Kang (1963) reported dominance of salmon or orange flesh colour over green. All these informations were suggestive of an allelomorphic series for flesh colour with dominance of white over orange and orange over green". (Chadha *et al.* 1972).

Cracking quality

Bursting of fruits on ripening is a characteristic feature among cultivars belonging to the botanical variety *Cucumis melo* var. *momordica*. According to Whitaker and Davis (1962) this character occured frequently in collections from India, Iran and China. Parthasarathy and Sambandam (1981) made crosses of 'Kakri', 'Phoont' and 'Vellari' with the wild *Cucumis melo* var. *callosus* Rottl. They found that this character had digenic control, bursting being dominant over non-bursting. Nath and Dutta (1971) also observed the dominance of fruit cracking in *Cucumis melo*.

Flavour

Nath and Dutta (1971) observed that flavour of the hybrids of the crosses between snap melon, musk melon and long melon lines was a blend of the parents used but slightly more towards snap melon wherever it was used as either male or female parent.

Total soluble solids

Arrasimovich (1934), Bains (1960), Nath and Dutta (1971) and Chadha et al (1972) reported that total soluble solids in the F_1 hybrids of musk melon were intermediate between the parents.

Quantitative characters

Earliness

"Earliness in musk melon cultivars and F_1 hybrids was studied by Bohn and Davis (1957). Earliness, as defined by these workers, was the period from the time of planting to the first female flower or to the first mature fruit. Their important conclusions were (1) Date of planting was the most important factor affecting rate of development in musk melon varieties and hybrids. (2) Partitioning the total growth period demonstrated that some hybrids were early flowering and slow ripening, while others were late flowering and fast ripening. (3) Partitioning the total growth period also demonstrated that a hybrid could exhibit apparent heterosis for either early flowering or early ripening. Such apparent heterosis would have resulted from dominance interactions rather than from heterozygosity. (4) The use of different planting materials explained the lack of agreement in the observations on heterosis in musk melons by different workers" (Whitaker and Davis 1962).

Chadha et al (1972) observed that in crosses between Hara Madhu and New Melon and Hara Madhu and Japanese Cantaloupe, the mean value for days to first female flower of the F_1s was lower than both the parents and the F_2 components of variance showed that additive component was more important than dominance. The mean number of days taken to first ripe fruit was lesser than both the parents in the cross Hara Madhu x New Melon. The segragating generations took more days than New Melon but less than Hara Madhu. In the cross Hara Madhu x Japanese Cantaloupe, the number of days taken by the F_1 and the segregating generations were in between the parental means. In both the crosses the F_2 generations took more days than the respective F_1s. In both the crosses dominance components were more predominant than the additive component. The values of degree of dominance showed over dominance.

Yield

Hayes and Jones (1916) found that F_1s from crosses between unrelated cultivars of cucumber exceeded the highest yielding parent by as much as 24.00% - 39.00% in yield. The F_1s exceeded the most prolific parent by an average of 1.60 - 8.00 fruits/plant or from 6.00% - 27.00% over the better parent. The length and weight of fruits from the F_1 plants were intermediate to the parents. Hutchins (1939) confirmed these results and observed heterosis for early maturity and early fruit yield. Smith (1977) reported that most of the genetic variances associated with yield were additive. Lower <u>et al</u> (1982) studied the gene action and heterosis for yield and vegetative characteristics in a cross between a gynoecious inbred of Cucumis sativus L. and a selection of Cucumis sativus var. hardwickii (R) Alef. He reported that an additive dominance model accounted for most of the variations among generations for fruit weight/plant, mature fruit length, diameter and length/diameter ratio. Additive x additive epistasis was involved in the variation among generation for fruits/plant.

Foster (1967) found that a group of F_1 hybrid musk melons with one common parent out yielded the diverse commercial parents by 84.00%.

More and Seshadri (1980) found that the maximum increase in average weight/fruit was 82.69% in musk melon hybrids. But Lippert and Hall (1972) recorded comparatively less amount of heterosis for the character.

According to Dutta and Nath (1971) heterosis for fruit yield in the crosses among musk melon, snap melon and long melon was probably the result of a number of factors, such as increased percentage of fruit set, fruits/plant and fruit weight. The fruit weight was observed to be governed by the size of the fruit and fruit cavity. They observed that the length of the fruit in the F_1 hybrids was intermediate but the width of the fruit exceeded the better parent (5.80% - 17.70%) except in two cases where it was intermediate. Size of the fruit and fruit cavity were intermediate in most of the F_1 hybrids except in two cases where it exceeded the better parent (12.51% and 0.38%).

Combining ability studies

Sprague and Tatum (1942) defined the term general combining ability as the average performance of a line in hybrid combinations and the term specific combining ability as to refer to those cases in which certain combinations do relatively better or worse than would be expected on the basis of the average performance of the lines involved.

Sprague and Tatum (1942) postulated that general combining ability was largely the result of additive gene action while specific combining ability was the result of dominance, epistasis and G x E interaction.

Henderson (1952) considered general combining ability as the average performance with respect to some trait or weighted combination of traits of a large number of progeny of an individual or line which mated with a random sample from a specified population under a specific set of environmental circumstances. He also defined specific combining ability as the deviation of an average value of a cross from the value which would be expected on the basis of the known general combining ability of these two lines or individuals.

Griffings (1956) suggested combining ability analysis to estimate the type of gene action governing the expression and inheritance of important metric traits in crop plants. The genotypic variance obtained from such studies could be sub divided into variances due to general combining ability and specific combining ability. These studies further led to the estimation of the type of gene action controlling the characters under observation.

Lippert and Legg (1972) used diallel analysis to evaluate musk melon cultivers for several characters related to maturity, fruit size and yield. From the data obtained from two or three locations they observed that additive gene action (gca) and non-additive gene action (sca) were significant in crosses for expression of days to first fruit harvest and average weight of first three fruits harvested. The gca was significant for all characters when evaluated from single location data and was more than sca for explaining differences among crosses.

Nandpuri et al (1974) studied several economic characters in sixteen F_1 hybrids of musk melon involving four male parents and four female parents which included two male sterile lines. The gca effects were more important for the male than for female parents. Male parents, Hara Madhu and Arka Rajhans, were good combiners for many of the economic characters.

Dyutin and Prosvirnin (1977) studied genetic control of dry matter content in melons and found that dry matter content was controlled mainly by additive genes. A significant correlation was observed between *per se* performance for dry matter content and general combining ability of the melon lines.

Chadha and Nandpuri (1978) conducted a diallel experiment with large number of varieties and found that earliness was partially dominant and controlled by the action of several genes.

Materials and Methods

MATERIALS AND METHODS

The investigation was conducted during October-January 1982-1983 and February-May 1983, at the Instructional Farm of College of Horticulture, Kerala Agricultural University, Vellanikara, Trichur. The Instructional Farm is located at an altitude of 22.25 m. above mean sea level and is situated at 10° 32" N latitude and 76° 10" E longitude. It enjoys a warm humid tropical climate.

A. Materials

The experimental materials comprised of five botanical varieties of Cucumis melo (Cucumis melo var. conomon Mak.- oriental pickling melon, Cucumis melo var. inodorous Naud.- muskmelon, Cucumis melo var. utilissimus Duth. and Full.- long melon, Cucumis melo var. flexuosus Naud.- snake melon, and Cucumis melo var. momordica Duth. and Full.- snap melon.)

All these five botanical varieties of Cucumis melo were viny in nature with green, pubescent and angular stems, elongated internodes, long and pubescent petioles, coiled tendrils, orbicular leaves with slightly serrated margin and blunt tip and yellow flowers.

Their sources, chromosome number and distinguishing morphological features are given in Table 1.

Table 1. Sources, chromosome numbers and distinguishing morphological features of five botanical varieties of *Cucumis melo*

Acc. No.	Parental materials	Chromosome number	Origin	Fruit rind colour	Fruit shape
	Oriental pickling melon				
CS 26	*Cucumis melo* var. *conomon*	24	Mudicode, Trichur	Golden yellow	long oval
	Musk melon				
CML 8	*Cucumis melo* var. *inodorous*	24	PAU, Ludhiana	Light green	spherical
	Long melon				
CS 4	*Cucumis melo* var. *utilissimus*	24	Pantnagar	Greenish white with stripes	Elliptical and elongated
	Snake melon				
CS 50	*Cucumis melo* var. *flexuosus*	24	Pantnagar	Yellow with mottling	Club shaped
	Snap melon				
CS 52	*Cucumis melo* var. *momordica*	24	Cochin	Yellow	Oblong

continued

Acc. No.	Flesh colour	Seediness	Fruit flavour	Fruit sweetness	Fruit cracking
CS 26	White	High	Poor	Less sweet	Not cracking
CML 8	Light green	Medium	Good	Very sweet	Not cracking
CS 4	Pale white	High	Poor	Less sweet	Not cracking
CS 50	Pale yellow	High	Poor	Less sweet	Not cracking
CS 52	White	High	Fair	Less sweet	Cracking

B. Experimental methods

1. Studies on compatibility of the five botanical varieties - Development of inter-varietal F_1 hybrids.

The five botanical varieties were grown at a spacing of 1.5 m between plants and 3 m between rows with ten pits for each, having two plants/pit. Bagging of the male and female mature flower buds, with butter paper covers, was done in the evening. Pollination was performed the next day morning between 6.30 - 8.30 a.m., when the stigmas were receptive. The pollinated flowers were covered and labelled. Along with selfs, 20 cross combinations (including reciprocals) among the five selected melons were made by hand pollinations.

(a) Observations

The following observations were made at F_0 level.

(i) Number of crosses made and percentage of success (fruit set)

$$\text{Percentage of success} = \frac{\text{No. of fruits set}}{\text{No. of crosses made}} \times 100 \quad (A)$$

(ii) Seeds/F_0 fruit (B)

(iii) Percentage of viable seeds

(iv) Days to germination

(v) Percentage of germination of the seeds

$$= \frac{\text{Seeds germinated}}{\text{No. of seeds sown}} \times 100 \quad (C)$$

(vi) Percentage survival of the germinated seedlings

$$= \frac{\text{Seedlings survived}}{\text{No. of seeds germinated}} \times 100 \quad (D)$$

Crossability index was then calculated (Rao, 1979)

$$\text{Crossability index (CI)} = \frac{\text{Crossing efficiency of the cross}}{\text{Selfing efficiency of the female parent}} \times 100$$

$$= \frac{A^{c^*} \times B^{c^*} \times C^{c^*} \times D^{c^*}}{A^{s^*} \times B^{s^*} \times C^{s^*} \times D^{s^*}} \times 100$$

c^* = Crossed s^* = Selfed

Effect of maternal parent on crossability was further studied using Student 't' test.

$t = \frac{|d|}{SEd}$ where 'd' was the difference between direct and reciprocal F_1s.

(vii) Percentage of seed forming efficiency

$$= \frac{\text{Seeds in crosses}}{\text{Seeds in selfed maternal parent}} \times 100$$

2. Evaluation of the inter varietal F_1 hybrids

All the inter varietal F_1 hybrids were grown along with parental lines in a randomised block design with three replications. The spacing was 1.5 x 3 m. There were four plants/variety/replication with two plants/pit.

(a) Observations

(i) The morphological description of the hybrids was made based on the following characters.

Habit	- Bushy/viny/spreading
Stem pubescence	- Smooth/pubescent/highly pubescent
Stem colour	- Green/purple/dark purple
Internodes	- Branched/elongated
Stem shape	- Rounded/angular
Petiole length	- Small/medium/long
Petiole pubescence	- Smooth/pubescent
Lamina type	- Entire/serrated/multifid
Lamina shape	- Cordate/oblong/obovate/orbicular
Lamina tip	- Blunt/pointed
Tendril type	- Coiled/straight/unbranched/branched
Flower colour	- Yellow/deep yellow/light yellow/others
Fruit rind colour	- Green/light green/dark green/yellow/ mottling
Fruit surface	- Smooth/prickly/striped/non-striped/ netted/non-netted
Fruit shape	- Spherical/oblong/round/flat-round/ elongated/club shaped
Flesh colour	- White/greenish/orange/red/yellow/ light yellow/others
Seediness	- Low/medium/high
Fruit flavour	- Poor/fair/good/excellent
Fruit sweetness	- Less sweet/sweet/very sweet
Fruit cracking	- Cracking on maturity/not cracking

(ii) Following quantitative observations were also recorded

Plant characters (Average of five plants/replication)

Nodes to first male flower

Nodes to first female flower

Female flowers in first ten nodes

Female flowers in first 20 nodes

Days to first female flower

Days to first mature fruit harvest

Days to fruit maturity

Primary vine length

Primary branches/plant

Nodes on main stem

Fruit characters (Average of five fruits/replication)

Fruit length

Fruit girth

Fruit weight

Fruit volume

Flesh thickness

Seeds/fruit

Seed yield/fruit

100 seed weight

Components of yield

Fruits/plant

Fruit yield/plant

(iii) Fertility of the F_1 hybrids was further examined through selfing and observing seediness in F_1 fruit

The percentage of fruit set at F_1 level was calculated using the formula

$$\text{Percentage of fruit set} = \frac{\text{No. of fruits set}}{\text{No. of selfings done}} \times 100$$

(b) Statistical analysis of data

The details of the statistical analysis followed are as follows:-

(i) Analysis of variance

Before proceeding with the detailed statistical analysis of the plant characters, the data were analysed for the analysis of variance as described by Ostle (1966), for a randomised block design. The model utilised in the analysis of this design was

$$Y_{ij} = \mu + b_i + t_j + e_{ij}$$

where Y_{ij} = performance of the j^{th} genotype in the i^{th} block

μ = general mean

b_i = true effect of the i^{th} block

t_j = true effect of the j^{th} genotype

e_{ij} = random error

Restrictions are $\sum_{i=1} b_i = 0$ and $\sum_{j=1} t_j = 0$

The variance due to genotypes was first broken up into variance due to parents, hybrids and parents versus hybrids. Then the variance due to hybrids was further split up into that due to direct hybrids, reciprocal hybrids and directs versus reciprocals.

(ii) Estimation of inter varietal F_1 hybrid vigour

Heterosis was calculated as percentage increase or decrease of the F_1s over the better parent (Hayes *et al* 1965) and over mid-parent (Briggle, 1963).

$$\text{Heterobeltiosis} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

$$\text{Relative heterosis} = \frac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$$

Heterobeltiosis was tested using standard error

$$SE = \sqrt{\frac{\sigma^2 F_1}{n_1} + \frac{\sigma^2 BP}{n_2}}$$

where $\sigma^2 F_1$ = F_1 variance

$\sigma^2 BP$ = Better parental variance

n_1 = Number of F_1 plants

n_2 = Number of better parental plants

Relative heterosis was tested using standard error

$$SE = \sqrt{\frac{\sigma^2 F_1}{n_1} + \frac{1}{4}\left(\frac{\sigma^2 P_1}{n_2} + \frac{\sigma^2 P_2}{n_3}\right)}$$

where $\sigma^2 P_1$ = Maternal parental variance

$\sigma^2 P_2$ = Paternal parental variance

n_2 = Number of maternal parents

n_3 = Number of paternal parents

(iii) Estimation of genetic distance among the five botanical varieties of Cucumis melo

The genetic distance was calculated considering the following characters

Nodes to first female flower

Fruit weight

Seeds/fruit and

Fruits/plant

The method suggested by Mahalanobis (1928) was used to estimate the total D^2 between the five varieties with X_1, X_2, X_3 and X_4 as the multiple measurements available on each variety and d_1, d_2, d_3 and d_4 as $\bar{x}_1^1 - \bar{x}_1^2$, $\bar{x}_2^1 - \bar{x}_2^2$, $\bar{x}_3^1 - \bar{x}_3^2$, $\bar{x}_4^1 - \bar{x}_4^2$ respectively being the differences in the means of two varieties. Mahalanobis D^2-statistics was defined as follows:-

$$D^2 = b_1d_1 + b_2d_2 + b_3d_3 + b_4d_4$$

Here the b_i values were to be estimated such that ratio of variance between population to variance within population was maximised. In terms of variances and covariances, the D^2 value was obtained as follows:-

$${}_pD^2 = W^{ij} (\bar{x}_i^1 - \bar{x}_1^2) (\bar{x}_j^1 - \bar{x}_j^2)$$

where W^{ij} was the inverse of estimated variance-covariance matrix.

From the data variances and covariances were calculated and a dispersion table was prepared from these estimates using 'V' statistic, which in turn utilised Wilk's criteria. A simultaneous test of differences between mean values of the correlated variables was done (Rao, 1948).

Error and error + variety variance and covariance matrices were then formed. Using pivotal condensation method, the determinants of error and error + variety matrices were calculated.

$$\Lambda = \frac{|W|}{|S|} = \frac{|\text{Determinant of error matrix}|}{|\text{Determinant of error + variety matrix}|}$$

But $'V'_{(stat)} = -m \log_e \Lambda = -(n - \frac{p+q+1}{2}) \log_e \Lambda$

where $m = n - \frac{(p+q+1)}{2}$

p = No. of characters = 4

q = No. of varieties -1 = 4

n = degrees of freedom for error + varieties $-$ 1 = 12

e = 2.71813

$'V'_{(stat.)}$ was distributed as χ^2 with pq degrees of freedom (16) and its significance at 5% level was computed. The D^2 value obtained for a pair of varieties was taken as the calculated value of χ^2 and was tested against the tabulated value of χ^2 for 'p' degrees of freedom. This method was suggested by Rao (1948) and Singh and Choudhury (1979).

(iv) General and specific combining ability analysis

Diallel analysis for combining ability was carried out according to Model I method 1 of Griffings (1956) as follows:

$$Y_{ij} = \quad + g_i + g_j + s_{ij} + r_{ij} + e_{ij}$$

where Y_{ij} = mean of i x j^{th} genotype

g_i = general combining ability (gca) effect of the i^{th} parent

g_j = gca effect of j^{th} parent

s_{ij} = specific combining ability effect (sca) of $(i \times j)^{th}$ cross

r_{ij} = reciprocal effect of $(i \times j)^{th}$ cross

e_{ij} = error associated with ij^{th} cross

The sum of squares (SS) were calculated as follows:-

SS due to gca = $\frac{1}{2n} \sum (Y_{i.} + Y_{.j})^2 - \frac{2}{n^2} Y_{..}^2$

SS due to sca = $\frac{1}{2} \sum_i \sum_j Y_{ij} (Y_{ji} + Y_{ji}) -$

$$\frac{1}{2n} \sum (Y_{.j} + Y_{.j})^2 + \frac{1}{n^2} Y_{..}^2$$

SS due to reciprocals $= \frac{1}{2} \sum_{i} \sum_{j}{}_{i<j} (Y_{ij} - Y_{ji})^2$

where n = Number of parents

$Y_{i.}$ = Total of the array of i^{th} parent summed over j direct crosses

$Y_{.j}$ = Total of the array of j^{th} parent summed over i indirect crosses

Y_{ij} = Mean value of ij^{th} cross

Y_{ji} = Mean value of ji^{th} cross

$Y_{..}$ = Grand total of $\frac{n(n-1)}{2}$ progenies, their reciprocals and 'n' parental lines.

The analysis of variance table was set up as follows:

Sources	Degrees of freedom	Sum of squares	Mean sum of squares
Gca	4	Sg	Mg
Sca	10	Ss	Ms
Reciprocals	10	Sr	Mr
Error	48	Se	Me'

$$Me' = \frac{\text{Mean sum of square of error (Me)}}{\text{Number of replications}}$$

The following 'F' ratios were used to test the significance of the variances due to general and specific combining ability effects

To test variance due to general combining ability effect

$$F_{4,\ 48}\ 5\% = \frac{Mg}{Me'}$$

To test the variance due to specific combining ability effect

$$F_{10,\ 48}\ 5\% = \frac{Ms}{Me'}$$

To test the variance due to reciprocal effect

$$F_{10,\ 48}\ 5\% = \frac{Mr}{Me'}$$

Estimates of general and specific combining ability effects and reciprocal effects were calculated as follows:

$$g_i = \frac{1}{2n}(Y_{i.} + Y_{.i}) - \frac{1}{n^2}Y_{..}$$

$$s_{ij} = \frac{1}{2}(Y_{ij} + Y_{ji}) - \frac{1}{2n}(Y_{i.} + Y_{.i} + Y_{j.} + Y_{.j}) + \frac{1}{n^2}Y_{..}$$

$r_{ij} = \frac{1}{2} (Y_{ij} - Y_{ji})$

n, $Y_{i.}$, $Y_{.j}$, Y_{ji}, Y_{ij}, $Y_{..}$ were the same as explained earlier.

Variances, standard errors and critical differences were estimated

$$\text{Var}(g_i) = \frac{n-1}{2n^2} \text{Me}'$$

$$\text{Var}(s_{ii}) = \frac{(n-1)^2}{n^2} \text{Me}'$$

$$\text{Var}(s_{ij}) = \frac{1}{2n^2} (n^2 - 2n + 2) \text{Me}'$$

$$\text{Var}(r_{ij}) = \frac{1}{2} \text{Me}'$$

$$\text{Var}(g_i - g_j) = \frac{1}{n} \text{Me}'$$

$$\text{Var}(s_{ii} - s_{jj}) = \frac{2(n-2)}{n} \text{Me}'$$

$$\text{Var}(s_{ii} - s_{ij}) = \frac{(3n-2)}{2n} \text{Me}'$$

$$\text{Var}(s_{ii} - s_{jk}) = \frac{3(n-2)}{2n} \text{Me}'$$

$$\text{Var}(s_{ij} - s_{ik}) = \frac{n-1}{n} \text{Me}'$$

$$\text{Var}(r_{ij} - r_{kl}) = \text{Me}'$$

These values were used for calculating the critical differences for making comparisons between different effects.

Critical differences (CD) to test the significance of the difference between two estimates was taken as the product of the 't' value for error degrees of freedom and the standard error of the difference between the estimates. The standard error of the difference between two estimates was calculated as the square root of the variance of the difference between two estimates.

(v) Correlation coefficient between gca effects and *per se* performance

The correlation coefficient 'r' was calculated using the formula

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\left\{\sum x^2 - \frac{(\sum x)^2}{n}\right\}\left\{\sum y^2 - \frac{(\sum y)^2}{n}\right\}}}$$

Where x = General combining ability effect

y = Mean *per se* performance

n = Number of lines

Results

RESULTS

The experimental results obtained in the present investigation are presented under the following subheads.

A. Crossability among *Cucumis melo* var. *conomon* Mak. (oriental pickling melon), *Cucumis melo* var. *inodorus* Naud. (musk melon), *Cucumis melo* var. *utilissimus* Duth. and Full. (long melon), *Cucumis melo* var. *flexuosus* Naud. (snake melon), and *Cucumis melo* var. *momordica* Duth. and Full. (snap melon).

B. General analysis of variance

C. Evaluation of the hybrids for discrete characters

D. Estimation of inter varietal heterosis

E. Analysis of combining ability

F. Correlation between gca values and *per se* performance of the melon lines.

G. Estimation of genetic distance.

A. Crossability among oriental pickling melon, musk melon, long melon, snake melon and snap melon

Cross compatibility among the five botanical varieties of *Cucumis melo* was studied (Table 2). Crosses among the five melons showed that wherever musk melon was used as the female parent, percentage of fruit set was poor. (37.04% - 42.86%). In crosses where oriental pickling melon was the female parent fruit set ranged from 52.94% to 61.42%. In cases where the maternal parent was long melon, the range of fruit set was from 52.00% to 72.22%. Snake melon, when used as female parent gave fruit set percentage ranging from 60.00 to 76.00. The percentage of fruit set varied from 58.82 to 68.75 when snap melon was the female parent.

Data on fruit set (Table 2) of the parental lines revealed that hand pollination was quite effective in oriental pickling melon (58.33%), long melon (76.92), snake melon (64.28%) and snap melon (73.33%). In musk melon, it was less effective (33.33%).

Experimental results on seed set studies revealed that in crosses among oriental pickling melon, musk melon, long melon, snake melon and snap melon, the average seeds/fruit was less than their respective better parents. The germination percentage of hybrid seeds was less than the parents except in oriental pickling melon x long melon (76.00%) and long melon x snap melon (80.00%). The percentage survival of the hybrid seedlings was maximum (100%) in oriental pickling melon x snake melon, musk melon x oriental pickling melon, musk melon x long melon, musk melon x snake melon, musk melon x snap melon, snake melon x musk melon and snake melon x long melon and minimum in snap melon x long melon (84.20%) and long melon x oriental pickling melon (84.20%). Among the parents maximum percentage of survival was in oriental pickling melon and musk melon (100%) and the minimum in snap melon (84.00%).

The crossability index was calculated and it was the highest for oriental pickling melon x long melon (79.91%) and the lowest for musk melon x snake melon (47.15%). The effect of maternal parent on crossability was found to be non-significant (Table 2).

The percentage of seed forming efficiency of the crosses (Table 3) at F_o level was also studied and it was the highest for oriental pickling melon x musk melon (90.52%) and the lowest for snake melon x long melon (63.16%). There was significant reciprocal effect for percentage of seed forming efficiency.

The fertility of the F_1 hybrids was further evaluated by observing the percentage of fruit set at F_1 level and seeds/F_1 fruit (Table 4). The percentage of fruit set ranged from 50.00 to 75.00. It was the highest in snap melon x long melon (75.00%) and the lowest (50.00%) in long melon x snap melon. The seeds/F_1 fruit was the highest in snap melon x snake melon (750.92) and the lowest in long melon x musk melon (508.93). In both cases the effect of female parent was significant.

Table 3. Percentage seed forming efficiency of the crosses at F_0 level

Genotypes	Seeds in selfed maternal parent	Seeds in crosses	Seed forming efficiency (%)
Oriental pickling melon (O)	722.75	-	-
Musk melon (M)	498.00	-	-
Long melon (L)	610.00	-	-
Snake melon (F)	722.00	-	-
Snap melon (S)	762.00	-	-
O X M	-	654.25	90.52
O X L	-	615.00	85.09
O X F	-	644.00	89.10
O X S	-	548.00	75.82
M X O	-	397.50	79.82
M X L	-	422.25	84.79
M X F	-	327.50	66.97
M X S	-	439.00	88.15
L X O	-	510.25	83.65
L X M	-	523.00	85.74
L X F	-	416,25	68.24
L X S	-	413.50	67.79
F X O	-	480.50	66.55
F X M	-	491.50	68.07
F X L	-	456.00	63.16
F X S	-	536.00	74.24
S X O	-	580.75	76.21
S X M	-	590.25	77.46
S X L	-	561.00	73.62
S X F	-	669.25	87.83

Table 4. Fertility of the F_1 hybrids

Hybrids	No. of selfings	Fruit set	Fruit set (%)	Seeds/fruit
O X M	17	12	70.59	532.00
O X L	18	11	61.11	638.25
O X F	15	10	66.67	715.38
O X S	15	8	53.33	618.50
M X O	18	14	66.67	509.33
M X L	16	14	70.00	547.33
M X F	17	11	64.71	536.00
M X S	18	11	61.11	519.36
L X O	21	12	52.17	540.87
L X M	22	14	63.64	508.93
L X F	18	10	55.56	746.00
L X S	20	10	50.00	680.00
F X O	22	15	68.18	629.25
F X M	20	12	60.00	604.00
F X L	19	12	63.16	742.00
F X S	14	10	71.43	756.96
S X O	18	13	72.22	635.54
S X M	16	10	62.50	530.00
S X L	16	12	75.00	666.87
S X F	15	9	60.00	750.92

B. General analysis of variance

Variance due to genotypes (Table 5) was significant for all the characters except primary vine length, primary branches/plant and nodes on main stem. In the case of parents, the differences were significant for nodes to first male flower, female flowers in first ten nodes, female flowers in first 20 nodes, days to first mature fruit harvest, days to fruit maturity, fruit length, fruit girth, fruit weight, fruit volume, flesh thickness, seeds/fruit, 100 seed weight, seed yield/fruit, fruits/plant and fruit yield/plant. The mean squares due to hybrids were significant for all the characters except primary vine length, primary branches/plant and nodes on main stem. For nodes to first female flower, primary vine length, primary branches/plant, nodes on main stem and fruit girth, the direct hybrid mean squares were not significant. Mean squares of reciprocal hybrids were found to be non-significant for primary vine length, primary branches/plant and nodes on main stem. Variance due to parents versus hybrids was significant for all characters except primary vine length, primary branches/plant, nodes on main stem, fruit length, fruit girth, fruit weight and fruit volume. Variance due to direct versus reciprocal hybrids was significant for nodes to

Table 5. General analysis of variance

Sources of variation	df	Mean Squares				
		Nodes to first male flower	Nodes to first female flower	Female flowers in first ten nodes	Female flowers in first 20 nodes	Days to first female flower
Replications	2	0.23	0.45	2.0	3.03	4.04
Genotypes	24	1.78**	1.26**	1.60**	1.85**	19.57**
Parents	4	2.27*	0.88	3.07**	3.23**	3.45**
Hybrids	19	1.22**	1.16**	1.41**	1.48**	6.03**
Direct hybrids	9	0.82*	0.70	1.59**	1.94**	11.47**
Reciprocal hybrids	9	1.42**	1.74**	1.38**	1.17**	5.07**
Direct vs reciprocal hybrids	1	1.83**	0.11	0.03	0.08	3.71*
Parents vs hybrids	1	11.07**	5.30**	1.18*	2.96*	303.41**
Error	48	0.32	0.42	0.30	0.48	0.64

* p = 0.05 ** p = 0.01

(contd)

continued

Sources of variation	af	Mean squares				
		Days to first fruit harvest	Days to fruit maturity	Primary vine length (m)	Primary branches/ plant	Nodes on main stem
Replications	2	34.82^{**}	3.69	1.40	29.81^{**}	55.00^{*}
Genotypes	24	46.76^{**}	16.88^{**}	0.18	3.44	22.10
Parents	4	17.73^{**}	3.49^{*}	0.23	3.61	27.65
Hybrids	19	17.89^{**}	7.47^{**}	0.93	2.46	13.10
Direct hybrids	9	17.26^{**}	7.86^{**}	0.09	3.01	15.90
Reciprocal hybrids	9	19.70^{**}	6.00^{**}	0.10	2.18	11.76
Direct vs reciprocal hybrids	1	7.26^{**}	17.27^{**}	0.03	0.04	0.05
Parents vs hybrids	1	711.49^{**}	249.16^{**}	1.63^{*}	21.28^{**}	77.86^{*}
Error	48	0.76	1.01	0.23	2.39	27.34

(contd.)

continued

Sources of variation	df	Mean squares				
		Fruit length (cm)	Fruit girth (cm)	Fruit weight (kg)	Fruit volume (l)	Flesh thickness (cm)
Replications	2	9.70	1.06	0.130	0.07	0.52
Genotypes	24	309.57**	12.06**	0.78**	0.85**	0.28**
Parents	4	528.41**	21.29**	1.30**	1.54**	0.57**
Hybrids	19	279.58**	10.11*	0.69**	0.73**	0.21**
Direct hybrids	9	362.38**	9.63	0.68**	0.76**	0.19**
Reciprocal hybrids	9	227.16**	10.83**	0.77**	0.77**	0.24**
Direct vs reciprocal hybrids	1	6.11	8.00	0.02	0.04	0.08
Parents vs hybrids	1	4.03	12.12	0.40	0.47	0.36**
Error	48	11.72	5.43	0.15	0.12	0.08

(contd.)

continued

Sources of variation	df	Mean squares				
		Seeds/ fruit	100 seed weight (g)	Seed yield/ fruit (g)	Fruits/ plant	Fruit yield/ plant (kg)
Replications	2	828.04	0.32	15.16**	1.09	3.38
Genotypes	24	26879.75**	0.31**	21.00**	4.71**	28.51**
Parents	4	49467.74**	0.45**	29.02**	10.09**	52.09**
Hybrids	19	18656.89**	0.25**	7.49**	3.45**	16.94**
Direct hybrids	9	20808.74**	0.22*	8.13**	4.51**	18.15**
Reciprocal hybrids	9	18482.68**	0.29*	6.99**	2.77**	17.56**
Direct vs reciprocal hybrids	1	868.21	0.17	6.12	0.05	0.05
Parents vs hybrids	1	92761.94**	1.03*	243.73**	10.42**	149.35**
Error	48	3918.95	0.12	6.75	0.60	14.02

first male flower, days to first female flower, days to first fruit harvest and days to fruit maturity.

C. Evaluation of the hybrids for discrete characters

The parents were similar in their discrete plant characters such as viny growth habit, angular and pubescent stem, elongated inter nodes, slightly serrated orbicular lamina with blunt tip, unbranched and coiled tendrils and yellow flowers. So also no difference was observed among the hybrids for these characters. The parents were quite distinctive in their fruit characters - rind colour, shape, flesh colour, seediness, flavour, sweetness, and fruit cracking at maturity (Table 1). The hybrids were intermediate between the parents for the above characters (Table 6).

Fruit rind colour

Fruit rind colour of the hybrids was intermediate between the parents. Rind colour of the hybrid oriental pickling melon x musk melon was light yellow on ripening, which was intermediate between the golden yellow colour of oriental pickling melon and light green colour of musk melon.

Fruit shape

Fruit shape in all F_1 hybrids was intermediate. In musk melon x long melon, oval fruits were produced though

Table 6. Qualitative characters of fruits of hybrids among oriental pickling melon, musk melon, long melon, snake melon and snap melon

Hybrids	Fruit rind colour	Fruit shape	Flesh colour	Fruit flavour	Fruit sweetness	Fruit cracking
O X M	Light yellow	Oval	Greenish yellow	Fair	Not sweet	Do not crack
O X L	Deep yellow	Oblong	White	Poor	Not sweet	Do not crack
O X F	Deep yellow with mottling	Oblong	Pale white	Poor	Not sweet	Do not crack
O X S	Deep yellow	Oblong	White	Fair	Not sweet	Crack
M X O	Light greenish yellow	Oval	Pale green	Good	Sweet	Do not crack
M X L	Light yellow	Oval	Pale green	Good	Sweet	Do not crack
M X F	Light yellow	Oval	Pale greenish yellow	Good	Sweet	Do not crack
M X S	Light yellow	Oval	Pale greenish yellow	Good	Sweet	Do not crack
L X O	Greenish yellow	Oblong	Cream	Poor	Not sweet	Do not crack
L X M	Light yellow	Oval	Pale greenish yellow	Good	Sweet	Do not crack
L X F	Yellow	Oblong	Light yellow	Poor	Not sweet	Do not crack
L X S	Light yellow	Oblong	White	Fair	Not sweet	Crack
F X O	Deep yellow	Oblong	Light yellow	Poor	Not sweet	Do not crack
F X M	Light yellow	Oval	Light yellow	Fair	Sweet	Do not crack
F X L	Light yellow	Oblong	Cream	Poor	Not sweet	Do not crack
F X S	Yellow	Oblong	Cream	Fair	Not sweet	Crack
S X O	Deep yellow	Oblong	White	Fiar	Not sweet	Crack
S X M	Light yellow	Oval	Pale green	Fair	Sweet	Crack
S X L	Light yellow	Oblong	Cream	Fair	Not sweet	Crack
S X F	Yellow	Oblong	Cream	Fair	Not sweet	Crack

O - Oriental pickling melon
M - Musk melon
L - Long melon
F - Snake melon
S - Snap melon

fruit shape of musk melon was round and that of long melon was elliptical and elongated. In all cases where musk melon was used as one of the parents oval fruits were produced. In other hybrids fruit shape was oblong.

Flesh colour

The flesh colour varied from light yellow to light green. The flesh colour of the hybrid long melon x snake melon was pale yellow while that of long melon x musk melon was pale greenish yellow. It was observed that in all cases where musk melon was one of the parents, the hybrids inherited the light green flesh colour of musk melon.

Seediness

The average number of seeds in the parents ranged from 437.6 to 782.47, the lowest being for musk melon and the highest for snake melon. Even in hybrids having musk melon as one of the parents, the seeds/fruit exceeded 500.

Fruit flavour

In all F_1 hybrids the fruit flavour was a blend of the parents used. In hybrids, with musk melon as one of the parents, flavour of musk melon was predominant.

Fruit sweetness

Among the five melons, only musk melon was sweet and sweetness was inherited by the hybrids involving musk melon.

Fruit cracking

Fruit cracking on ripening is a characteristic feature of *Cucumis melo* var. *momordica*. In all the hybrids involving snap melon, except, snap melon x musk melon and musk melon x snap melon fruit cracking was observed. The thick pericarp of musk melon was inherited by its hybrids and the hybrids snap melon x musk melon and musk melon x snap melon did not crack.

D. Estimation of inter varietal heterosis

Differences between the parents and F_1 hybrids were substantial for most of the characters studied (Table 7).

Table 7. Percentage of increase or decrease, expressed by the F_1s over better parental and mid-parental values

Parents and hybrids	Nodes to first male flower	Increase or decrease over (%)		Nodes to first female flower	Increase or decrease over (%)	
		Mid-parent	Better parent		Mid-parent	Better parent
Oriental pickling melon (O)	4.47			6.47		
Musk melon (M)	4.20			5.30		
Long melon (L)	2.53			5.70		
Snake melon (F)	4.73			6.60		
Snap melon (S)	3.67			5.80		
O X M	2.53	-41.71**	-39.76**	5.07	-19.14**	-14.50**
O X L	2.53	- 0.28**	- 0.40**	5.73	- 6.07	- 3.37
O X F	3.73	-18.91**	-16.55**	5.73	- 6.07*	- 3.37*
O X S	2.40	-41.03	-34.60	5.13	-17.25	-13.49
M X O	4.10	- 5.55	- 2.40**	5.80	- 7.50**	- 2.19*
M X L	3.60	- 4.76**	26.98**	5.10	-20.81**	-14.00**
M X F	2.50	-44.07**	-40.48**	4.47	-30.70*	-29.05
M X S	2.10	-46.70**	-42.78**	5.67	-13.30	-12.36
L X O	2.80	20.00**	11.11**	5.60	- 8.20*	- 5.56*
L X M	2.27	-32.44	- 9.92**	5.30	-17.70**	-15.47**
L X F	3.47	- 4.41**	37.70	4.93	-21.62**	-21.37**
L X S	2.53	-18.39**	- 0.39**	4.70	-26.24*	-25.04*
F X O	4.06	-11.74**	- 9.17**	5.10	-16.67*	-14.00*
F X M	3.67	-17.90**	-12.62	5.60	-13.18*	-15.51*
F X L	2.60	-28.37**	3.17**	5.53	-12.08*	-11.80*
F X S	2.20	-47.62**	-14.05**	5.26	-17.68*	-16.50*
S X O	3.00	-26.29**	-18.26**	5.10	-17.74**	-14.00*
S X M	3.07	-22.08**	-16.35**	4.60	-29.66**	-28.90**
S X L	2.80	-20.00**	-11.11	3.87	-39.25	-38.28
S X F	3.53	-15.95	- 3.81	6.00	- 6.10	- 4.76
CD (p = 0.05)	0.94			1.07		

*p = 0.05
**p = 0.01

(Contd.)

continued

Parents and hybrids	Female flowers in first ten nodes	Increase or decrease over (%)		Female flowers in first 20 nodes	Increase or decrease over (%)	
		Mid-parent	Better parent		Mid-parent	Better parent
Oriental pickling melon (O)	3.67			5.00		
Musk melon (M)	4.33			5.67		
Long melon (L)	2.33			3.50		
Snake melon (F)	2.33			3.67		
Snap melon (S)	2.00			3.33		
O X M	4.50	12.50^{*}_{**}	3.93	6.07	13.67^{**}_{**}	-7.05_{*}
O X L	3.63	21.00	-1.09_{*}	5.43	26.57	8.60_{*}
O X F	3.33	11.00	-9.26_{**}	4.67	7.60	-8.66_{*}
O X S	3.00	5.63	-18.26	4.40	7.91_{**}	-10.00_{*}
M X O	4.67	16.75	7.85_{**}	6.33	18.54	11.64_{*}
M X L	3.43	3.00_{*}	-20.79_{**}	5.00	8.23_{**}	-11.82
M X F	3.67	10.21_{**}	-15.24	5.33	14.13_{**}	-5.99
M X S	4.00	26.18_{**}	-7.62_{*}	5.33	18.44	-5.99
L X O	3.33	11.00_{*}	-9.26_{**}	4.67	8.86	-6.60_{*}
L X M	3.43	9.26_{**}	-20.79_{**}	4.73	2.34_{**}	-16.58_{**}
L X F	2.67	14.59_{**}	14.59_{**}	4.33	19.61_{**}	17.98
L X S	2.67	23.04	14.59_{*}	4.33	25.50	23.71
F X O	3.23	7.67	-11.98_{**}	4.63	6.68	-7.40_{*}
F X M	3.40	2.10	-21.48	4.73	1.28_{*}	-16.58_{*}
F X L	2.43	4.29_{**}	4.29	4.00	10.49_{**}	8.99
F X S	2.43	11.98	4.29_{**}	4.00	14.29	8.99_{*}
S X O	2.97	4.58	-19.07_{**}	4.43	6.24	-11.40_{*}
S X M	3.23	6.31	-22.17	4.70	4.44	-17.10^{*}
S X L	2.37	7.37	1.72	3.67	6.38_{*}	4.85
S X F	2.37	7.37	1.72	3.77	7.71	2.72
CD (p = 0.05)	0.91			1.93		

(Contd.)

continued

Parents and hybrids	Days to first female flower	Increase or decrease over (%) Mid-parent	Increase or decrease over (%) Better parent	Days to first fruit harvest	Increase or decrease over (%) Mid-parent	Increase or decrease over (%) Better parent
Oriental pickling melon (O)	35.67			67.67		
Musk melon (M)	33.53			70.00		
Long melon (L)	33.73			64.00		
Snake melon (F)	35.73			67.33		
Snap melon (S)	34.87			64.67		
O X M	28.73	-17.04**	-14.32**	60.33	-12.36**	-10.85**
O X L	31.67	- 6.02**	- 5.54**	63.00	- 4.30**	- 1.56**
O X F	31.20	- 8.77**	- 6.95**	59.67	-11.60**	11.37**
O X S	29.40	-15.03**	-12.32	59.00	-10.84**	- 8.77**
M X O	32.07	- 7.4 **	- 4.35**	62.33	- 9.46**	- 7.89**
M X L	29.33	-15.55**	-13.04**	58.33	-12.62**	- 8.86**
M X F	27.47	-22.18**	-21.93**	60.00	-12.62**	-10.89**
M X S	30.73	-13.92**	- 8.35**	59.00	-11.38**	- 8.77
L X O	30.40	- 9.60**	- 9.33**	62.00	- 5.83**	- 3.12**
L X M	29.87	-13.99**	-11.44**	56.76	-15.23**	-13.02**
L X F	28.48	-16.99**	-15.59**	55.67	-15.41**	-13.02**
L X S	28.20	-18.73**	-16.39**	57.00	-10.90**	-10.42**
F X O	28.83	-15.70**	-14.02**	55.67	-17.53**	-17.32**
F X M	30.60	-13.07**	-12.25**	61.33	-10.69**	- 8.91**
F X L	30.20	-12.95**	-10.47**	57.00	-13.20**	-10.94**
F X S	29.47	-16.44**	-15.49**	57.00	-11.62**	- 9.80**
S X O	28.87	-16.56**	-13.90**	60.00	- 7.22**	- 7.22**
S X M	27.80	-22.13**	-22.06**	57.33	-11.35**	-14.86**
S X L	27.20	-21.61**	-19.36	55.00	-14.52**	-14.95**
S X F	33.60	- 4.73	- 3.64	62.67	- 5.05	- 3.09
CD (p = 0.05)	0.65			1.43		

(contd.)

continued

Parents and hybrids	Days to fruit maturity	Increase or decrease over (%)		Primary vine length (m)	Increase or decrease over (%)	
		Mid-parent	Better parent		Mid-parent	Better parent
Oriental pickling melon (O)	34.33			2.85		
Musk melon (M)	34.67			3.44		
Long melon (L)	32.13			2.91		
Snake melon (F)	32.67			3.36		
Snap melon (S)	33.20			2.97		
O X M	29.67	-14.00**	-13.57**	3.30	5.20**	- 4.07**
O X L	31.93	- 3.91**	- 0.65**	3.22	11.81**	10.65**
O X F	29.00	-13.23**	-11.43**	3.63	13.08**	8.04**
O X S	28.53	-15.52**	-14.07*	3.44	13.90	15.82
M X O	31.00	-14.07**	- 9.07**	3.54	3.20**	2.91*
M X L	28.00	-16.17**	-12.85**	3.71	10.42**	8.72**
M X F	29.13	-13.48**	-10.84**	3.79	11.57**	10.17
M X S	29.13	-14.17*	-12.26	3.52	10.00*	2.34**
L X O	30.33	- 8.73**	- 5.42**	3.15	9.40**	10.53
L X M	27.33	-18.17**	-14.94**	3.52	10.69**	2.33**
L X F	26.67	-17.69**	-16.99**	3.58	14.01**	16.67**
L X S	27.60	-15.52**	-16.87**	3.54	20.40**	19.19
F X O	26.73	-20.21**	-18.18*	3.50	12.58**	3.89**
F X M	29.87	-11.29**	- 8.57	3.78	11.18**	12.50*
F X L	29.13	-10.09**	- 9.34**	3.52	12.46*	5.06
F X S	28.27	-14.18**	-14.85**	3.33	5.50**	0.89**
S X O	29.53	-12.56**	-11.05**	3.30	13.40	11.11
S X M	27.87	-17.88**	-16.05**	3.31	5.40**	- 3.78**
S X L	26.00	-20.42*	-19.08	3.46	17.69*	18.90
S X F	31.13	- 5.50	- 4.71	3.41	7.58	1.49
CD (p = 0.05)	1.65			0.30		

(Contd.)

continued

Parents and hybrids	Primary branches/ plant	Increase or decrease over (%)		Nodes on main stem	Increase or decrease over (%)	
		Mid-parent	Better parent		Mid-parent	Better parent
Oriental pickling melon (O)	9.73			31.00		
Musk melon (M)	7.47			34.33		
Long melon (L)	8.00			26.50		
Snake melon (F)	8.33			32.00		
Snap melon (S)	6.80			33.33		
O X M	9.33	8.49^{*}_{**}	-4.11_{**}	38.33	17.32^{**}_{**}	11.65^{**}
O X L	11.00	24.01_{*}	13.05_{**}	33.00	14.78_{**}	6.45_{**}
O X F	10.33	6.17_{**}	14.40	37.33	19.76_{**}	19.15_{**}
O X S	10.00	20.92	2.78	36.60	13.77_{*}	9.81
M X O	9.07	5.47_{**}	-6.78_{**}	35.07	7.66_{*}	2.91
M X L	9.17	18.48_{**}	14.63_{**}	33.00	8.48_{**}	-3.87_{*}
M X F	9.00	13.92_{*}	8.04	36.20	10.27_{*}	5.45_{*}
M X S	7.63	6.86_{**}	2.14_{*}	35.73	5.61_{**}	4.08_{*}
L X O	10.33	16.46_{**}	6.17_{**}	33.33	15.93_{**}	7.52
L X M	9.33	20.54_{**}	16.63_{**}	33.80	11.11_{**}	- 1.54
L X F	10.00	22.40_{**}	20.05_{**}	32.00	10.65_{**}	2.14_{**}
L X S	10.40	40.54_{*}	30.00	38.00	27.00_{**}	14.01_{*}
F X O	9.90	9.63_{**}	1.75_{**}	35.00	9.08_{**}	8.51_{**}
F X M	9.20	16.46_{**}	10.44_{**}	37.73	14.93_{**}	9.90
F X L	10.33	26.44_{**}	24.01	32.67	12.97_{**}	4.28_{*}
F X S	8.47	11.89_{**}	1.68	36.00	11.35_{**}	8.01_{*}
S X O	9.60	16.08_{*}	- 1.33	37.00	11.91	8.01
S X M	7.67	7.42_{**}	2.68_{**}	35.20	0.38_{**}	4.05
S X L	9.33	26.08_{**}	16.63	32.00	13.64_{**}	2.01_{*}
S X F	8.57	13.21	2.83	37.13	14.85	8.16
CD (p= 0.05)	3.20			6.59		

(contd.)

continued

Parents and hybrids	Fruit length (cm)	Increase or decrease over (%)		Fruit girth (cm)	Increase or decrease over (%)	
		Mid-parent	Better parent		Mid-parent	Better parent
Oriental pickling melon (O)	36.50			34.65		
Musk melon (M)	18.36			33.03		
Long melon (L)	46.37			34.60		
Snake melon (F)	53.77			39.93		
Snap melon (S)	39.13			36.77		
O X M	28.82	5.10	-21.01**	34.23	1.15	- 1.20
O X L	44.33	7.00	- 4.40**	36.67	5.89	- 0.27
O X F	43.20	- 4.30*	-19.66	38.97	4.51	- 2.50
O X S	41.20	8.94	5.29**	36.26	2.49	- 0.46
M X O	24.13	- 8.38**	-31.15**	35.53	4.99	2.54**
M X L	25.57	-21.0 **	-44.86**	37.06	9.58	7.11
M X F	29.60	-17.94	-44.95**	37.02	1.51**	- 7.30**
M X S	19.83	-31.03**	-49.32	40.80	16.91	10.96
L X O	44.87	8.28	- 3.52**	36.53	4.49	5.43
L X M	31.63	- 2.29**	-31.79**	35.30	4.38	2.02**
L X F	45.23	- 9.67*	-15.88	34.81	- 6.50	-12.82
L X S	47.63	11.42	2.72	38.17	6.95	3.81
F X O	44.82	- 0.71**	-16.64**	36.60	- 1.85	- 8.30
F X M	29.43	-18.13	-45.08**	37.57	2.99	- 5.91
F X L	47.13	- 5.87	12.35**	36.57	- 1.89	- 8.41
F X S	47.33	1.89**	-11.98	40.53	5.68	1.52
S X O	40.22	6.35	2.79	35.04	- 1.88	- 4.70
S X M	29.27	1.81**	-25.20	34.27	- 1.81	- 1.03
S X L	51.89	21.38	11.90	35.70	0.28	- 2.91
S X F	47.70	2.69	2.69	38.03	- 0.83	- 4.76
CD (p = 0.05)	5.82			3.82		

(contd.)

continued

Parents and hybrids	Fruit weight (Kg)	Increase or decrease over (%)		Fruit volume (l)	Increase or decrease over (%)	
		Mid-parent	Better parent		Mid-parent	Better parent
Oriental pickling melon (O)	1.99			1.76		
Musk melon (M)	0.77			0.60		
Long melon (L)	2.06			2.05		
Snake melon (F)	2.47			2.49		
Snap melon (S)	2.21			2.04		
O X M	1.49	7.97* **	-25.12** *	1.27	4.96* **	-30.22**
O X L	2.23	9.85**	8.25	2.23	9.79**	3.90
O X F	2.57	15.25	4.47	2.50	15.74**	0.40*
O X S	2.30	6.19	0.90**	2.02	6.32	- 6.91**
M X O	1.39	0.72	-30.15**	1.25	3.31	-31.32**
M X L	1.47	3.52	-28.64**	1.35	1.50	-34.14**
M X F	1.65	1.85	-32.92**	1.57	1.29*	-36.95**
M X S	1.50	0.67**	-32.13**	1.38	4.32*	-33.18
L X O	2.25	10.84	9.22**	2.03	4.64**	0.98**
L X M	1.52	7.04	-26.21	1.42	7.52**	-30.24
L X F	2.48	9.73**	0.81**	2.49	7.93**	- 1.60
L X S	2.62	22.42**	18.55	2.58	22.27**	18.89
F X O	2.53	13.45*	2.85**	2.37	9.72*	- 4.80
F X M	1.72	6.17*	-30.08	1.72	4.41**	- 4.82**
F X L	2.39	5.75**	2.84**	2.37	10.96**	-30.92
F X S	2.69	14.95	9.35	2.60	11.59	4.42
S X O	2.22	5.71	0.45**	2.20	10.00**	1.38**
S X M	1.52	2.01**	-31.22**	1.47	5.75**	-32.25*
S X L	2.49	16.36**	12.66	2.32	9.95**	6.91
S X F	2.56	8.97	3.66	2.58	10.73	3.61
CD (p = 0.05)	0.64			0.57		

(contd.)

continued

Parents and hybrids	Flesh thick-ness (cm)	Increase or decrease over (%) Mid-parent	Increase or decrease over (%) Better parent	Seeds/ fruit	Increase or decrease over (%) Mid parent	Increase or decrease over (%) Better parent
Orient pickling melon (O)	2.74			572.00		
Musk melon (M)	1.97			437.60		
Long melon (L)	2.69			600.20		
Snake melon (F)	2.86			782.47		
Snap melon (S)	3.15			681.13		
O X M	2.54	7.23^{*}_{**}	-8.73^{*}_{*}	570.67	18.32^{**}_{**}	8.30^{*}_{*}
O X L	2.97	9.59_{**}	8.59_{*}	660.37	17.17_{**}	10.03^{*}
O X F	3.07	9.64_{**}	7.34^{*}	809.31	23.62_{*}	3.43
O X S	3.13	6.46_{*}	-0.63_{*}	731.82	21.11_{**}	7.40
M X O	2.47	5.11_{*}	-9.86_{*}	547.33	13.48_{**}	3.86_{*}
M X L	2.50	7.30	-7.06_{**}	649.33	19.99_{*}	9.85_{**}
M X F	2.55	5.81_{**}	-10.84_{**}	677.33	11.03_{*}	-13.43_{*}
M X S	2.80	9.38_{**}	-11.11_{*}	618.33	10.54_{**}	-9.22_{*}
L X O	2.96	9.23_{*}	8.03_{*}	681.87	15.07_{**}	8.05
L X M	2.50	7.30	-7.06	615.27	19.77_{*}	3.55
L X F	2.80	4.32	1.40	774.00	11.96_{**}	1.08_{**}
L X S	3.07	5.14_{*}	-2.54	738.60	15.29_{*}	8.43_{*}
F X O	3.02	7.86	5.60_{**}	732.33	10.48_{*}	-7.56_{**}
F X M	2.71	4.98	-11.54^{**}	677.67	11.09_{*}	-13.39
F X L	2.39	5.40_{*}	2.45	778.00	12.45_{*}	-0.56
F X S	3.23	7.67_{*}	2.54	811.33	10.87_{**}	3.69_{*}
S X O	3.21	9.18_{*}	1.90_{**}	772.72	24.88_{**}	10.75
S X M	2.71	5.86_{*}	-13.96^{**}	664.20	18.74_{**}	-2.49_{**}
S X L	2.98	2.05	0.63	764.87	19.39_{*}	12.29
S X F	3.40	5.70	0.63	814.00	11.24^{*}	-0.22
CD ($p = 0.05$)	0.46			102.85		

(contd.)

continued

Parents and hybrids	Seed yield/ fruit (g)	Increase or decrease over (%)		100 seed weight (g)	Increase or decrease over (%)	
		Mid-parent	Better parent		Mid-parent	Better Parent
Oriental pickling melon (O)	16.53			2.87		
Musk melon (M)	12.26			3.06		
Long melon (L)	13.09			2.18		
Snake melon (F)	20.12			2.57		
Snap melon (S)	15.35			2.23		
O X M	18.34	27.36**	10.95**	3.21*	8.08*	4.90*
O X L	17.7	7.08**	2.68**	6.35	6.35**	- 6.62**
O X F	22.35	21.93**	11.08**	3.20	17.64**	11.49
O X S	21.48	34.46**	29.94**	2.94	15.29*	2.44*
M X O	17.90	24.31**	8.29**	3.27	10.10**	6.86
M X L	20.36	60.00**	55.53*	3.11	18.70**	1.63
M X F	21.31	31.62**	5.91**	3.18	12.76**	3.92
M X S	19.21	39.02**	25.00**	3.10	16.98	1.31*
L X O	17.97	21.34**	8.71**	2.63	3.95**	- 8.36
L X M	19.17	51.18**	46.44*	3.11	18.70*	1.63
L X F	19.17	15.41**	- 4.72**	2.49	4.06	- 3.11
L X S	18.08	27.06**	17.71*	2.30	4.07*	3.14
F X O	21.11	15.16**	4.92*	2.92	7.35**	1.74
F X M	21.52	32.91**	6.96	3.17	12.41**	3.59
F X L	20.11	21.07**	- 0.05*	2.57	8.44**	0.79**
F X S	21.6	21.76**	7.36**	2.91	10.00**	18.39
S X O	21.19	32.85**	28.19**	2.85	11.76*	- 0.70
S X M	18.99	37.51**	23.63**	2.85	7.55**	- 5.88**
S X L	19.64	38.02**	27.86**	2.48	12.22**	11.21
S X F	22.64	27.62	12.52	2.61	8.75	1.56
CD (p = 0.05)	4.27			0.57		

(contd.)

continued

Parents and hybrids	Fruits/ plant	Increase or decrease over (%)		Fruit yield/ plant (Kg)	Increase or decrease over (%)	
		Mid-parent	Better parent		Mid-parent	Better parent
Orient pickling melon (O)	7.95			15.78		
Musk melon (M)	8.10			4.72		
Long melon (L)	5.00			10.30		
Snake melon (F)	5.47			15.46		
Snap melon (S)	4.60			10.17		
O X M	9.20	14.86**	13.58**	13.71	33.75**	-13.12**
O X L	7.80	20.55**	- 1.64	17.39	33.58**	10.20**
O X F	7.53	12.59*	- 5.04**	19.35	32.35**	22.62
O X S	7.00	11.82**	-11.72**	15.61	20.26**	- 1.07**
M X O	9.37	16.98**	15.67	13.02	27.02**	-17.49**
M X L	7.57	15.57**	- 6.50*	11.13	48.20**	8.06
M X F	7.90	16.35**	-10.00	13.04	43.45**	- 3.12**
M X S	8.03	26.45**	- 0.86	12.05	61.74**	18.49
L X O	7.27	12.36**	- 8.32	16.36	25.46**	3.68*
L X M	7.53	14.96**	- 7.04**	11.45	52.26**	11.17**
L X F	7.50	18.32**	13.35**	15.36	29.46**	14.26**
L X S	6.20	29.17	24.00	16.23	58.59**	57.66*
F X O	6.80	7.91	- 8.83**	18.29	25.10**	15.60**
F X M	6.97	5.60**	-11.48	12.33	35.64*	- 8.39
F X L	5.75	9.56**	4.75	13.69	15.24*	1.70*
F X S	5.76	13.10**	4.20**	15.33	23.69*	18.89
S X O	6.87	9.57**	-13.36**	15.25	17.49**	- 3.34**
S X M	7.10	11.85**	-12.35**	10.79	44.83**	6.10**
S X L	5.55	15.21**	10.60	16.24	54.47*	53.88*
S X F	5.23	9.72	1.10	14.10	19.23*	4.75
CD (p = 0.05)	1.27			18.81		

Nodes to first male flower

All the hybrids except long melon x oriental pickling melon produced male flowers in lower nodes when compared to their mid-parents. The lowest node in which male flower was produced was in the hybrid musk melon x snap melon (2.10) followed by snake melon x snap melon (2.20).

Nodes to first female flower

All the hybrids produced their first female flower in lower nodes when compared to their respective better and mid-parents. The most heterotic among these was snap melon x long melon in which first female flower was produced at the fourth node. This was followed by musk melon x snake melon (4.47) and snap melon x musk melon (4.60).

Female flowers in first ten nodes

All hybrids produced more female flowers when compared to their mid-parents. Significant difference was observed only in ten hybrids. Eight hybrids had more female flowers than their respective better parents. Musk melon x oriental pickling melon had the highest number of female flowers (4.67) in the first ten nodes.

Female flowers in the first 20 nodes

All the 20 F_1 hybrids produced more female flowers in the first 20 nodes compared to their mid-parents.

Relative heterosis ranged from 1.28% in snake melon x musk melon to 26.57% in oriental pickling melon x long melon. Significant relative heterosis was observed in nine hybrids. Heterobeltiosis was also observed in nine hybrids. Maximum number of female flowers in the first 20 nodes was produced by musk melon x oriental pickling melon (6.33).

Days to first female flower

11 hybrids were earlier than their respective parents. Snap melon x long melon produced the first female flower 27 days after sowing, thus expressing heterobeltiosis of -19.36% and relative heterosis of -21.61%. Musk melon x snake melon and snap melon x musk melon were earlier hybrids (27 days and 28 days respectively).

Days to fruit harvest

All hybrids produced fruits early compared to their respective better parents. Relative heterosis ranged from -4.5% to -17.53% and heterobeltiosis from -1.56% to -17.32%. The earlier hybrids were snap melon x long melon (55 days), snake melon x oriental pickling melon (56 days) and long melon x snake melon (56 days).

Days to fruit maturity

In all 20 F_1 hybrids fruits matured earlier than their respective early parents. Snap melon x long melon took 26 days for fruit maturity followed by long melon x snake melon and snake melon x oriental pickling melon in which the average days to fruit maturity were 26.67 and 26.73 respectively.

Primary vine length

Eighteen F_1 hybrids were observed to be longer than their respective longer parents. The percentage increase ranged from 0.89% in snake melon x snap melon to 19.19% in long melon x snap melon. The relative heterosis ranged from 3.20% to 20.40%. Musk melon x snake melon had 3.79 cm length of primary vine which was 10.17% higher than its better parent and 11.57% higher than the mid-parent.

Primary branches/plant

Oriental pickling melon x long melon had the maximum number of primary branches (11) which was 13.05% more than the better parent and 24.01% more than the mid-parent. Seventeen hybrids exhibited heterobeltiosis ranging from 1.33% to 30.00%. All 20 F_1 hybrids expressed relative heterosis ranging from 6.17% in oriental pickling melon x snake melon to 40.54% in long melon x snap melon.

Nodes on main stem

Oriental pickling melon x long melon had 38.33 nodes on the main stem which was 11.65% more than musk melon, the better parent and 17.32% more than the mid-parent. Another F_1 hybrid, long melon x snap melon had

38 nodes on the main stem, expressing heterobeltiosis to the extent of 14.01% and relative heterosis of 27.00%. The extent of heterobeltiosis ranged from 2.01% to 19.15% and relative heterosis from 0.38% to 27.00%.

Fruit length

Fruit length in most of the hybrids was lesser than their better parents. Increased fruit length over their respective better parents was observed in six hybrids, ranging from 2.69% to 12.35%. Snap melon x long melon had a fruit length of 51.89 cm which was 11.90% more than the better parent, long melon and 21.38% more than the mid-parent. Ten hybrids had increased fruit length when compared to their mid-parental values, ranging from 1.81% in snap melon x musk melon to 21.38% in snap melon x long melon.

Fruit girth

Significant increase in fruit girth over their respective parents was observed in hybrids musk melon x snap melon (40.80 cm) and musk melon x long melon (37.06 cm). Increase in fruit girth over better parents was observed in five more hybrids but the increase was not significant. The remaining hybrids registered decreased fruit girth over their better parents.

Fruit weight

Snake melon x snap melon had the highest fruit weight of 2.69 kg which was 9.35% more than the better parent and 14.95% more than the mid-parent. This was followed by long melon x snap melon with a fruit weight of 2.02 kg. This hybrid expressed heterobeltiosis of 18.55% and relative heterosis of 22.42%. Fruit weight in eight hybrids was less than their respective better parents and it was the least in musk melon x oriental pickling melon (1.39 kg).

Fruit volume

Twelve hybrids expressed a higher fruit volume than their respective better parents ranging from 0.40% to 15.89%. The fruit volume was the highest in snap melon x snake melon (3.40 l) closely followed by snake melon x snap melon (3.23 l) and snap melon x oriental pickling melon (3.21 l). The range of relative heterosis was from 1.29% in musk melon x snake melon to 22.27% in long melon x snap melon.

Flesh thickness

Flesh thickness was observed to be the maximum in snap melon x snake melon (3.40 cm) followed by snake melon x snap melon (3.23 cm) and snap melon x oriental pickling melon (3.21 cm). The hybrids manifested heterobeltiosis ranging from -13.96% to 8.39% and relative heterosis from 2.05% to 9.64%.

Seeds/fruit

Snake melon x snap melon had 811.33 seeds/fruit which was 3.69% more than the better parent, snake melon (782.42) and 10.87% more than the mid-parent. The seeds/fruit were more than their respective better parents in thirteen hybrids, the increase ranging from 1.08% to 10.75%. Six hybrids had fewer seeds/fruit and the decrease was significant in all except snap melon x snake melon (-0.22%). All the hybrids expressed relative heterosis ranging from 10.48% to 24.8[illegible]%.

Seed yield/fruit

Seed yield/fruit was found to be the highest in snap melon x snake melon (22.64 g). This was 12.52% more than the better parent, snake melon (20.12 g) and 27.62% more than the mid-parent. This was followed by oriental pickling melon x snake melon (22.35 g) manifesting heterobeltiosis to an extent of 11.08% and relative heterosis of 21.93%. The range of heterobeltiosis was from 0.05% to 46.44% and relative heterosis from 21.07% to 60.00%.

100 seed weight

Weight of 100 seeds was higher than their respective better parents in fifteen hybrids. Hundred seed weight was the highest in musk melon x oriental pickling melon (3.27 g) exhibiting heterobeltiosis to the tune of 6.86% and relative heterosis of 10.10%. The lowest 100 seed weight was observed for long melon x snap melon (2.30 g). All the hybrids except long melon x oriental pickling melon (2.63 g) and long melon x snap melon (2.30 g) expressed significant relative heterosis.

Fruits/plant

Eight hybrids had more fruits than their better parents. Musk melon x oriental pickling melon had 9.37 fruits/plant. This was followed by oriental pickling melon x musk melon (9.20). Musk melon x oriental pickling melon manifested heterobeltiosis to the extent of 15.67% and relative heterosis to the tune of 16.98%. Heterobeltiosis in oriental pickling melon x musk melon was 14.86% and relative heterosis was 13.58%. The range of heterobeltiosis was from -13.36% in snap melon x oriental pickling melon to 24.00% in long melon x snap melon. All hybrids expressed increased relative heterosis ranging from 5.60% in snake melon x musk melon to 29.17% in long melon x snap melon.

Fruit yield/plant

Yield of fruits/plant was more than their respective better parents in twelve hybrids. Heterobeltiosis varied from -13.12% in oriental pickling melon x musk melon to 57.60% in long melon x snap melon. The best F_1 hybrid oriental pickling melon x snake melon gave a mean yield of 19.35 kg of fruits/plant. This was 22.62% more than the better parent, snake melon (13.46 kg) and 35.58% more than the mid-parent. All hybrids were significantly higher yielding than their respective mid-parents. Relative heterosis ranged from 15.24% in snake melon x long melon to 61.74% in musk melon x snap melon.

C. Analysis of combining ability

The combining ability analysis was conducted for each quantitative character studied (Table 8).

Table 8. Analysis of variance for Gca, Sca, and reciprocal effects in a 5 x 5 diallel cross

Sources of variation	df	Mean squares				
		Nodes to first male flower	Nodes to first female flower	Female flowers in first ten nodes	Female flowers in first 20 nodes	Days to first female flower
Gca	4	1.13*	1.14**	2.91**	2.97**	2.04**
Sca	10	0.57**	0.55**	0.07	0.17	12.25**
Reciprocals	10	0.44**	0.03	0.05	0.10	2.59**
Error	48	0.11	0.05	0.10	0.16	0.21

*p = 0.05

**p = 0.01

(contd.)

continued

Sources of variation	df	Mean squares					
		Days to first fruit harvest	Days to fruit maturity	Fruit length (cm)	Fruit girth (cm)	Fruit weight (kg)	Fruit volume (l)
Gca	4	11.31**	3.26**	53.51**	9.62**	1.47**	1.63**
Sca	10	31.29**	10.71**	26.04**	2.23	0.032	0.019
Reciprocals	10	1.60**	1.49**	7.58	3.56	0.0034	0.01
Error	48	0.25	0.33	3.91	1.81	0.05	0.04

continued

Sources of variation	df	Mean squares					
		Flesh thickness (cm)	Seeds/ fruit	100 seed weight	Seed yield/ fruit	Fruits/ plant	Fruit yield/ plant (kg)
Gca	4	0.52**	43648.89**	0.48**	15.56**	7.76**	39.62**
Sca	10	0.004	3341.74**	0.047	10.19**	0.366	6.335
Reciprocals	10	0.01	702.49	0.014	0.39	0.302	0.468
Error	48	0.03	1306.32	0.04	2.25	0.20	4.67

The general combining ability (gca) effects, specific combining ability (sca) effects and reciprocal effects were estimated (Table 9).

Nodes to first male flower

Variances due to gca, sca and reciprocal effects were significant (Table 9). Snake melon had the highest gca value (0.57) and the lowest gca value was recorded in long melon (-0.42). Long melon x snake melon had the lowest sca effect (-0.67). The highest sca effect was manifested by long melon x musk melon (0.45). Maximum reciprocal effect was shown by snake melon x long melon (0.44) and the minimum by musk melon x oriental pickling melon (-0.79) (Table 9).

Nodes to first female flower

Variations due to gca and sca were significant. Snake melon expressed the highest gca effect (0.40) and the lowest gca value (-0.42) by musk melon. The maximum sca effect was manifested by musk melon x snap melon (0.20). Musk melon x snake melon expressed the minimum sca effect (-0.71) followed by long melon x snap melon (-0.46) (Table 9). The reciprocal effect was not significant for this character.

Female flowers in first ten nodes

Only variance due to sca was significant. (Table 8). Sca effect of oriental pickling melon x musk melon was

Table 9. General combining ability effects (Gca) specific combining ability effects (Sca) and reciprocal effects

Character		O	M	L	F	S	Gca
Nodes to first male flower	O	0.80	-0.13	-0.32	0.11	-0.46	0.26
	M	-0.79	0.98	-0.27	-0.47	-0.35	0.36
	L	-0.14	0.47	0.23	-0.67	0.19	-0.42
	F	-1.16	-0.59	0.44	-0.84	0.41	0.37
	S	-0.30	-0.49	-0.14	-0.67	1.03	-0.25

(Values below the diagonal represent reciprocal effects.

Values on and above the diagonal represent specific combining ability effects.

General combining ability effects are presented in separate column.)

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.10	-
Sca (s_{ii})	0.27	-
Sca (s_{ij})	0.15	-
Reciprocal (r_{ij})	0.24	-
$g_i - g_j$	0.15	0.30
$s_{ii} - s_{jj}$	0.36	0.73
$s_{ii} - s_{ij}$	0.38	0.76
$s_{ii} - s_{jk}$	0.26	0.52
$r_{ij} - r_{kl}$	0.33	0.67

O - Oriental pickling melon
M - Musk melon
L - Long melon
F - Snake melon
S - Snap melon

(contd.)

continued

Character		O	M	L	F	S	Gca
Nodes to first female flower	O	0.76	-0.19	-0.06	0.19	-0.45	0.28
	M	0.05	0.70	-0.05	-0.71	0.20	-0.42
	L	-0.42	0.25	0.54	-0.02	-0.46	-0.14
	F	0.02	0.23	-0.07	0.38	0.14	0.40
	S	-0.10	-0.42	-0.87	0.14	0.56	-0.09

Effects/Comparison	Standard form	Critical difference
Gca (g_i)	0.06	-
Sca (S_{ii})	0.18	-
Sca (S_{ij})	0.05	-
Reciprocal (r_{ij})	0.16	-
$g_i - g_j$	0.10	0.20
$S_{ii} - S_{ij}$	0.24	0.49
$S_{ii} - S_{jk}$	0.26	0.51
$S_{ii} - S_{jj}$	0.21	0.43
$S_{ij} - S_{kl}$	0.17	0.35
$S_{ij} - S_{ik}$	0.20	0.40

(contd.)

continued

Character		O	M	L	F	S	Gca
Number of female flowers in first ten nodes	O	-0.36	0.26	0.21	0.03	0.15	0.43
	M	0.09	-0.30	-0.14	-0.01	0.18	0.73
	L	0.15	0.01	-0.29	0.06	0.15	-0.33
	F	0.05	0.14	0.12	-0.14	0.05	-0.35
	S	0.02	0.39	0.15	0.03	-0.24	-0.47

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.09	-
Sca (s_{ii})	0.25	-
Sca (s_{ij})	0.05	-
Reciprocal (r_{ij})	0.22	-
$g_i - g_j$	0.14	0.28

(contd.)

continued

Character		O	M	L	F	S	Gca
Female	O	-0.50	0.41	0.30	-0.06	-0.15	0.43
flowers	M	-0.13	-0.41	-0.14	-0.02	0.16	0.73
in first	L	0.38	0.14	-0.50	0.19	-0.33	0.31
20 nodes	F	0.02	0.30	-0.17	-0.26	0.11	-0.35
	S	-0.02	0.32	-0.33	0.12	-0.30	-0.50

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.11	-
Sca (S_{ii})	0.32	-
Sca (S_{ij})	0.01	-
Reciprocal (r_{ij})	0.28	-
$g_i - g_j$	0.18	0.56

(contd.)

continued

Character		O	M	L	F	S	Gca
Days to first female flower	O	3.38	-0.51	0.22	-1.65	-1.90	0.54
	M	-1.67	3.51	-0.34	-1.74	-1.64	-0.34
	L	0.64	-0.27	3.88	-1.36	-2.37	-0.43
	F	1.15	-1.57	-0.87	4.18	0.62	0.42
	S	0.27	0.72	0.50	-2.07	4.58	-0.21

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.14	-
Sca (s_{ii})	0.36	-
Sca (s_{ij})	0.06	-
Reciprocal (r_{ij})	0.32	-
$g_i - g_j$	0.20	0.41
$s_{ii} - s_{jj}$	0.50	1.00
$s_{ii} - s_{ij}$	0.52	1.04
$s_{ii} - s_{jk}$	0.44	0.88
$s_{ij} - s_{ik}$	0.41	0.83
$s_{ij} - s_{kl}$	0.36	0.73
$r_{ij} - r_{kl}$	0.46	0.92

(contd.)

continued

Character		O	M	L	F	S	Gca
Days to first fruit harvest	O	4.69	-1.45	1.72	-3.84	-1.21	1.24
	M	-1.00	7.43	-3.08	-0.43	-2.37	1.04
	L	0.05	0.83	5.42	-2.76	-1.34	-0.90
	F	2.0	-0.67	+0.67	7.95	-1.41	-0.42
	S	-0.05	0.84	-0.17	-0.67	6.23	-0.89

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.14	-
Sca (s_{ii})	0.40	-
Sca (s_{ij})	0.07	-
Reciprocal (r_{ij})	0.35	-
$g_i - g_j$	0.22	0.45
$s_{ii} - s_{jj}$	0.55	1.10
$s_{ii} - s_{ij}$	0.57	1.15
$s_{ii} - s_{jk}$	0.47	0.95
$s_{ij} - s_{ik}$	0.45	0.90
$r_{ij} - r_{kl}$	0.50	1.01
$s_{ij} - s_{kl}$	0.39	0.78

(contd.)

continued

Character		O	M	L	F	S	Gca
Days to fruit maturity	O	3.01	-0.58	1.22	-2.45	-1.2	0.78
	M	-0.67	4.16	-1.84	-0.37	0.63	0.35
	L	0.80	0.34	3.63	-1.61	-2.02	-0.63
	F	1.14	-0.37	-1.25	3.37	1.43	-1.61
	S	-0.50	0.63	0.80	-1.43	4.06	-0.31

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.16	-
Sca (s_{ii})	0.46	-
Sca (s_{ij})	0.08	-
Reciprocal (r_{ij})	0.41	-
$g_i - g_j$	0.26	0.52
$s_{ii} - s_{jj}$	0.63	1.27
$s_{ii} - s_{ij}$	0.66	1.32
$s_{ii} - s_{jk}$	0.55	1.10
$s_{ij} - s_{ik}$	0.51	1.03
$s_{ij} - s_{kl}$	0.45	0.89
$r_{ij} - r_{kl}$	0.57	1.10

(contd.)

continued

Character		O	M	L	F	S	Gca
	O	-2.85	2.43	1.08	-0.62	0.04	0.42
Fruit	M	-0.42	4.91	-1.97	-1.11	-3.25	-12.53
length	L	-0.27	-3.03	-1.32	-2.62	4.83	4.59
(cm)	F	-0.81	0.04	-0.95	3.86	1.49	5.70
	S	0.49	-4.72	-2.13	-0.19	-3.03	1.82

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.56	-
Sca (s_{ii})	1.58	-
Sca (s_{ij})	0.28	-
Reciprocal (r_{ij})	1.40	-
$g_i - g_j$	0.88	1.76
$s_{ii} - s_{jj}$	2.17	4.36
$s_{ii} - s_{ij}$	2.25	3.77
$s_{ii} - s_{jk}$	1.88	4.53
$s_{ij} - s_{ik}$	1.77	3.50
$s_{ij} - s_{kl}$	1.53	3.08

(contd.)

continued

Character		O	M	L	F	S	Gca
Fruit girth (cm)	O	-0.64	0.25	1.25	0.45	-0.80	-0.69
	M	-0.65	-1.94	0.99	0.12	1.09	-0.81
	L	0.07	0.33	-0.80	-1.70	0.27	-0.60
	F	1.19	-0.27	-0.36	0.54	0.01	1.39
	S	0.78	3.27	1.24	1.25	-1.17	0.69

Effects/comparison	Standard error	Critical difference
Gca (g_i)	0.38	-
Sca (s_{ii})	1.08	-
Sca (s_{ij})	0.04	-
Reciprocal (r_{ij})	0.91	-
$g_i - g_j$	0.60	1.21

(contd.)

continued

Character		O	M	L	F	S	Gca
Fruit weight (kg)	O	-0.16	0.01	0.31	0.14	-1.02	0.05
	M	0.05	0.05	0.01	0.04	-0.06	-0.66
	L	-0.01	-0.03	0.21	0.03	0.21	0.11
	F	0.02	-0.04	0.05	-0.20	0.08	0.31
	S	0.04	-0.01	0.07	-0.07	-0.21	0.19

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.04	-
Sca (s_{ii})	0.18	-
Sca (s_{ij})	0.03	-
Reciprocal (r_{ij})	0.16	-
$g_i - g_j$	0.10	0.20

(contd.)

continued

Character		O	M	L	F	S	Gca
	O	-0.17	0.01	0.03	0.15	-0.01	-0.01
	M	0.01	0.02	-0.02	0.01	-0.02	-0.68
Fruit	L	0.1	-0.04	-0.18	-0.03	0.19	0.14
volume	F	0.07	-0.08	-0.06	-0.19	0.10	0.37
(1)	S	-0.09	-0.05	0.13	0.01	-0.26	0.18

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.06	-
Sca (s_{ii})	0.16	-
Sca (s_{ij})	0.12	-
Reciprocal (r_{ij})	0.14	-
$g_i - g_j$	0.09	0.18

(contd.)

continued

Character		O	M	L	F	S	Gca
Flesh thick-ness (cm)	O	-0.19	0.01	0.11	0.06	0.04	0.05
	M	0.04	-0.13	0.06	0.05	0.04	-0.37
	L	0.01	0.01	-0.09	-0.05	-0.03	-0.03
	F	0.03	-0.08	-0.07	-0.19	0.13	0.11
	S	-0.04	0.05	-0.05	-0.09	-0.18	0.25

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.05	-
Sca (s_{ii})	0.02	-
Sca (s_{ij})	0.02	-
Reciprocal (r_{ij})	0.12	-
$g_i - g_j$	0.08	0.16

(contd)

continued

Character		O	M	L	F	S	Gca
100 seed weight (g)	O	0.2	0.01	-0.04	0.12	0.12	0.08
	M	-0.03	-0.34	0.25	0.06	0.03	0.29
	L	0.03	0.01	-0.15	-0.04	-0.01	-0.25
	F	0.14	0.01	-0.04	0.35	0.11	-0.01
	S	0.15	0.13	-0.09	0.15	-0.25	-0.17

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.05	-
Sca (s_{ii})	0.16	-
Sca (s_{ij})	0.03	-
Reciprocal (r_{ij})	0.14	-
$g_i - g_j$	0.09	0.18

(contd)

continued

Character		G	M	L	F	S	Gca
	G	-70.13	-8.55	6.86	25.34	46.65	-22.01
	M	11.67	-55.32	42.68	11.13	10.07	-96.62
Seeds/	L	-10.75	17.03	-86.19	12.39	23.81	0.12
fruit	F	41.99	-0.135	2.00	-57.36	[illegible].01	76.34
	S	-20.45	-22.94	-6.14	-1.34	-88.35	41.66

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	10.22	-
Sca (s_{ii})	23.91	-
Sca (s_{ij})	5.11	-
Reciprocal (r_{ij})	25.56	-
$g_i - g_j$	16.16	32.50
$s_{ii} - s_{jj}$	39.59	79.62
$s_{ii} - s_{ij}$	41.21	82.37
$s_{ii} - s_{jk}$	34.29	68.95
$s_{ij} - s_{kl}$	27.99	5[illegible].30
$s_{ij} - s_{ik}$	32.33	65.01

(contd.)

continued

Character		O	M	L	F	S	GCA
	O	-2.60	-0.03	-0.02	0.70	1.96	0.02
Seed	M	0.22	-4.91	2.88	1.37	0.70	-0.96
yield/	L	0.14	0.60	-3.50	-0.12	0.76	-1.25
fruit	F	0.62	-0.11	-0.47	[illegible]	0.89	1.32
(g)	S	0.15	0.11	-0.78	-0.52	-4.26	0.27

Effects/Comparison	Standard error	Critical difference
GCA (g_i)	0.42	-
SCA (s_{ii})	1.20	-
SCA (s_{ij})	0.21	-
Reciprocal (r_{ij})	1.06	-
$g_i - g_j$	0.71	1.35
$s_{ii} - s_{jj}$	1.64	3.30
$s_{ik} - s_{ij}$	1.71	3.44
$s_{ii} - s_{jk}$	1.42	2.86
$s_{ij} - s_{ik}$	1.34	2.70
$s_{ij} - s_{kl}$	1.16	2.34

(contd.

continued

Character		O	M	L	F	S	Gca
Fruits/ plant	O	-0.68	0.46	0.25	-0.03	0.01	0.34
	M	-0.09	-0.94	0.05	0.02	0.42	1.06
	L	0.27	0.02	-0.95	0.38	0.27	-0.49
	F	0.27	0.47	0.32	-0.31	-0.05	-0.57
	S	0.00	0.48	0.34	0.24	-0.64	-0.84

Effects/Comparison	Standard error	Critical difference
gca (g_i)	0.13	-
sca (s_{ii})	0.36	-
sca (s_{ij})	0.06	-
Reciprocal (r_{ij})	0.32	-
$g_i - g_j$	0.20	0.40

(contd.

continued

Character		O	M	L	F	S	Gca
Fruit yield/ plant (kg)	O	-2.52	0.42	0.78	1.78	-0.41	2.23
	M	0.35	-2.86	0.55	0.93	0.94	-3.11
	L	0.52	-0.16	1.49	-0.33	2.59	0.04
	F	0.53	0.36	0.85	-2.43	0.08	1.04
	S	0.18	0.63	-0.01	-0.62	-3.21	-0.21

Effects/Comparison	Standard error	Critical difference
Gca (g_i)	0.61	-
Sca (s_{ii})	1.73	-
Sca (s_{ij})	0.31	-
Reciprocal (r_{ij})	1.53	-
$g_i - g_j$	0.97	1.94

the highest (0.26) followed by oriental pickling melon x long melon (0.21). Lowest sca effect was shown by oriental pickling melon x snap melon (-0.15)(Table 9).

Female flowers in first 20 nodes

Variance due to gca was significant. The variances due to sca and reciprocal effects were not significant in the expression of this character (Table 8). The variance due to gca was found to be 2.3 times greater than variance due to sca. Musk melon had the highest gca value (0.73) followed by oriental pickling melon (0.43) (Table 9).

Days to first female flower

Variances due to gca and reciprocal effects were significant (Table 8). The values of the gca effects indicated that long melon had the minimum gca effect (-0.45) followed by musk melon (-0.34). The maximum gca value was recorded for oriental pickling melon (0.54). The lowest sca value was expressed by long melon x snap melon (-2.37) and the highest sca effect was recorded by oriental pickling melon x long melon (0.22). Reciprocal effect was the least in snap melon x snake melon (-2.07) (Table 9).

Days to first fruit harvest

Variances due to gca, sca and reciprocal effects were significant (Table 8). The highest gca value was for oriental pickling melon (1.24) and the lowest was for long melon (-0.96). The maximum sca effect was shown by oriental pickling melon x long melon (1.72) and the minimum sca value was expressed by oriental pickling melon x snake melon (-3.64). The reciprocal effect was the highest for snake melon x oriental pickling melon (2.00) and the lowest for musk melon x oriental pickling melon (-1.00) (Table 9).

Days to fruit maturity

The combining ability analysis for the character indicated that gca, sca and reciprocal effects were significant (Table 8). Oriental pickling melon manifested the highest gca effect (0.78). The lowest gca value was shown by snake melon (-1.61) followed by long melon (-0.63). Oriental pickling melon x snake melon registered the minimum sca value of -2.45. The maximum sca value was expressed by oriental pickling melon x long melon (1.22). The reciprocal effect was observed to be the highest in snake melon x oriental pickling melon (1.14) and the least in snap melon x snake melon (-1.43) (Table 9).

Fruit length

Variances due to gca and sca were highly significant. But the variance due to gca was twice greater than variance due to sca. The gca value was the highest for snake melon (5.70), followed by long melon (4.59). The sca value was observed to be the highest for oriental pickling melon x musk melon (2.43) (Table 9).

Fruit girth

Both variances due to gca and sca were significant. Snake melon exhibited the highest gca value (1.59) followed by snap melon (0.69). The sca value was the maximum for oriental pickling melon x long melon (1.25) and the least for musk melon x oriental pickling melon (-0.65) (Table 9).

Fruit weight

Only variance due to gca was significant. The estimates of various effects were presented in Table 9. The highest gca effect was for snake melon (0.31) and the lowest for musk melon (-0.66).

Fruit volume

Only variance due to gca effect was significant. The gca effect was the maximum for snake melon (0.57) and the minimum for snap melon (0.18) (Table 9).

Flesh thickness

Only variance due to general combining ability was significant. Snap melon had the highest gca effect (0.25) (Table 9).

100 seed weight

In the analysis of variance table for combining ability effect, it was found that only variance due to gca was significant. The maximum gca effect was expressed by musk melon (0.29) (Table 9).

Seeds/fruit

Variances due to gca and sca were significant (Table 8). Snake melon and snap melon had high gca values of 76.84 and 41.66 respectively (Table 9).

The hybrids oriental pickling melon x snap melon (46.65) and musk melon x long melon (42.65) were having higher sca effects.

Seed yield/fruit

Both variances due to gca and sca were highly significant. Snake melon had the highest gca effect (1.92). The hybrid musk melon x long melon had the highest sca effect (2.88).

Fruits/plant

Only gca was highly significant. Maximum gca effect was for musk melon (1.06) followed by oriental pickling melon (0.84). Gca effect was the minimum for snap melon (-0.80).

Fruit yield/plant

Variance due to gca was highly significant. The gca value for oriental pickling melon was the highest (2.25) followed by snake melon (1.04).

F. Correlation between general combining ability values and *per se* performance of the parents

A highly significant correlation between *per se* performance of the parents and their general combining ability effects was observed (Table 10), for all the characters under study.

Table 10. Correlation coefficient between Gca values and *per se* performance of five botanical varieties of *Cucumis melo* for different characters

Characters	Correlation Coefficient
Nodes to first male flower	0.95*
Nodes to first female flower	0.98**
Female flowers in first ten nodes	0.99**
Female flowers in first 20 nodes	0.99**
Days to first female flower	0.92*
Days to first mature fruit harvest	0.89*
Days to maturity	0.91*
Fruit length	0.94*
Fruit girth	0.96*
Fruit weight	0.98**
Fruit volume	0.98**
Flesh thickness	0.97**
Seeds/fruit	0.98**
100 seed weight	0.82*
Seed yield/fruit	0.96**
Fruit/plant	0.99**
Fruit yield/plant	0.99**

* P = 0.05

** P = 0.01

A near perfect correlation (>0.95) was observed for nodes to first male flower, nodes to first female flower, female flowers in first ten nodes, female flowers in first 20 nodes, fruit girth, fruit weight, fruit volume, flesh thickness, seeds/fruit, 100 seed weight, seed yield/fruit, fruits/plant and fruit yield/plant.

5. Estimation of genetic distance

The genetic distance among the five botanical varieties of *Cucumis melo* was calculated taking into consideration nodes to first female flower, fruit weight, seeds/fruit and fruits/plant. Maximum genetic distance of 14.49 was observed between musk melon and snake melon. Long melon and snap melon were the closest (0.58)(Table 11). Fruits/plant contributed maximum (80%) to total genetic divergence (Table 12).

Table 11. Genetic distance (D^2) among the five botanical varieties of *Cucumis melo*

Parents	O	M	L	F	S
O	-	5.29	2.62	3.88	3.40
M	5.29	-	9.16	14.49	8.79
L	2.62	9.16	-	2.94	0.38
F	3.88	14.49	2.94	-	1.58
S	3.40	8.79	0.38	1.58	-

O - Oriental pickling melon
M - Musk melon
L - Long melon
F - Snake melon
S - Snap melon

Table 12. Relative contribution of a few characters to total genetic divergence (D^2)

Characters	% contribution towards total D^2
Nodes to first female flower	10
Fruits/plant	80
Fruit weight	10
Seeds/plant	0

Discussion

DISCUSSION

Melons occupy an important position as vegetables not only in the genus <u>Cucumis</u> but also among the most versatile vegetable family - Cucurbitaceae. Musk melon and snap melon are highly relished as dessert for their attractive flavour and refreshing sensation. Melons are good sources of vitamins and minerals. In India, in spite of its large scale cultivation only a little work has been done to improve the quality and yield of the crop. It is imperative to know the mode of inheritance and genetic make up of the germplasm under observation to persue an effective breeding strategy. Estimates of genetic variances and the relative magnitude of additive and non-additive gene actions, are helpful to understand the genetic potentiality of the population and to decide the usefulness of different selection procedures to improve a given population. The diallel analysis is the quickest possible approach in this direction. In melons, earliness, fruit yield and fruit quality are the deciding factors which indicate whether a variety or a hybrid could be successful.

Crossability among the five botanical varieties of <u>Cucumis melo</u>

In the investigation crossability among the five botanical varieties of *Cucumis melo* was studied as a function of percentage of fruit set, average seeds/fruit, percentage of germination of the seeds and percentage of survival of the germinated seedlings. The poor fruit set (37.04% - 42.86%) observed in crosses where musk melon was used as the female parent resulted from the maternal influence of musk melon, attributed to cytoplasmic incompatibility. Similar results were obtained by Dutta and Nath (1969). They observed only 20.00% - 33.33% fruit set when musk melon was used as the female parent.

Data on fruit set (Table 2) of the parental lines revealed that hand pollination was less efficient in musk melon (33.33%) but was quite efficient in other parents. Whitaker and Davis (1962) obtained similar results. Dutta and Nath (1969) reported 64.29% - 85.00% fruit set in long melon, 61.50% - 73.20% in snap melon and 10.00% - 35.00% in musk melon, under hand pollination.

Experimental results of seed set studies revealed that in crosses among the five botanical varieties of *Cucumis melo*, the average seeds/fruit was less than their respective parents. This result was in accordance with that of Dutta and Nath (1969) who reported that in crosses among musk melon, snap melon and long melon lines, average seeds/fruit was either almost equal or less than their better parent.

The percentage of germination of the hybrid seeds was less than their parents except in oriental pickling melon x long melon (76.00%) and long melon x snap melon (80.00%). Dutta and Nath (1969) observed that percentage of germination in almost all the hybrid seeds exceeded their better parents. The survival percentage of the germinated seedlings varied from 84.20% to 100.00%. This indicated that there was no hybrid inviability.

All the five botanical varieties of _Cucumis_ _melo_ were found to be crossable with each other. (Figure 1). There was no significant reciprocal effect on overall crossability index indicating that the maternal parent did not have any influence on crossability index. The crossability index was the highest for oriental pickling melon x long melon (79.19%) and lowest for musk melon x snake melon (47.15%). It was less than 50.00% in musk melon x snake melon, long melon x musk melon, long melon x snap melon and snap melon x long melon. Crossability index was found to be more than 70.00% in oriental pickling melon x long melon and snake melon x oriental pickling melon. In other crosses, crossability index varied between 50.00% to 70.00%. Dutta and Nath (1969) reported that musk melon, snap melon and long melon were cross compatible with each other. Pangelo (1951) reported that _Cucumis_ _melo_ var. _cantaloupensis_ Naud., _Cucumis_ _melo_ var. _reticulatus_ Naud.

Figure 1. Crossability index (CI) among five botanical varieties of *Cucumis melo*

	O	M	L	F	S
O	-	***	****	***	***
M	**	-	**	*	***
L	***	*	-	**	*
F	***	**	**	-	****
S	**	**	*	***	-

* - C I < 50% (Generally crossable)

** - C I > 50% < 60% (Moderately crossable)

*** - C I > 60% < 70% (Highly crossable)

**** - C I > 70% (Perfectly crossable)

O - Oriental pickling melon

M - Musk melon

L - Long melon

F - Snake melon

S - Snap melon

Cucumis melo var. *inodorus* Naud., *Cucumis melo* var. *flexuosus*. Naud., *Cucumis melo* var. *conomon* Mak., *Cucumis melo* var. *chito* Naud., and *Cucumis melo* var. *dudaim* Naud., hybridized readily among each other and there was apparently very little sterility even among progenies from crosses involving varient types.

The observations on percentage of seed forming efficiency of the crosses at F_o level (Table 3), percentage of fruit set at F_1 level and seeds/F_1 fruit (Table 4) were further indications of the cross compatibility among the botanical varieties. Reciprocal effect was significant for percentage of seed forming efficiency, percentage of fruit set at F_1 level and seeds/F_1 fruit. The percentage of seed forming efficiency ranged from 66.55% to 90.52%. The percentage of fruit set in all the hybrids was above 50.00%. Snap melon x long melon recorded the highest fruit set percentage of 75.00. The seeds in the F_1 fruits were all normal and viable and the number of seeds/fruit was above 500. Parthasarathy and Sambandam (1981) also studied the percentage of fruit set in crosses, number of developed seeds in crossed fruits, percentage of pollen fertility and viability as indications of the cross compatibility between 'Dosakaya', a local melon grown in Andhra Pradesh and other species of *Cucumis*.

They concluded that since the results were well comparable to that of selfing, 'Dosakaya' type was freely crossable with Cucumis melo.

Evaluation of hybrids for discrete characters

Melons, especially musk melon and snap melon being dessert fruits, total yield was not the only objective for heterosis breeding but fruit quality was also a deciding factor. "Since quality characters have a complex mechanism of inheritance and manifestation, it is necessary to find out whether F_1 can prove superior to pure bred varieties and whether F_1 per se can bring about the genetic balance necessary in the manifestation of quality attributes along with high yield and early maturity" (More and Seshadri, 1980). The qualitative characters - fruit rind colour, fruit shape, flesh colour, fruit flavour and fruit sweetness were found to be intermediate between the parents in almost all hybrids. The flavour and sweetness of musk melon were predominant in the hybrids when musk melon was used as one of the parents (Table 6). When round fruited musk melon was crossed with other parents hybrids had oval fruit shape. The cracking quality of snap melon was inherited by the hybrids having snap melon as one of the parents except snap melon x musk melon and musk melon x snap melon. The thick pericarp of musk melon was inherited by these hybrids and they did not crack. Intermediate fruit shape in inter varietal crosses among musk melon, snap melon and long melon was earlier reported by Nath and Dutta (1971). Foster (1967) also observed intermediate fruit shape in hybrids of musk melon. The fruit rind colour on ripening varied from cream to deep yellow. Chadha *et al* (1972) reported the dominance of yellow colour over light green in the cross Hara Madhu x Japanese Cantaloupe. Sageret (1826) reported that white colour was recessive to yellow skin colour. Lumsden (1914) observed that F_1 musk melon hybrids were intermediate between parents and green colour of skin was recessive to yellow.

Heterosis

"The importance of heterosis is two fold. It will assess the extent of heterosis present in the F_1 crosses and ascertain the possibility of exploring heterosis in hybrid breeding programme provided there is a biological feasibility. The second aim will be to find out whether there is a relationship between high heterosis in the F_1 and superior segregation in the F_2" (Rao and Singh, 1985).

The earliness of the F_1 hybrids was evaluated in the investigation taking into consideration constituent characters - nodes to first male flower, nodes to first female flower, days to first fruit harvest and days to maturity. Out of 20 hybrids sixteen expressed significant relative heterosis and out of sixteen heterobeltiotic hybrids fifteen were significantly heterotic for nodes to first male flower (Table 13) which was found to be under

Table 13. Number of heterotic F_1 hybrids for important economic characters

Characters	Relatively heterotic hybrids	Heterobeltiotic hybrids
Nodes to first male flower	20 (16)	16 (15)
Nodes to first female flower	20 (15)	16 (12)
Female flowers in first ten nodes	20 (12)	8 (2)
Female flowers in first 20 nodes	20 (10)	8 (5)
Days to first female flower	20 (20)	20 (18)
Days to first fruit harvest	20 (20)	20 (18)
Days to fruit maturity	20 (20)	20 (18)
Primary vine length	20 (17)	18 (12)
Primary branches/plant	20 (16)	17 (12)
Nodes on main stem	20 (18)	18 (12)
Fruit length	10 (9)	5 (2)
Fruit girth	14 (2)	7 (3)
Fruit weight	20 (11)	12 (5)
Fruit volume	20 (15)	8 (3)
Flesh thickness	20 (14)	10 (3)
Seeds/fruit	20 (20)	13 (7)
Seed yield/fruit	20 (20)	18 (18)
100 seed weight	20 (18)	15 (6)
Fruits/plant	20 (18)	8 (5)
Fruit yield/plant	20 (20)	14 (12)

(Values given in brackets indicate significantly heterotic hybrids) the control of dominant genes (Hayes, _et al_ 1965). Out of 20 hybrids, fifteen showed significant relative heterosis and out of sixteen, twelve were significantly heterobeltiotic. This character was also under dominant gene action. All the 20 hybrids expressed significant relative heterosis and eighteen hybrids showed heterobeltiosis for days to first female flower, days to first fruit harvest and days to fruit maturity (Table 13). Snap melon x long melon was the earliest hybrid. Snap melon x long melon produced the first female flower in 27.20 days followed by musk melon x snake melon (27.47 days). Snap melon x long melon took 55 days for first fruit harvest and the fruits matured in 26 days. Musk melon x snake melon took 56 days for fruit harvest and 27 days for fruit maturity (Table 14). Earliness in musk melon hybrids was reported by Bohn and Davis (1957), Manukjan (1967), Chadha _et al_ (1972), Lippert and Hall (1972) and Kalman (1973).

Out of 20 hybrids, the number of relatively heterotic hybrids was twelve and ten respectively for female flowers in first ten and 20 nodes. Out of eight hybrids only two were significantly heterobeltiotic for female flowers in first ten nodes and five were significantly heterobeltiotic for female flowers in first 20 nodes (Table 13).

Table 14. Performance of salient inter varietal F_1 hybrids

Character	Hybrids	Performance	% over better parent	% over mid-parent
Nodes to first male flower	M x S	2.10	-42.78	-46.70
	F x S	2.20	-47.62	-14.05
Nodes to first female flower	S x L	3.87	-38.28	-39.25
	M x F	4.47	-29.05	-30.70
Female flowers in first ten nodes	M x O	4.67	7.85	16.75
	O x M	4.50	3.93	12.50
Female flowers in first 20 nodes	M x O	6.33	11.64	18.54
	O x M	6.07	- 7.05	13.67
Days to first female flower	S x L	27.20	-19.36	-21.61
	M x F	27.47	-21.93	-22.18
Days to first fruit harvest	S x L	55.00	-14.95	-14.52
	M x F	55.67	-17.32	-17.52
Days to fruit maturity	S x L	26.00	-19.08	-20.42
	L x F	26.67	-16.99	-17.69
Primary vine length (m)	M x F	3.79	10.17	11.57
	F x M	3.70	12.50	11.18
Primary branches/ plant	O x L	11.00	13.05	24.01
	L x S	10.40	30.00	40.00
Nodes on main stem	O x M	38.33	11.65	17.32
	L x S	38.00	14.01	27.00

(contd.)

continued

Character	Hybrids	Performance	% over better parent	% over mid-parent
Fruit length (cm)	S x L	51.89	11.90	21.38
	S x F	47.70	2.69	2.60
Fruit girth (cm)	M x S	40.80	10.96	16.91
	F x S	40.53	1.52	5.68
Fruit weight (kg)	S x F	2.69	9.35	14.95
	F x S	2.56	3.66	8.97
Fruit volume (l)	S x F	2.58	3.61	10.73
	F x S	2.60	4.42	11.59
Flesh thickness (cm)	S x F	3.40	0.63	5.70
	F x S	3.23	2.54	7.67
Seeds/fruit	S x F	814.00	0.22	11.24
	F x S	811.33	3.69	10.87
Seed yield/ fruit (g)	S x F	22.64	12.52	27.62
	F x S	21.60	7.36	21.76
100 seed weight (g)	M x O	3.27	6.68	10.10
	O x M	3.21	4.90	8.08
Fruits/ plant	M x O	9.37	15.87	16.98
	O x M	9.20	13.58	14.86
Fruit yield/ plant (kg)	O x F	19.35	22.62	32.35
	F x O	18.29	15.60	25.10

Musk melon x oriental pickling melon had the highest number of fruits/plants. It expressed heterobeltiosis to the extent of 15.67% and relative heterosis of 16.98%. Eighteen hybrids expressed significant relative heterosis while only five were significantly heterobeltiotic (Table 13). It could be inferred that dominant gene action was more important in the manifestation of this character than over dominance.

Primary vine length was found to be the maximum in musk melon x snake melon (3.79 m) followed by snake melon x musk melon (3.78 m). Seventeen hybrids were significantly heterotic over their mid-parents while only twelve were significantly heterobeltiotic (Table 13). This character was governed by dominant gene action.

The hybrid oriental pickling melon x long melon had the maximum number of primary branches/plant (11.00) which manifested a heterobeltiosis of 13.05% and a relative heterosis of 24.01% (Table 14). Sixteen hybrids exhibited significant relative heterosis and twelve showed significant heterobeltiosis. This character was also inferred to be under the control of dominant genes.

Nodes on the main stem were found to be more in oriental pickling melon x musk melon (36.33) and long melon x snap melon (36.00) (Table 14). Since eighteen hybrids exhibited significant relative heterosis with regard to this character, dominant gene action was predominant.

fruit weight, fruit volume, flesh thickness, seeds/fruit and seed yield/fruit were found to be higher in snap melon x snake melon and snake melon x snap melon when compared to other hybrids. Snap melon x snake melon exhibited a heterosis ranging from 5.70% to 27.62% for these characters. In snake melon x snap melon the heterobeltiosis ranged from 2.54% to 9.35% and relative heterosis varied from 7.67% to 21.76%. All these fruit characters were found to be governed by dominant gene action (Table 13). Fruit length in snap melon x snake melon was high (47.70cm) while fruit girth was high in snake melon x snap melon (40.53cm).

The above results indicated that fruit weight and fruit volume in these hybrids were influenced by a number of factors - fruit length, fruit girth, flesh thickness, and seeds/fruit. The fruits/plant were influenced by the number of female flowers in the first ten and 20 nodes. The fruit weight varied depending upon the number and size of the fruits. The seeds/fruit was directly related to the size of the fruits. Total yield of fruits/plant mainly depended upon the fruit weight and fruits/plant. Fruit yield/plant was found to be the highest in oriental pickling melon x snake melon (19.35 kg) followed by snake melon x oriental pickling melon (18.29 kg). Oriental pickling melon x snake melon exhibited a heterobeltiosis of 32.35% and a relative heterosis of 22.62% (Table 14). Dominant gene action was more important in the manifestation of this character as indicated in Table 15. Among the parents, the earliest fruiting one was musk melon which had the highest number of fruits/plant. In long melon fruits matured early. Snake melon had the highest fruit length, girth, weight, volume, seeds/fruit and seed yield/fruit. Flesh thickness was the highest in snap melon and oriental pickling melon had the maximum fruit yield/plant. Heterosis for yield was first reported by Hayes and Jones (1916). Hutchins (1939), Nath and Dutta (1971), Smith (1971), Lippert and Hall (1972) and More and Seshadri (1980) were the other workers who observed higher fruit yield.

Studies on combining ability and gene action

Concept of combining ability is becoming increasingly important in plant breeding. It is especially useful in connection with testing procedures in which it is desired to study and compare the performance of the lines in hybrid combinations. The common approach of selecting parents on the basis of _per se_ performance does not necessarily lead to fruitful results (Allard, 1960). The selection of the best parents for hybridization has to be based on complete genetic information and knowledge of the combining ability of the potential parents. Combining ability studies in musk melon were undertaken by Lippert and Hall (1972), Lippert and Legg (1972) and More and Seshadri (1980).

In plant research the diallel analysis has been frequently used to study the gene action. For this analysis Griffings (1956) model is frequently used for testing the performance of genotypes in hybrid combinations and also for characterising the nature and magnitude of gene effect involved in controlling a quantitative trait. The information on gca and sca enabled the plant breeder to select the best breeding system for maximum character improvement. From the genetical point of view it was inferred that general combining ability and specific combining ability could be attributed to additive and non-additive gene action (Sprague and Tatum, 1942). Combining ability analysis (Table 8) revealed that variances due to gca and sca were highly significant for nodes to first male flower, nodes to first female flower, days to first fruit harvest, days to fruit maturity, fruit length, seeds/fruit and seed yield/fruit. Both additive and non-additive gene actions were important in the expression of the above characters (Table 15). Gca alone was significant in the manifestation of female flowers in first ten and 20 nodes, fruit girth, fruit weight, fruit volume, flesh thickness, 100 seed weight, fruits/plant and fruit yield/plant. These characters were governed by additive gene system (Table 15). Reciprocal effect was significant for nodes to first male flower, days to first female flower,

Table 15. Gene action governing quantitative characters in *Cucumis melo*

Characters	Gene action		Reciprocal effect (R)
	Additive (A)	Non-additive (N)	
Nodes to first male flower	A	N	R
Nodes to first female flower	A	N	-
Female flowers in first ten nodes	A	-	-
Female flowers in first 20 nodes	A	-	-
Days to first female flower	A	N	R
Days to first fruit harvest	A	N	R
Days to fruit maturity	A	N	R
Fruit length	A	N	-
Fruit girth	A	-	-
Fruit weight	A	-	-
Fruit volume	A	-	-
Flesh thickness	A	-	-
100 seed weight	A	-	-
Seeds/fruit	A	N	-
Seed yield/fruit	A	N	-
Fruits/plant	A	-	-
Fruit yield/plant	A	-	-

days to first fruit harvest and days to fruit maturity (Table 15). Maternal influence was important in the expression of these characters. As there was considerable amount of additive gene action present good progress could be made with simple selection programmes. In the study of combining ability effects negative values (Table 9) for nodes to first male and female flowers, days to first female flower, days to first fruit harvest, and days to fruit maturity indicated earliness.

The better parents with regard to early fruit harvest were long melon and snap melon. Long melon and snap melon had more negative gca values (-0.96 and -0.89 respectively). Musk melon and oriental pickling melon were the better parents for fruits/plant. The gca was the highest for fruits/plant in musk melon (1.06) followed by oriental pickling melon (0.84). Significant sca effect was observed for oriental pickling melon x musk melon (0.46). Smith (1977) reported that most of the genetic variances associated with yield were additive.

The correlation coefficient between gca effects and *per se* performance of parents were highly significant for all the characters (Table 10). It showed that *per se* performance might give indications of the gca of the parents. It was considered as a criterion for selection of parents for further breeding programme. This would considerably save the time required for the determination of gca effects.

The investigation indicated that the best parents were the best general combiners for a character. Maurya and Singh (1977), Singh (1977), Singh and Kichharia (1977) and Tanwar and Baroda (1983) reported the relation between *per se* performance and gca values of the parents.

Genetic divergence

Genetic divergence could also be considered as a measure of affinity. It would also be helpful to develop transgressive segregants. The problem of selecting diverse parental lines could be narrowed down if characters responsible for the discrimination among population could be located. Genetic divergence based on nodes to first female flower, fruit weight, seeds/fruit and fruits/plant, among parental lines, was estimated using Mahalanobis D^2 statistics (1928). Musk melon and snake melon were found to be the most divergent (D^2 = 14.49) while long melon and snap melon were the closest (D^2 = 0.38) (Table 12).

In the order of affinity the five melon varieties could be arranged as oriental pickling melon, long melon, snap melon, snake melon and musk melon. The character contributing maximum towards genetic divergence was fruits/plant (80%) (Table 12). No apparent relation was observed between genetic divergence and heterosis for earliness and yield (Table 16). This could be due to characters selected for the estimation of divergence (Singh, S.P. and Ramanujam, S., 1981).

Table 16. Relation between genetic distance and heterosis

Crosses	Genetic distance D^2	Heterobeltiosis (%)			
		Primary vine length (m)	Days to first female flower	Fruit yield/ plant (kg)	Seed yield/ plant (g)
O x M	5.29	- 4.07	-14.32	-13.12	10.95
O x L	2.62	10.65	- 5.54	10.20	7.08
O x F	3.88	8.04	- 6.95	22.62	11.08
O x S	3.40	15.82	-12.30	- 1.07	29.94
M x O	5.29	2.91	- 4.35	-17.49	8.29
M x L	9.16	8.72	-13.04	8.00	55.53
M x F	14.49	10.17	-21.93	- 3.12	5.91
M x S	8.79	2.34	- 8.35	18.49	25.00
L x O	2.62	10.53	- 9.33	3.68	8.71
L x M	9.16	2.33	-11.44	11.17	46.44
L x F	2.94	16.67	-15.59	14.26	4.72
L x S	0.38	19.19	-16.59	57.66	17.71
F x O	3.88	3.89	-14.02	15.60	4.92
F x M	14.49	12.50	-12.25	- 8.39	6.96
F x L	2.94	5.06	-10.47	1.70	- 0.05
F x S	1.58	0.89	-15.49	13.89	7.36
S x O	3.40	11.11	-13.90	- 3.94	28.19
S x M	8.79	- 3.78	-22.06	6.10	23.63
S x L	0.38	18.90	-19.36	55.68	27.86
S x F	1.58	1.49	- 3.64	4.79	12.52

Summary

SUMMARY

The investigation on compatibility among Cucumis melo var. conomon Mak. Cucumis melo var. inodorous Naud., Cucumis melo var. utilissimus Duth. and Full., Cucumis melo var. flexuosus Naud. and Cucumis melo var. momordica Duth. and Full. was conducted during October - January 1982-1983 and February - May 1983, at the Instructional Farm of College of Horticulture, Kerala Agricultural University, Vellanikara, Trichur.

2. The compatibility among the five botanical varieties of Cucumis melo was studied at F_0 and F_1 levels. They were found to be crossable among each other. The crossability was partitioned into four classes. Oriental pickling melon x long melon and snake melon x snap melon were perfectly crossable. Oriental pickling melon x musk melon, oriental pickling melon x snake melon, oriental pickling melon x snap melon, long melon x oriental pickling melon, snake melon x oriental pickling melon and snap melon x snake melon were highly crossable. There was no significant reciprocal effect for crossability index. Maternal effect was significant for percentage of fruit set and percentage of seed forming efficiency at F_0 level and fertility of the F_1 hybrids. There was good fruit set and seed set indicating fertility of the F_1 hybrids.

3. The hybrids were evaluated for discrete characters and were found to be intermediate between the parents for fruit rind colour, fruit shape, flesh colour, seediness, fruit flavour and fruit sweetness.

4. Inter varietal heterosis was calculated as purposed by Hayes *et al* (1965) and Briggle (1963). Heterosis was observed for nodes to first male flower, nodes to first female flower, days to first female flower, days to first fruit harvest, days to fruit maturity, female flowers in first ten and 20 nodes, primary vine length, primary branches/plant, nodes on main stem, fruit length, fruit girth, fruit weight, fruit volume, flesh thickness, seeds/fruit, seed yield/fruit , fruits/plant and fruit yield/plant.

5. Combining ability analysis was carried out as suggested by Griffings (1956). Variances due to general combining ability and specific combining ability were significant for nodes to first male flower, nodes to first female flower, days to first female flower, days to first fruit harvest, days to fruit maturity, fruit length, seeds/fruit and seed yield/fruit, indicating the role of both additive and non-additive gene action in the expression of the above characters.

6. Variances due to general combining ability alone was significant for female flowers in first ten and 20 nodes,

fruit girth, fruit weight, fruit volume, flesh thickness, 100 seed weight, fruits/plant and fruit yield/plant indicating additive type of gene action. Selection could bring about improvement for the above characters.

7. Reciprocal effect was significant in the expression of nodes to first male flower, days to first female flower, days to first fruit harvest and days to fruit maturity, indicating the influence of maternal parent.

8. Correlation between gca values and *per se* performance of the parents was calculated. A near perfect correlation (> 0.95) was observed for nodes to first male flower, nodes to first female flower, female flowers in first ten and 20 nodes, fruit girth, fruit weight, fruit volume, flesh thickness, seeds/fruit, 100 seed weight, seed yield/fruit, fruits/plant and fruit yield/plant.

9. Genetic distance between the botanical varieties was estimated using Mahalanobis D^2 statistics (1928) and observed that musk melon and snake melon had the maximum genetic distance of 14.49. Long melon and snap melon were the closest ($D^2 = 0.38$). Fruits/plant contributed maximum (80%) to total genetic divergence.

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Table 17. Mean performance of five botanical varieties of *Cucumis melo* and 20 F_1 hybrids

Genotypes	Nodes to first male flower	Nodes to first female flower	Female flowers in first ten nodes	Female flowers in first 20 nodes
Oriental pickling melon (O)	4.47	6.47	3.67	5.00
Musk melon (M)	4.2	5.30	4.33	5.67
Long melon (L)	2.53	5.70	2.33	3.50
Snake melon (F)	4.73	6.60	2.33	3.67
Snap melon (S)	3.67	5.80	2.00	3.33
O X M	2.53	5.07	4.50	6.07
O X L	2.53	5.73	3.63	5.43
O X F	3.73	5.73	3.33	4.67
O X S	2.40	5.13	3.00	4.40
M X O	4.10	5.80	4.67	6.33
M X L	3.60	5.10	3.43	5.00
M X F	2.50	4.47	3.67	5.33
M X S	2.10	5.67	4.00	5.33
L X O	2.80	5.60	3.33	4.67
L X M	2.27	5.30	3.43	4.73
L X F	3.47	4.93	2.67	4.33
L X S	2.53	4.70	2.67	4.33
F X O	4.00	5.10	3.23	4.63
F X M	3.67	5.60	3.40	4.73
F X L	2.60	5.53	2.43	4.00
F X S	2.20	5.26	2.43	4.00
S X O	3.00	5.10	2.97	4.43
S X M	3.07	4.60	3.23	4.70
S X L	2.80	3.87	2.37	3.67
S X F	3.53	6.00	2.37	3.77
Sem ±	0.33	0.37	0.32	0.40
CD (p= 0.05)	0.94	1.07	0.91	1.33

(contd.)

continued

Genotypes	Days to first female flower	Days to first fruit harvest	Days to fruit maturity	Primary vine length (m)
Oriental pickling melon (O)	35.67	67.67	34.33	2.85
Musk melon (M)	33.53	70.00	34.67	3.44
Long melon (L)	33.73	64.00	32.13	2.91
Snake melon (F)	35.73	67.33	32.67	3.36
Snap melon (S)	34.87	64.67	33.20	2.97
O X M	28.73	60.33	29.67	3.30
O X L	31.67	63.00	31.93	3.22
O X F	31.20	59.67	29.00	3.63
O X S	29.40	59.00	28.53	3.44
M X O	32.07	62.33	31.00	3.54
M X L	29.33	58.33	28.00	3.71
M X F	27.47	60.00	29.13	3.79
M X S	30.73	59.00	29.13	3.52
L X O	30.40	62.00	30.33	3.15
L X M	29.87	56.67	27.33	3.52
L X F	28.47	55.67	26.67	3.58
L X S	28.20	57.00	27.60	3.54
F X O	28.83	55.67	26.73	3.49
F X M	30.60	61.33	29.67	3.78
F X L	30.20	57.00	29.13	3.52
F X S	29.47	57.00	28.27	3.33
S X O	28.87	60.00	29.53	3.30
S X M	27.80	57.33	27.87	3.31
S X L	27.20	55.00	26.00	3.46
S X F	33.60	62.67	31.13	3.41
Sem ±	0.46	0.50	0.58	0.23
CD (p = 0.05)	0.65	1.43	1.65	0.30

(contd.)

continued

Genotypes	Primary branches/ plant	Nodes on main stem	Fruit length (cm)	Fruit girth (cm)
Oriental pickling melon (O)	9.73	31.00	36.5	34.65
Musk melon (M)	7.47	34.33	18.36	33.03
Long melon (L)	8.00	26.50	46.37	34.60
Snake melon (F)	8.33	32.00	55.77	39.95
Snap melon (S)	6.80	33.33	39.13	36.77
O X M	9.33	38.33	28.83	34.23
O X L	11.00	33.00	44.33	36.67
O X F	10.33	37.33	43.20	38.97
O X S	10.00	36.60	41.20	36.26
M X O	9.07	35.07	25.13	35.53
M X L	9.17	33.00	25.57	37.06
M X F	9.00	36.20	29.60	37.03
M X S	7.63	35.73	19.83	40.80
L X O	10.33	33.33	44.87	36.53
L X M	9.33	33.80	31.63	35.30
L X F	10.00	32.00	45.23	34.81
L X S	10.40	38.00	47.63	38.17
F X O	9.30	34.00	44.82	36.60
F X M	9.20	37.73	29.53	37.57
F X L	10.33	32.67	47.13	36.57
F X S	8.47	36.00	47.33	40.53
S X O	9.60	37.00	40.22	35.04
S X M	7.67	35.20	29.27	34.27
S X L	9.33	32.00	51.89	35.70
S X F	8.57	37.13	47.70	38.03
Sem ±	0.89	3.02	1.98	1.13
CD (p = 0.05)	3.20	8.59	5.62	3.82

(contd.)

continued

Genotypes	Fruit weight (Kg)	Fruit volume (l)	Flesh thickness (cm)	Seeds/ fruit
Oriental pickling melon (O)	1.99	1.76	2.74	572.00
Musk melon (M)	0.77	0.60	1.97	437.60
Long melon (L)	2.06	2.05	2.69	600.20
Snake melon (F)	2.47	2.49	2.86	782.47
Snap melon (S)	2.21	2.04	3.15	681.13
O X M	1.49	2.27	2.54	570.67
O X L	2.23	2.23	2.97	660.37
O X F	2.57	2.50	3.07	809.31
O X S	2.30	2.02	3.13	731.82
M X O	1.39	1.25	2.47	547.33
M X L	1.47	1.35	2.50	649.33
M X F	1.65	1.57	2.55	677.33
M X S	1.50	1.38	2.80	618.33
L X O	2.25	2.03	2.96	681.67
L X M	1.52	1.42	2.50	615.27
L X F	2.48	2.49	2.80	774.00
L X S	2.62	2.58	3.07	738.60
F X O	2.53	2.37	3.02	732.33
F X M	1.72	1.72	2.71	677.67
F X L	2.39	2.37	2.39	778.00
F X S	2.69	2.60	3.23	811.33
S X O	2.22	2.20	3.21	772.72
S X M	1.52	1.47	2.71	664.20
S X L	2.49	2.32	2.98	764.37
S X F	2.56	2.58	3.40	814.00
Sem ±	0.22	0.2	0.16	36.14
CD (p = 0.05)	0.64	0.57	0.46	102.83

(contd.)

continued

Genotypes	Seed yield/ fruit (g)	100 seed weight (g)	Fruits/ plant	Fruit yield/ plant (kg)
Oriental pickling melon (O)	16.53	2.87	7.93	15.78
Musk melon (M)	12.26	3.06	8.10	4.72
Long melon (L)	13.09	2.18	5.06	10.50
Snake melon (F)	20.12	2.57	5.47	13.46
Snap melon (S)	15.36	2.25	4.60	10.17
O X M	18.34	3.21	9.2	13.71
O X L	17.7	2.68	7.8	17.39
O X F	22.35	3.20	7.55	19.35
O X S	21.48	2.94	7.00	15.61
M X O	17.90	3.27	9.57	13.02
M X L	20.36	3.11	7.57	11.15
M X F	21.31	3.18	7.90	13.04
M X S	19.21	3.10	8.05	12.05
L X O	17.97	2.83	7.27	16.56
L X M	19.17	3.11	7.53	11.45
L X F	19.17	2.49	7.50	15.38
L X S	18.03	2.30	6.20	16.25
F X O	21.11	2.92	6.80	15.25
F X M	21.52	3.17	6.97	12.35
F X L	20.11	2.57	5.78	13.09
F X S	21.6	1.91	5.76	15.35
S X O	21.19	2.85	6.87	15.25
S X M	18.99	2.35	7.10	10.79
S X L	19.64	2.48	5.55	16.24
S X F	22.64	2.61	5.25	14.1
Sem ±	1.50	0.20	0.45	2.16
CD (p = 0.05)	4.27	0.57	1.27	18.81

Table 18. Pooled variance - covariance matrix

	x_1	x_2	x_3	x_4
x_1	3.43	-0.8	-1.03	-74.49
x_2		5.23	-0.6	128.29
x_3			1.41	-52.01
x_4				34627.27

x_1 - Nodes to first female flower

x_2 - Fruits/plant

x_3 - Fruit weight

x_4 - Seeds/fruit

COMPATIBILITY AMONG *Cucumis melo* VARIETIES

inodorus, conomon, flexuosus, momordica & *utilissimus*

BY

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ABSTRACT OF THE THESIS

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ABSTRACT

The investigation on compatibility among *Cucumis melo* var. *conomon* Mak., *Cucumis melo* var. *inodorous* Naud., *Cucumis melo* var. *utilissimus* Duth. and Full., *Cucumis melo* var. *flexuosus* Naud. and *Cucumis melo* var. *momordica* Duth. and Full. was conducted during October-January 1982-1983 and February - May 1983 at the Instructional Farm of College of Horticulture, Kerala Agricultural University, Vellanikkara, Trichur.

The five botanical varieties of *Cucumis melo* were observed crossable among each other. Oriental pickling melon x long melon and snake melon x snap melon were perfectly crossable (CI > 70%). There was significant maternal effect on crossability index. There was good fruit set and seed set at F_1 level. The F_1 hybrids were found to be intermediate between the parents for discrete fruit character. Inter varietal heterosis was significant for earliness, yield and their components. Combining ability analysis indicated the role of both additive and non-addetive gene action in the expression of nodes to first male and female flowers, days to first female flower, days to first fruit harvest, days to fruit maturity, seeds/fruit and seed yield/fruit. Additive gene action was predominant in nodes to first male and female flowers,

female flowers in first ten and 20 nodes, fruit length, fruit girth, fruit weight, fruit volume, flesh thickness, seeds/fruit, 100 seed weight, seed yield/fruit, fruits/plant and fruit yield/plant. Reciprocal effect was significant in nodes to first male flower, days to first female flower, days to first fruit harvest and days to fruit maturity. The correlation between gca values and *per se* performance of the parents was significant for all characters. This showed that *per se* performance of melon varieties would indicate their relative general combining ability effects. Musk melon and snake melon had the maximum genetic distance of 14.49. Long melon and snap melon were the closest (D^2 = 0.38). In the order of affinity the five melon varieties could be arranged as oriental pickling melon, long melon, snap melon, snake melon and musk melon. Fruits/plant contributed maximum (30%) to total genetic divergence.