HOMEOSTATIC ANALYSIS OF COMPONENTS OF GENETIC VARIANCE AND INHERITANCE OF FRUIT COLOUR, FRUIT SHAPE AND BITTERNESS IN BITTER GOURD (*Momordica charantia* L.)

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Doctor of Philosophy in Horticulture

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Vellanikkara - Trichur

1989

DECLARATION

I hereby declare that this thesis entitled "Homeostatic analysis of components of genetic variance and inheritance of fruit colour, fruit shape and bitterness in bitter gourd (*Momordica charantia* L.)" is a bonafide record of research work done by me during the course of research and 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.

Vellanikkara,
15th April, 1989.

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CERTIFICATE

Certified that this thesis entitled "Homeostatic analysis of components of genetic variance and inheritance of fruit colour, fruit shape and bitterness in bitter gourd (*Momordica charantia* L.)" is a record of research work done independently by Sri Abdul Vahab, M. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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ACKNOWLEDGEMENT

I have great pleasure to express my profuse and sincere gratitude to Dr.P.K.Gopalakrishnan former Associate Dean, College of Horticulture and Chairman of Advisory Committee, for his keen interest, bountiful guidance and everhelping nature all through the investigation until the consummation of this thesis.

I am greatly indebted to Dr.K.V.Peter, Professor and Head, Department of Olericulture, College of Horticulture and Member of Advisory Committee, for his constant encouragement, sustained guidance, constructive suggestions and unruffled demenour at every stage of investigation and preparation of this thesis.

I express my sincere thanks and gratitude to Dr.K.M.N. Namboodiri, Professor of Agricultural Botany and Member of Advisory Committee for his valuable guidance and immense help for the investigation and preparation of the thesis.

It is with sincere thanks that I acknowledge the immense help and suggestions in the statistical analysis rendered for me by Dr.K.C.George, Professor and Head, Dept. of Statistics and Member of Advisory Committee.

My thanks are due to Dr.A.I.Jose, Professor and Head, Department of Soil Science and Agricultural Chemistry and

Member of Advisory Committee for his critical and valuable suggestions in the preparation of the thesis.

The help rendered to me by Sri V.K.G.Unnithan, Associate Professor of Agricultural Statistics is sincerely acknowledged.

I take this opportunity to place on record my heartful thanks and gratitude to all my friends, particularly to Dr.K.Rajmohan, Dr.T.R.Gopalakrishnan, Dr.T.P.Murali, Sri V.K.Raju, Sri V.S.Devadas, Sri P.G.Sadankumar, Sri M.C. Narayanankutty, Smt.Meagle Joseph, Kum.Anita K. Cheriyan and Kum.Ushamani for their sincere and timely help at every stage of research and preparation of the thesis.

I am indebted to my wife, Nisa for her encouragement and help all through the investigation.

I am very thankful to Sri Joy for typing the thesis neatly in time.

The award of Senior Fellowship of the Indian Council of Agricultural Research is gratefully acknowledged.

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Introduction

INTRODUCTION

Cucurbits were among the first plants used by man. Apart from this historical awareness, they are now recognised to have high economic, nutritional and medicinal values. They form the single largest group of summer vegetables. Out of the 750 species under 90 genera of the family Cucurbitaceae, approximately 30 species under nine genera have achieved global recognition. In the tropics, subtropics and milder portions of the temperate zones of both hemispheres, these crops find an important place in human diet, besides having other minor uses.

In many countries, much attention has been given towards the improvement, and considerable progress has been made in various aspects of cucurbits in general. Bitter gourd (Momordica charantia L.), the most popular Indian vegetable remained neglected and under-researched without any effective attention till recently. It has now been understood that, this less known crop when represented nutritionally on a per hectare basis can very well compare and even compete with any other well known vegetables (Whitaker and Bemis, 1976 and Esquinas-Alcazar and Gulick, 1983).

In the late 1970s, workers in many developed countries started bestowing attention towards the improvement of this crop. The International Board for Plant Genetic Resources (IBPGR) expert consultation held in January, 1979 at the National Vegetable Research Station (NVRS), U.K., included *Momordica* among the nine high priority groups of vegetables in the tropics (Esquinas-Alcazar and Gulick, 1983).

In India, bitter gourd is the most important cucurbitaceous vegetable. In terms of nutritive value, it ranks first among the cucurbits, the most important contribution being vitamins and minerals. The large and small fruited varieties contain 4.2 g and 9.8 g of carbohydrate, 1.6 g and 2.1 g of protein, 88 mg and 96 mg of vitamin C, 210 I.U each of vitamin A and 1.6 mg and 9.4 mg of iron respectively in 100 g of edible portion (Choudhury, 1967). Although bitter in taste, the tender fruits are used in various preparations like pickles, curries and fries.

The fruits and leaves are used in various indigenous medicines (Nadkarni, 1954).

Despite the economic, nutritional and medicinal importance of bitter gourd, the availability of high yielding variety/s or hybrid/s is limited. There is an imperative need for developing variety/s or hybrid/s suited to the agroclimatic conditions of Kerala. This calls for a need based crop improvement programme.

Originated in the Indi-Burma Centre of Origin (Garrison, 1977), considerable variability is observed in bitter gourd in India. Information on genetic divergence, variability and components of variation are basic for any crop improvement programme.

Being a cross pollinated crop due to monoecy, considerable scope exists for commercial exploitation of heterosis. Identification of specific parental combination(s) with heterobeltiotic effects for economic characters are very important.

Informations on type of gene action governing economic characters are pre-requisites for any breeding programme. This helps in choice of appropriate breeding method(s) for improvement of any particular character.

Homeostatic analysis of components of genetic variance would reveal the genetic basis of stability of F_1 hybrids grown over different environments. A phenotypically stable and heterobeltiotic F_1 hybrid is more important considering the possibility for growing bitter gourd through out the year in tropics.

Preferences of bitter gourd with respect to fruit colour, shape (surface) and intensity of bitterness vary with locality. Colour, surface and size determine market price considerably. Information on inheritance of such characters is useful in transfering them to a desired variety.

There are three related species of *Momordica*: *charantia*, *cymbalaria* (Syn. *Momordica tuberosa*, *Luffa tuberosa*) and *dioica*. Information on phylogenetic association among the above species would help transfer desirable attributes from the related species to *Momordica charantia*.

The present research is formulated with the following objectives.

1) To study genetic divergence, variability and components of variation in the bitter gourd germ plasm,

2) To identify specific parental combination(s) heterobeltiotic for economic characters,

3) To find out components of genetic variance, preponderantly responsible for inheritance of economic characters and their homeostatic behaviour,

4) To identify phenotypically stable and hetero-beltiotic F_1 hybrid(s),

5) To study number and type of gene(s) action, linkage, penetrance, expressivity, etc. of genetic factors responsible for transmission of fruit characters like colour, shape (surface) and bitterness and

6) To investigate into the crossability association among three species of Momordica: charantia, cymbalaria and dioica.

Review of literature

REVIEW OF LITERATURE

Bitter gourd (*Momordica charantia* L.) has long been a less researched crop compared to other cucurbits and hence literature available is very few. Mainly because of efforts of International Bureau of Plant Genetic Resources, Rome, much emphasis is given on this crop now. It has slowly attained global recognition and attention among Agricultural Scientists. The available information on various aspects of the crop is reviewed under the following heads:

A. Genetic variability and divergence in bitter gourd,

B. Combining ability analysis in bitter gourd,

C. Heterosis in bitter gourd,

D. Gene action in bitter gourd,

E. Inheritance of qualitative characters in bitter gourd and

F. Crossability studies among the related species of *Momordica*

A. Genetic variability and divergence in bitter gourd:

Observations on variability, genetic divergence and components of phenotypic and genotypic variation are basic to crop improvement work. The effectiveness of selection of a genotype depends on estimates of heritability based on the phenotypic performance. Estimates of heritability along with estimates of genetic advance, are more useful in the choice of selection method rather than heritability or genetic advance alone (Johnson et al., 1955).

The existence of very high variability in respect of all the vegetative, productive and quality characters were observed by many workers in bitter gourd. Scientific studies in respect of extent of variability, by estimating the genetic parameters like phenotypic coefficient of variation, genotypic coefficient of variation, heritability, genetic advance and genetic gain are not sufficiently enough in bitter gourd.

Varieties possessing marked differences in fruit size and quality characters are observed by Choudhury (1967). Varieties differing in blooming time, blooming period, bud emergence and development, anthesis and dehiscence, per cent of fruit set, pollen viability and pollen size were reported by Pal et al. (1972). Srivastava and Srivastava (1976) obtained highest genotypic coefficient of variation (37.45%), heritability (99.31%) and genetic gain (71.73%) for fruits/plant and, lowest genotypic coefficient of variation (11.47), heritability (49.93%) and genetic gain (16.73%) for male flowers per plant in ten lines of bitter gourd. High heritability in conjuction with high genetic gain was also observed for fruit weight, yield/plant and fruit length which might be attributed to action of additive genes. Characters such as lateral branches/plant, female flower/plant and days to appearance of first female flower which showed high values of heritability, but very low values of genetic gain might be attributed to non-additive effects.

While trying to establish the possible centre of origin as Indo-Burma region, Garrison (1977) observed considerable genetic variability in respect of vegetative and productive characters in bitter gourd.

Singh et al. (1977) while investigating the genetic variability and correlation in 25 lines of bitter gourd reported significant differences among the varieties for yield/plant, fruit/plant, fruit width, days to flowering and age of edible fruit. The yield and its main components fruits/plant and fruit length showed high genotypic coefficient of variation (35%, 39% and 34% respectively), high heritability (92%, 93% and 95% respectively) and high expected genetic advance (69%, 76% and 68% respectively).

Days to flower had the least genotypic coefficient of variation (4%), low heritability (22%) and very low genetic advance (3.52). The correlations at genotypic level were more significant than their corresponding phenotypic correlations. The fruit/plant and fruit length were positively and significantly correlated at genotypic and phenotypic levels. The variability for yield was primarily dependant upon fruits/plant and fruit length.

Ramachandran and Gopalakrishnan (1979) carried out detailed variability studies and observed significant variability for primary branches/plant, main vine length, node to first female flower, days to first female flower opening, number of female flowers, days to picking maturity, yield/plant, number, weight, length and girth of fruits, seeds/plant and 100 seed weight in 25 diverse types of bitter gourd. They observed highest phenotypic coefficient of variation (39.88%), genotypic coefficient of variation (37.82%) and genetic gain (81.9%) for yield/plant. The value of heritability was highest for fruits/plant (99.8%) followed by yield/plant (99.74%), days to opening of first female flower (98.5%), female flowers/plant (98.39%) and main vine length (98.18%). The lowest values of genotypic coefficient of variation (5.72), heritability (43.3%) and genetic gain (7.76%) were observed for seeds/fruit. In the case of female flowers/plant, yield/plant, fruits/plant, both the values of heritability and genetic gain were higher indicating the action of additive genes for these characters. Characters such as days to opening of first female flowers and days to fruit maturity which showed higher values of heritability but low values of genetic gain might be attributed to non additive gene action.

Ramachandran and Gopalakrishnan (1980) observed significant variability with respect to certain biochemical traits also. The variance components, genotypic coefficient of variation, heritability and genetic gain were calculated for total soluble solids, vitamin C, protein, potassium, phosphorus and iron contents in all the genotypes. The range of variation was wide and the differences between types highly significant. High or moderate estimates of heritability and high genetic gain were found for vitamin C (99.65%, 70.72%), phosphorus (94.9%, 40.8), total soluble solids (82.69%, 35.99) and iron (75.65%, 5181) suggesting that these traits were controlled by additive genes, while protein (60.55, 20.74) and potassium (96.73%, 22.2) contents were governed by non additive genes.

Mangal et al. (1981) estimated genotypic and phenotypic coefficients of variation in 21 varieties for various characters. Highly significant variation was observed for all the characters among the varieties. Yield/plant recorded the highest gcv, while days to first female flower opening the minimum. In general, the pcv was greater than the gcv. High heritability values were noted for leaf length, plant height, average fruit weight, branches, fruits, and yield/plant and seeds/fruit. They also observed parallelism in the magnitude of the value of heritability and genetic gain in respect of plant height, average fruit weight, branches, fruits and yield/plant.

Chaudhary (1987) also observed significant variability in respect of various vegetative and yield characters. The highest phenotypic and genotypic coefficient of variation was observed for yield/plant, fruits/plant, vine length and fruit weight. For fruit length, fruit diameter, seeds/fruit and seed weight/fruit, the genotypic and phenotypic coefficients of variation were of average order. The estimates of pcv and gcv were low for early female flower formation and early harvest. Genetic advance was very high for yield/plant (1114.39) and vine length (151.53).

B. Combining ability analysis in bitter gourd

In heterosis breeding programme, the concept of combining ability is very important. Bitter gourd being a cross pollinated crop due to monoecy there is ample scope for exploitation of heterosis. Though there are strong indications of manifestation of hybrid vigour in bitter gourd, an F_1 hybrid is yet to be evolved for commercial utilization. For this, good combiners are to be first isolated. The selection of desirable parents for production of F_1 hybrids has to be based on genetic information and knowledge of their combining ability.

Sirohi and Choudhury (1977) undertook a detailed investigation in a group of eight genetically diverse lines of bitter gourd and obtained information regarding estimates of general and specific combining ability. They took eight inbred lines of bitter gourd of diverse nature namely, Pusa Do Mausmi (P_1), S.113 (P_2), Coimbatore Long (P_3), S.98 (P_4) S.144 (P_5), S.72 (P_6), S.63 (P_7) and S.77 (P_8) for the study and developed the F_1s. These 28 F_1s along with their parents were used to study the combining ability in bitter gourd for vine length, days to first harvest, fruit length, fruit diameter, flesh thickness, fruit/plant, fruit weight, seeds/ fruit, seed weight/fruit and total yield/plant.

Out of the eight parental lines used significant gca values were noted in four for vine length, and seed weight/fruit, five for fruit length fruit weight and total yield/plant, three for fruit diameter, flesh thickness and fruits/plant, and two for seeds/fruit. The four parents had significant general combining ability effects for earliness. The parent Pusa Do Mausmi had the highest gca effect for total yield/plant and high gca for weight, length and diameter of fruits; vine length, seeds/fruit and seed weight/fruit. The Parent, S.63 had the maximum gca effects for fruit diameter, flesh thickness fruit weight, seeds/fruit and seed yield/fruit and P_5, (S.144) had the highest gca effects for vine length and fruit length. P_2, (S.113) had highest gca effects for days to first harvest and fruits/plant.

Among the 28 hybrids, 14 for vine length, 7 for fruit weight, 12 for fruit diameter, 13 for flesh thickness, 16 for fruits/plant, 10 for fruit weight, 9 for seeds/fruit, 6 for seed weight/fruit and 18 for total yield/plant showed significant specific combining ability effects. It was observed that when either one or two of these parental lines having high gca effects for yield and its component characters were involved in the crosses, the F_1 hybrids gave best performance. The variance due to gca was greater than that due to sca for all the characters studied.

Singh and Joshi (1979) studied a 5 parental diallel of bitter gourd and worked out the combining ability effects. The five lines of bitter gourd collected from different places were purified to obtain five inbreds namely BWM 1, BB 1, BWL 1, Coimbatore Long and BS 1. They were crossed in all possible combinations. The ten hybrids along with the parents were studied for combining ability effects with respect to plant height, primary branches, fruit length and number and yield/plant.

The variance due to gca for all the above characters were highly significant. The variance due to sca were significant for fruits/plant and yield/plant only. The mean squares for gca were higher than those for sca.

None of the parental lines had significant gca effects for plant height and primary branches/plant. BWL 1 had significant positive gca effect for fruits/vine, but significant negative gca for fruit length and yield/plant. Significantly positive sca effects were observed in one hybrid for fruit length, in 2 hybrids for fruits/plant and in 4 hybrids for yield/plant. BWL 1 having high significant gca effects for fruit yield/plant and fruit length, showed significantly higher sca effects for yield/plant in combinations with BB 1, BWM 1 and BS 1.

Pal et al. (1983) conducted a line x tester analysis of combining ability in bitter gourd with the objective of selecting suitable parents for hybridisation and for characterising the nature and magnitude of gene action, using five lines Arka Harit, Monsoon Miracle, The Largest, Uchhe and China and two testers Holly Green and Indian Prime. Observations were made on days to first female flower, node to the first female flower, days to first fruit maturity, number of fruits, single fruit weight, fruit size index (length x width) and fruit yield/plant. The estimates of sca and gca were calculated.

They observed that the parents showed relatively higher gca for days to female flower formation, and fruits/plant. Higher variances due to sca were exhibited by node to first female flower, days to maturity, fruit yield, fruit size, fruit weight and fruit cavity size.

The phenotypically superior parent Monsoon Miracle was the best general combiner for fruit yield, fruit weight, fruit size and fruit cavity size. However, the gca values were negative for fruit weight and fruit size.

The sca effects were not significant in all the hybrids. However, in a few combinations like Monsoon Miracle x Holly Green, The Largest x Indian Prime and China x Indian Prime, the absolute values of sca effect were negative and higher than the standard error for days to first female flower. The negative value indicated that the hybrids can be exploited for earliness. For fruit size index, the hybrid, The Largest x Indian Prime possessed higher positive value than the standard error. Monsoon Miracle x Holly Green and Monsoon Miracle x Indian Prime possessed absolute values higher than the standard error and was negative. These may be exploited for breeding small cavity fleshy fruits. Inspite of high sca effects, these hybrids are not heterotic, where as heterosis was exhibited by three other hybrids having no marked sca effects.

In a combining ability study in bitter gourd, Srivastava and Nath (1983) observed that both gca and sca effects were operative in the expression of all the four characters studied. They observed high gca effects for three parents and high sca effects for combinations for yield. Their study also indicated that the gca effects of parents had no particular influence on sca effects of a combination. All the three types of combinations, ie., high x high, high x low and low x low showed high sca effects and inferred that only high x low and low x low effects could be made use of for commercial exploitation of herterosis.

Chaudhari (1987) studied a 11 parental diallel in bitter gourd and observed that the gca and sca variances were significant for all the 13 characters observed. The variances due to gca were consistently greater than the sca variances for all the characters. The parents Coimbatore Long, Hissar Selection and Khandesh Mali were the best combiners since they made significant contributions towards most of the yield contributing characters as evidenced by their high gca effects.

C. Heterosis in bitter gourd

It was Pal and Singh (1946) who first observed heterosis in crosses involving five diverse lines of bitter gourd, T_1 - Panipat Local, T_2 - Delhi Local, T_3 - Small Fruited, T_4 - Ambala Local and T_5 - Bihar Local.

Heterobeltiosis was observed for male and female flowers, main vine length, fruit size and total yield/ plant. In addition to heterobeltiosis for male and female flowers, there were proportionately more female flowers in the hybrids as compared to the proportion of their parents. The hybrids had significantly longer vines than their parents. Higher increase in fruits/plant was observed in hybrids between small fruited varieties than hybrids between big fruited varieties. In a few cases, there was negative heterosis. For fruit girth only, two F_1s showed heterobeltiosis. In Panipat Local x Ambala Local, though fruits were smaller in size, they were heavier than the better parent. The small size of the F_1 hybrids was compensated by more number of fruits whereby the total yield approaches or even exceeds that of hybrids between bigger fruited varieties themselves. In case of fruit length all hybrids exhibited negative heterosis.

In case of yield all except a few showed striking increase over the better parent. In a cross between Delhi Local x Panipat Local the percentage increase over the better parent was as high as 191.3. All the crosses inferior to the better parent were intermediate. In the two seasons tested, the performance of the hybrid in hot season was significantly better than in rainy season. The hybrid between Panipat Local x Ambala Local gave consistently higher yield as compared to other hybrids.

There was distinct differences in the reciprocal crosses for all the characters studied. Only in one character - interval between the appearance of male and female flowers - the hybrids did not differ significantly from their parents.

Aiyadurai (1951) also gave information on heterosis. In preliminary studies on bitter gourd he observed heterosis in earliness, fruits/plant, fruit size, fruit flesh thickness and total yield. The F_1s were intermediate for vine length.

Agrawal et al. (1957) crossed wild types of bitter gourd with cultivated varieties and observed intermediate performance for earliness, vine length, female flowers, fruits and yield/plant.

Srivastava (1970) in his attempt on exploitation of heterosis found that as much as 45 out of 90 F_1 hybrids produced female flowers significantly earlier than the better parent and concluded that days to female flower formation could be reduced to 16.7% from that of the parents. He also observed 64% heterobeltiosis for yield. Significant increase was also observed in hybrids for fruit length, fruit girth, fruit weight and fruits/plant.

Kohle (1972) examined hybrid vigour in yield in six hybrids selected from various cross combinations of six parents - M.P-14, Bihar-15, Coimbatore-16, Jamur-21, Mulshi-26 and Local. None of the hybrids possessed standard heterosis. However, the cross B-15 x J-21 showed a heterobeltiosis of 2.41% and 29.7%. Another cross, B-15 x M-26 gave an average heterosis of 16.56%. All others showed negative heterosis.

Lal et al. (1976) isolated two hybrids - Green Local x White Local and Green Local x Bundelkhand Local - as heterotic for vegetative growth, floral character and fruit yield. They observed heterosis for internode length, leaf petiole length, leaf length, leaf width, branches/plant, shoot length, node at which first female flowers formed, fruits/plant, length, girth and weight of fruits and total yield. In total yield, Green Local x White Local gave 139.1% increase over the better parent whereas it was only 35.2% in the hybrid, Green Local x Bundelkhand Local. In case of days to flower, there was 7.02% negative heterosis in the hybrid, Green Local x Bundelkhand Local.

Sirohi and Choudhury (1978) developed 28 F_1 hybrids using eight diverse lines of bitter gourd and observed that, when either one or two of these parental lines having high gca effects for yield and its component characters were involved in the crosses, the F_1 hybrids gave the best performance. Among the 28 hybrids, crosses between Pusa Do Mausmi x S.144, Pusa Do Mausmi x S.63 and Coimbatore Long x S.63 appeared the best performing for total yield/plant and its component characters, and they showed 84.10%, 72.00% as 45.46% higher yield respectively than the top parent Pusa Do Mausmi.

Singh and Joshi (1979) studied a 5 parental diallel cross of bitter gourd using five inbreds developed from five lines collected from different places. The inbreds namely BWM 1, BB 1, BWL 1, Coimbatore Long and BS 1 were crossed in all possible combinations to develop ten hybrids. The ten hybrids along with their parents were studied and the extent of heterosis was worked out. Heterobeltiosis ranged from 2.1% to 22.3% for plant height, and 7.8% to 37.1% for primary branches/vine. Fruit length registered significant heterobeltiosis in BWM 1 x Coimbatore Long having 29.9% heterobeltiosis. Crosses BW 1 x BWL 1 and BWL 1 x BS 1 had significantly more fruits/plant with 13.7% and 34.4% heterobeltiosis respectively. These two crosses yielded significantly higher than their respective better parents. The former cross exhibited 16.8% and 7.7% and latter 16.4% and 6.00% heterobeltiosis and standard heterosis, respectively. Heterosis for plant height and primary branches showed 22.3% and 37.1% heterobeltiosis. Among medium fruited lines, significant heterobeltiosis for fruit length was observed in BWM 1 x Coimbatore Long. Standard heterosis for fruit yield was low indicating that F_1 hybrids of these parental lines are not of commercial value.

Pal *et al.* (1983) in a line x tester analysis with five lines and two testers examined the presence of hybrid vigour and its feasibility of exploitation. In all the ten hybrids with five lines, namely Arka Harit, Monsoon Miracle, The Largest, Uchhe and China and two testers, Holly Green and Indian Prime, manifestation of heterosis was found to be very limited as a whole. However, in some combinations, like Monsoon Miracle x Holly Green, The Largest x Indian Prime and China x Indian Prime, the absolute values were negative and higher indicating the possibility of exploitation for earliness. It was suggested that the limited hybrid vigour in the crosses could be due to limited diversity in the parents. The trend showed that more pronounced hybrid vigour could be observed with inclusion of more of diverse parents.

Srivastava and Nath (1983) observed heterosis for various characters. They observed significant reduction in days to opening of first female flower (0.3 to 16.7%). Out of 90 hybrids heterobeltiosis was observed in 35 for vine length (0.4 to 27.1%) and 40 for fruits/plant (0.2 to 47.2%). They also observed as much as 64% increased yield in the hybrids.

Significant relative heterosis, heterobeltiosis and standard heterosis were also reported by Ranpise (1985) for vine length, fruits/plant and yield/plant.

Chaudhari (1987) observed relative heterosis, heterobeltiosis and standard heterosis for various characters in a 11 x 11 diallel cross in bitter gourd. Out of 55 hybrids, he observed relative heterosis in 33 for vine length, 15 for fruit diameter, 14 for fruit flesh thickness, 15 for fruit weight, 11 for seeds/fruit, 23 for seed weight, 19 for fruits/plant, 16 for yield/plant and 25 for T.S.S. Heterobeltiosis was observed for vine length in 8, days to female flower in 42, days to harvest in 51, days to maturity in 10, fruit length in 5, fruit diameter in 7, flesh thickness in 1, fruit weight in 8, seeds/fruit in 1, seed weight in 15, fruits/plant in 15, yield/plant in 15 and T.S.S. in 18 crosses. Standard heterosis was observed for days to first female flower in 23, days to harvest in 25, fruit weight in 1, seed weight/fruit in 2, fruits/plant in 1, yield/plant in 2 and T.S.S. in 2 crosses.

He also observed that the average performance of F_1 hybrids exceeded that of the parents by 26.32% in vine length, 22.98% in early female flower formation, 19.26% in early harvest and 1.26% in days to fruit set. For fruit characters, the figures exceeded 11.57% for length, 2.88% for diameter, 16.18% for flesh thickness, 2.12% for seeds/fruit, 5.89% for seed weight/fruit, 18.11% for fruits/plant, 25.32% for total yield/plant and 11.87% for T.S.S.

Relative heterosis was maximum for yield/plant (276.43%) followed by fruits/plants (127.44%), fruit weight (121.45%), flesh thickness (118.73%) and fruit diameter (106.53). Heterobeltiosis also was maximum for yield/plant (235.94%) followed by fruit diameter (93.12%), fruit weight (85.7%) and flesh thickness (74.24%). Standard heterosis was high for seed weight/fruit (62.59%) followed by seeds/fruit (55.42%) and fruit weight (50.4%). The hybrids C.96 x Green bitter gourd, Khandesh Mali x Green bitter gourd, B.G. 112 x Washin Local, BG 114 x Co Long and Washin Local x BG 110 which recorded 53.03%, 24.47%, 12.32% and 10.45% heterosis respectively for yield over the top parent; Khandesh Mali were the most promising.

D. Gene action in bitter gourd

Sirohi and Choudhury (1979) had examined gene effects in bitter gourd at the Division of Vegetable Crops, Indian Agricultural Research Institute, New Delhi. They used five parents, Pusa Do Mausmi (P_1), Sl. 113 (P_2), Coimbatore Long (P_3), Sl. 144 (P_4) and Sl. 63 (P_5) and their six generations (P_1, P_2, F_1, F_2, B_1 and B_2) for the estimation of gene effects for four important characters vine length, days to first harvest, fruit/plant and total yield/plant. In many of the crosses, duplicate epistasis was observed for vine length. The dominance (h) and dominance x dominance (l) components chiefly contributed to this character. This leads to the conclusion that heterosis breeding is useful for getting longer vines in bitter gourd. In majority of the crosses for days to first harvest and fruit/plant, role of the additive (d) and additive x additive (i) components were more pronounced, although in a few crosses the dominance (h) and dominance x dominance (l) components of genetic variance were more important. These characters could be fixed in a progeny by following proper selection methods. For total yield/ plant, majority of the crosses showed the presence of complementary epistasis and the contribution of the dominance (h) and the dominance x dominance components (l) of genetic variance were observed to be higher than the additive (d), the additive x additive (i) and the additive x dominance (j) components of genetic variance. This, like the vine length, also could be improved by heterosis breeding.

Sirohi and Choudhury (1979) while investigating the combining ability analysis using eight diverse genotypes of bitter gourd also observed additive x additive type of epistatic interaction for all the characters. In a diallel cross with 5 parents, Singh and Joshi (1979) observed preponderance of additiveness for fruits/plant and their weight.

Pal and Singh (1983), in a line x tester analysis using five lines of bitter gourd for characterising the nature and magnitude of gene actions observed the operation of more additive genes for days to first female flower and fruits/plant, and non-additive genes for node of first female flower formation, days to maturity, fruit yield, fruit size, fruit weight and fruit cavity size. In crosses involving the variety Monsoon Miracle, characters such as fruit yield/plant, individual fruit weight, fruit size and fruit cavity size also showed the preponderance of additive x additive gene interaction.

Investigating yield and seven yield related characters in an eight partial diallel without reciprocals, Sirohi and Choudhury (1983) reported additive gene action with partial dominance for vine length, days to first fruit harvest, fruit length and diameter, fruit flesh thickness, fruits/plant and fruit weight.

Sirohi and Choudhury (1983) studied gene action by the diallel method also. The study with 28 F_1 hybrids in a diallel set involving eight parents excluding reciprocals showed partial dominance for vine length, days to first harvest, fruit length, fruit diameter, flesh thickness, fruits/plant and fruit weight. It was observed that all the characters were governed by additive genes. There was assymmetry in the distribution of genes with positive and negative effects in all the cases, except for fruit diameter for which they were in equal proportion. Epistasis, particularly of complementary type, was observed for total yield/plant. Dominant alleles were more frequent for all the characters, except for vine length, days to first harvest and fruit weight. They suggested that heterosis breeding programme may be advantageous as there was presence of dominance and complementary type of gene action.

E. Inheritance of qualitative character in bitter gourd

In bitter gourd, information on inheritance of qualitative characters is very few. Esquinas-Alcazar and Gulick (1983) reported the inheritance of certain qualitative characters in bitter gourd. White epicarp is controlled by a single gene 'w' white being recessive to green. Similarly light brown seed is recessive to dark brown seed, being governed by the gene 'lbs'. Large seed is recessive to small seed, being governed by 'ls'. The nature of inheritance of other characters are not yet reported.

F. Crossability studies among the related species of *Momordica*

A good amount of work has been done on the phylogenetical studies in other cucurbits like *Cucumis*, *Cucurbita* (Esquinas-Alcazar and Gulick, 1983) and *Luffa* (Choudhury and Thakur, 1965; Roy *et al*., 1975; Dutt and Roy, 1969).

In bitter gourd, works in this line are quite insufficient. Trivedi and Roy (1972) investigated the cytological aspects of three species of Momordica - Momordica charantia, Momordica balsamina and Momordica dioica. They found that the somatic chromosome number in Momordica charantia, Momordica balsamina and Momordica dioica are 22, 22 and 28 respectively.

In addition to the diploid, natural triploids and tetraploids of M. dioica have been reported from Assam and Darjeeling (Agarwal and Roy, 1976), which show 42 and 56 chromosomes respectively at the root tips.

Interspecific crosses have been attempted among Momordica charantia, Momordica balsamina and Momordica dioica (Trivedi and Roy, 1972). About 500 attempts of crossing between M. charantia and M. dioica failed to set any seed. The ovaries dried about 40 hours after pollination. The pollen grains did not germinate even two hours after pollination, although 2-4% of pollen grains germinated after four hours. The ovaries fell down after 40 hours of pollination.

About 400 crosses were made between Momordica dioica and Momordica balsamina, all of which failed. Only a few pollen grains germinated 6 hours after pollination and the growth of the pollen tube was very slow. The ovaries shrivelled and fell down after 30 hours. Thus it was clearly established that *Momordica charantia* is incompatible with *Momordica dioica* and *Momordica balsamina*.

Materials and Methods

MATERIALS AND METHODS

The investigations were carried out at the Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara, during 1980-85. The experimental field is located at an altitude of 22.5 M above M.S.L. between 70° 32' N latitude and 76° 16' E longitude. The area enjoys a warm humid tropical climate. The experimental site has a sandy loam soil with a pH of 5.1. These climatic and soil factors are ideal for bitter gourd cultivation through out the year.

The studies were conducted under the following four heads:

A. Genetic variability and divergence in bitter gourd,

B. Development of F_1 hybrids and their homeostatic analysis,

C. Inheritance of fruit colour, fruit shape and bitterness in bitter gourd and

D. Crossability studies among the related species of *Momordica*.

A. Genetic variability and divergence in bitter gourd

1. Experimental materials

The germplasm of bitter gourd maintained at the Department of Olericulture, College of Horticulture along with the collections from different parts of Kerala were utilized for the variability studies. This included fifty diverse types varying in fruit size, shape, colour and bitterness. These were grown in a Randomized Block Design with two replications during 1981-82 to find out the extent of genetic variability and to select ten parents for further attempt on development of F_1 hybrids and their homoeostatic analysis. There were 2 plants/pit and 2 pits/replication. The field culture was done as per the recommendations of the Package of Practices of the Kerala Agricultural University (1980). The morphological fruit characters of 50 bitter gourd lines are given in Table 1.

2. Observations recorded

All the plants were considered for recording observations. Data are recorded on the following 18 characters and the average values were calculated for statistical analysis.

a) Main branches/plant

b) Main vine length (m)

c) Node to first female flower

d) Days to first female flower opening

e) Female flower/plant

f) Percentage of female flowers

g) Days to picking maturity

h) Yield/plant (kg)

i) Fruits/plant

j) Fruit weight (g)

k) Fruit length (cm)

l) Fruit girth (cm)

m) Flesh thickness (mm)

n) Seeds/fruit

o) 100 seed weight (g)

p) Total soluble solids

q) Vitamin C content: mg/100 g — Estimated volumetrically by 2,6-dichlorophenol indophenol visual titration method (A.O.A.C., 1960)

r) Protein content (%): Estimated by macrokjeldahl method (A.O.A.C., 1960)

Table 1. Morphological fruit characters of 50 bitter gourd genotypes *

Sl. No.	Genotype	Colour	Length	Girth at the middle	Spines	Ridges
1	2	3	4	5	6	7
1	MC-4	Green	Long	Narrow in the middle and broad at the tip	Present, not prominent	Absent
2	MC-10	Green	Long	Broad	Present	Absent
3	MC-15	Green	Medium long	Broad	Present	Absent
4	Priya	Green	Long	Narrow	Present	Absent
5	Arka Harit	Dark green	Medium long	Broad	Absent	Present, discontinuous
6	MC-34	White	Medium long	Broad	Present, prominent	Absent
7	MC-42	Whitish green	Long	Broad	Present	Absent
8	MC-48	Green, light green at the tip	Medium	Narrow	Absent	Present continuous
9	MC-49	Green long	Medium long	Broad	Absent	Present continuous
10	MC-50	Light green	Medium long	Broad	Present	Absent
11	MC-51	White	Medium long	Narrow	Present	Absent
12	MC-52	Whitish green	Medium long	Narrow	Present, not prominent	Absent
13	MC-53	Dark green	Medium long	Broad	Present	Absent

* Source in appendix III

Contd.

Table 1. Continued

1	2	3	4	5	6	7
14	MC-54	Green	Medium long	Broad	Present	Absent
15	MC-57	Green	Medium long	Broad	Present, prominent	Absent
16	MC-60	Light green	Medium long	Broad	Present, not pro-minent	Absent
17	MC-61	Green	Medium long	Broad	Present	Absent
18	MC-62	Dark green	Long	Narrow	Present	Absent
19	MC-63	White	Long	Narrow	Present	Absent
20	MC-64	White	Long	Narrow	Present	Absent
21	MC-65	White	Long	Narrow	Present	Absent
22	MC-66	White	Long	Narrow	Present	Absent
23	MC-67	Light green	Medium long	Narrow	Present	Absent
24	MC-68	Green	Medium long	Broad	Present	Absent
25	MC-69	White	Long	Broad	Absent	Present, contin-uous
26	MC-70	Green	Medium long	Broad	Absent	Present, discont-inuous
27	MC-71	Light green	Long	Narrow	Present, prominent	Absent
28	MC-72	Green	Medium long	Narrow	Present	Absent
29	MC-73	Light green	Medium long	Narrow	Present	Absent
30	MC-74	Green	Long	Narrow	Present	Absent
31	MC-75	Dark green	Medium long	Broad	Present	Absent

Contd.

Table 1. Continued

1	2	3	4	5	6	7
32	MC-76	Green	Medium long	Broad	Present	Absent
33	MC-77	Whitish green	Medium long	Broad	Present	Absent
34	MC-78	White	Long	Narrow	Present	Absent
35	MC-79	White	Short	Broad	Present, not prominent	Absent
36	MC-80	Green	Medium long	Narrow	Present	Absent
37	MC-82	Green	Short	Broad	Present	Absent
38	MC-83	Green	Medium long	Broad	Present	Absent
39	MC-84	White	Medium long	Broad	Present	Absent
40	MC-85	Green	Short	Broad	Present	Absent
41	MC-86	Light green	Short	Broad	Present	Absent
42	MC-87	Green	Medium long	Broad	Present	Absent
43	MC-88	Green	Medium long	Broad	Present	Absent
44	MC-89	Light green	Medium long	Narrow	Present	Absent
45	MC-90	Green	Short	Broad	Present	Absent
46	MC-91	Whitish green	Short	Broad	Present	Absent
47	MC-92	Green	Medium long	Broad	Absent	Present discontinuous
48	MC-93	Light green	Medium Long	Broad	Absent	Present, discontinuous
49	MC-94	Green	Short	Broad	Present	Absent
50	MC-95	Green	Short	Broad	Present	Absent

3. Statistical analysis

(a) Analysis of variance

The analysis of variance was done as described by Ostle (1966) for a randomised block design.

The somatic analysis of variability was conducted as suggested by Burton (1952).

(i) Genotypic coefficient of variation (gcv) =

$$\frac{\text{Genotypic standard deviation}}{\text{Mean of that character}} \times 100$$

(ii) Phenotypic coefficient of variation (pcv) =

$$\frac{\text{Phenotypic standard deviation}}{\text{Mean of the character}} \times 100$$

(iii) Standard error of mean = $\frac{\text{Environmental standard deviati}}{\sqrt{\text{Replications}}}$

Environmental variance = Mean square due to error

Genotypic variance =

$$\frac{\text{Mean square due to genotype - Mean square due to error}}{\text{Replications}}$$

Phenotypic variance = Genotypic variance + error variance

(iv) Heritability in broad sense was estimated by the formula suggested by Burton and Devane (1953)

$$h_b^2 = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}}$$

(v) Expected genetic advance at 5% intensity of selection was calculated using the formula of Johnson *et al.* (1955).

$$GA = h^2 \times p \times i$$

Where, h^2 = heritability

p = phenotypic standard deviation

i = coefficient of intensity of selection (2.06 at p = 0.05)

(vi) Genetic advance % = $\frac{\text{Genetic advance}}{\text{Mean of the character}} \times 100$

(b) Genetic divergence

The genetic divergence among the 50 bitter gourd genotypes were calculated using all the 18 characters in the somatic analysis. The method suggested by Mahalanobis (1928), was used to estimate the D^2. With $x_1, x_2, x_3 \ldots x_{18}$ as the multiple measurements, available on each genotype and $d_1, d_2, d_3 \ldots\ldots\ldots d_{18}$ as $\bar{x}_1^1 - \bar{x}_1^2$, $\bar{x}_2^1 - \bar{x}_2^2$, $\bar{x}_3^1 - \bar{x}_3^2$ $\ldots\ldots\ldots \bar{x}_{18}^1 - \bar{x}_{18}^2$ respectively being the difference in the means of two genotypes, where power denotes the genotypes and suffix denotes the characters, Mahalanobis D^2 statistics is defined as follows:

$$_pD^2 = b_1d_1 + b_2d_2 + b_3d_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots b_{18}d_{18}$$

Here, the b_1 values were estimated such that the rate of variance between the genotypes to the variance within the genotype was maximised

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

Where W^{ij} is the ij^{th} element of the inverse of the estimated variance - Covariance matrix.

Grouping of genotypes to clusters was done by Tocher's method (Rao, 1952).

B. Development of F_1 hybrids and their homeostatic analysis

1. Experimental materials

Ten parents Priya, MC-78, MC-84, Arka Harit, MC-82, MC-79, MC-66, MC-49, MC-69 and MC-34 which were originally included in the germplasm were selected based on genetic divergence (Plates 1 to 10). These ten diverse parental lines were crossed in all possible combinations to develop 45 F_1 hybrids. These hybrids along with their parents were grown in a randomised block design with two replications continuously for three seasons.

2. Observations

Observations were recorded on branches/plant, main vine length, node to first female flower, days to first

Plate-1.   Priya

Plate-2.   MC 78

PLATE-1

PLATE-2

Plate-3. MC 84

Plate-4. Arka Harit

PLATE - 3

PLATE-4

Plate-5. MC 82

Plate-6. MC 79

PLATE-5

PLATE-6

Plate-7.   MC 66

Plate-8.   MC 49

PLATE-7

PLATE-8

Plate-9. MC 69

Plate-10. MC 34

PLATE-9

PLATE-10

female flower opening, female flowers/plant, percentage of female flowers, fruits/plant, fruit weight, fruit length, fruit girth and yield/plant.

3. Statistical analysis

(a) Stability analysis

The homogeneity of error variance in different environments was tested using Bartletts' test. To test the G x E interaction unweighted analysis of variance of the pooled data was carried out in cases where error variance was homogeneous (Panse and Sukhatme, 1954). Weighted analysis was done in cases where the errors were heterogenøous.

Table 2. Weighted analysis of variance of pooled data

Source	df	SS
Total	St-1	$\sum_{j=1}^{S} W_j S_j - C$
Environments	S-1	$\frac{1}{t} \sum_{j=1}^{S} W_j P_j Z - C$
Genotypes	t-1	$\frac{\sum_{i=1}^{t} \left(\sum_{j=1}^{S} W_j Y_{ij} \right)^2}{\sum_{j=1}^{S} W_j} - C$
G x E interaction	(S-1)(t-1)	Total SS - Environment SS - Genotype SS

Where, $W_j = \frac{r}{S_j^2}$

S_j^2 = Error mean square in the j^{th} environment

r = Number of replications in each environment

S = Number of environments

t = Number of genotype

S_j = Crude SS for j^{th} environment

P_j = Total for j^{th} environment

$$C = \frac{G^2}{t \sum_{j=1}^{S} W_j} \qquad G = \sum_{j=1}^{S} W_j P_j$$

Significance of G x E interaction was tested using χ^2 test

$$\chi^2 = \frac{(n-4)(n-2)}{n(n+t-3)} I \quad \text{with df} = \frac{(S-1)(t-1)(n-4)}{(n+t-3)}$$

where,

I = Interaction SS

n = Number and degrees of freedom on which error mean square was based in each environment.

The analysis was further proceeded for estimating the stability parameters (Eberhart and Russell, 1966) as the G x E interactions were significant for all the characters.

Eberhart and Russell model (1966) (ER Model)

$$Y_{ij} = \mu_i + b_i I_j + \delta_{ij}$$

where, μ_i = Mean of i^{th} variety over all environments

b_i = Regression coefficient that measures the response of the i^{th} variety to varying environments

I_j = Environmental index which is defined as the deviation of the mean of all varieties at the j^{th} environment from the grand mean.

δ_{ij} = Deviation from the regression of the i^{th} variety in the j^{th} environment

I_j is obtained as

$$I_j = \sum_{i=1}^{t} \frac{Y_{ij}}{t} - \sum_{i=1}^{t} \sum_{j=1}^{S} \frac{Y_{ij}}{St}$$

$i = 1 \ldots\ldots\ldots\ldots 55$

$j = 1 \ldots\ldots\ldots\ldots 3$

So that, $\sum_{j=1}^{S} I_j = 0$

The two parameters of stability are

Regression coefficient $(b_i) = \dfrac{\sum_{j=1}^{S} Y_{ij}.I_j}{\sum_{j=1}^{S} I_j^2}$

Mean square deviation $(Sd_i^2) = \sum_{j=1}^{S} \dfrac{\delta_{ij}^2}{S-2} - \dfrac{Se^2}{r}$

where, $\sum_{j=1}^{S} \delta_{ij}^2 = \sigma v_i^2 - b_i \sum_{j=1}^{S} Y_{ij} I_j$

$$\sigma v_i^2 = \sum_{j=1}^{S} Y_{ij}^2 - \frac{Y_{i.}^2}{S}$$

$$b_{i.}\sum_{j=1}^{S} Y_{ij.}\ I_j = \frac{\sum_{j=1}^{S} Y_{ij.} I_j^2}{\sum_{j=1}^{S} I_j^2}$$

Table 3. Analysis of variance table under Eberhart and Russell (1966) model are given below:

Source	df	SS	MS
Total	St-1	$\sum_{i=1}^{t}\sum_{j=1}^{S} Y_{ij}^2 - CF$	
Varieties	t-1	$\frac{1}{S}\sum_{i=1}^{t} Y_{i.}^2 - CF$	MS_1
Environment + Varieties x environment	(-1)+(t-1) (S-1)	$\sum_{i=1}^{t}\sum_{j=1}^{S} Y_{ij}^2 - \sum_{i=1}^{t}\frac{Y_{i.}^2}{S}$	
Environment (linear)	1	$\frac{\frac{1}{t}\left(\sum_{j=1}^{S} Y_{ij} I_j\right)^2}{\sum_{j=1}^{S} I_j^2}$	
Variety x Environment (linear)	(t-1)	$\sum_{i=1}^{t}\frac{\sum_{j=1}^{S} Y_{ij} I_j^2}{\sum_{j=1}^{S} I_j^2}$ - SS due to Environment	MS_2
Pooled deviation	t(S-2)	$\sum_{i=1}^{t}\sum_{j=1}^{S} \delta_{ij}^2$	MS_3
Variety 1	(S-2)	$\sum_{j=1}^{S} \delta_{ij}^2$	
⋮		⋮	
Variety t	S-2	$\sum_{j=1}^{S} \delta_{ij}^2$	
Pooled error	S(t-1)(r-1)		$\frac{Se^2}{r}$

'F' test

1. To test the significance of the differences among the variety means, the 'F' test is defined as, $F = MS_1/MS_3$.

2. The equality of regression coefficient is tested by 'F' test, $F = M_2/MS_3$.

3. The individual deviation from linear regression is tested as,

$$F = \frac{\sum_{j=1}^{s} (\delta_{ij}^2 \quad s-2)}{S_e^2}$$

A genotype with unit regression coefficient ($b_{(i)} = 1$) and deviations from regression not significantly different from zero ($S^2d_{(i)} = 0$) was considered to be stable one.

(b) Analysis for combining ability

The data from the three environments were separately analysed for combining ability using Method of Griffing (1956) as given in Table 4.

Table 4. Analysis of variance for combining ability

Source	df	SS	MS	Expected MS
General combining ability (gcv)	p-1	Sg	Mg	$\sigma_e^2 + \sigma_s^2 + (p+2)\sigma_g^2$
Specific combining ability (scv)	$\frac{P(p-1)}{2}$	Ss	Ms	$\sigma_e^2 + \sigma_s^2$
Error	m	Se	M'e	σ_e^2

where, $Sg = \frac{1}{p+2} \sum_i (Y_{i.} + Y_{ii})^2 - \frac{4}{p} Y_{..}^2$

$$Ss = \sum_{i \leq j} \sum Y_{ij}^2 - \frac{1}{p+2} \sum (Y_{i.} + Y_{ii})^2 + \frac{2}{(p+1)(p+2)} Y_{..}^2$$

P = number of parents involved

$M'e = \sigma_e^2$

General combining ability effects, g_i and specific combining ability effects, S_{ij} were estimated as follows:

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

$$s_{ij} = Y_{ij} - \frac{1}{p+2} (Y_i + Y_{ii} + Y_{ij} + Y_{.j} + Y_{ii}) + \frac{2}{(p+1)(p+2)} Y_{..}$$

$$SE (g_i) = \left[(p-1) \sigma^2 e/p (p+2)\right]^{½}$$

$$SE (s_{ij}) = \left[(p^2+p+2) \sigma^2 e/(p+1) (p+2)\right]^{½}$$

$$SE (g_i-g_j) = \left[(2 \sigma^2 e/p+2)\right]^{½}$$

$$SE (s_{ij}-s_{ik}) = \left[2(p+1) \sigma^2 e/p+2\right]^{2}$$

$$SE (s_{ij}-s_{kl}) = \left[(2n \sigma^2 e/n+2)\right]^{½}$$

Analysis of variance for combining ability over three environments was done as suggested by Singh (1973b) as given in table 5.

Notation: The analysis is done on genotype mean taken over blocks for 3 environments. P_1 number of parents, v genotypes, l environments, b blocks/environment and c individuals/plot.

$X_{ij.} = \sum_k X_{ijk}$, $X_{i.k} = \sum_i X_{ijk}$ where $X_{ijk} = X_{jik}$,

$X_i = \sum_i X_{ij.} = \sum_k X_{i-k}$ where $X_{ij} = X_{ji}$,

$X_{.k} = \sum_{i \leq j}\sum X_{ijk}$, $X_{...} = \sum_k S_{..k}$.

Table 5. Analysis of variance for combining ability over environments

Source	df	SS	MS	Expected MS
General combining (G)	p-1	SS(g)	Ag	$\sigma^2 + \sigma^2_{sl} + (p+2)\sigma^2_{gl} + l\,\sigma^2_s + (p+2)\,l\,\sigma^2_g$
Specific combining ability (S)	$\frac{p(p-1)}{2}$	SS(s)	As	$\sigma^2 + \sigma^2_{sl} + l\,x\,\sigma^2_s$
Environment (L)	l-1	SS(l)	A_l	$\sigma^2 + \sigma^2_{sl} + 2(p+1)\,\sigma^2_{gl} + \frac{p(p+1)}{2}\,\sigma^2_l$
Interaction (GxC)	(-1)(l-1)	SS(gl)	A_{gl}	$\sigma^2 + \sigma^2_{sl} + (p+2)\,\sigma^2_{gl}$
Interaction (S xL)	$\frac{p(p-1)(l-1)}{2}$	SS(sl)	A_{sl}	$\sigma^2 + \sigma^2_{sl}$
Error	l(v-1)(b-1)		A_e	σ^2

where, $$SS(g) = \frac{\sum_i (X_{i..} + X_{ii.})^2}{(p+2)\,l} - \frac{4\,X_{...}^2}{p(p+2)\,l}$$

$$SS(i) = \frac{\sum\sum_{i \leq j} X_{ij.}^2}{l} - \frac{\sum_i (X_{i..} + X_{ii.})^2}{(p+2)\,l} + \frac{2X_{...}^2}{p(p+2)\,l}$$

$$SS(l) = \frac{2\sum_k X_{..k}}{p(p+1)} - \frac{2\,X^2_{...}}{p(p+1)\,l}$$

$$SS(gl) = \frac{\sum_k \sum_i (X_{i.k} + X_{iik})^2}{p+2} - \frac{4\sum_k X_{..k}}{p(p+2)}$$

$$- \frac{\sum_i (X_{i..} + X_{ii.})^2}{(p+2)\,l} + \frac{4\,X_{...}^2}{p(p+2)\,l}$$

$$SS(sl) = \sum_k \sum_{i \leq j} X^2_{ijk} - \frac{\sum_t \sum_i (X_{i.k} + X_{iik})^2}{p+2}$$

$$+ \frac{2\sum_k X^2_{..k}}{(p+1)(p+2)} - \frac{\sum\sum_{i \leq j} X_{ij}^2}{l} + \frac{\sum_i (X_{i..} + X_{ii})^2}{(p+2)\,l}$$

$$- \frac{2\,X_{...}^2}{(p+1)(p+2)\,l}$$

(c) Heterosis in bitter gourd

Magnitude of heterosis was calculated in terms of three parameters for all the three seasons. Heterosis over mid parent (Relative heterosis), better parent (Heterobeltiosis) and standard variety (Standard heterosis) were worked as suggested by Brigle (1963) and Hayes (1965).

$$\text{Relative Heterosis (RH)} = \frac{F_1 - MP}{MP} \times 100$$

$$\text{Heterobeltiosis (HB)} = \frac{F_1 - TP}{BP} \times 10$$

$$\text{Standard heterosis (SH)} = \frac{F_1 - TP}{TP} \times 100$$

For testing heterosis over mid parent

$$SE = \frac{\sqrt{3 \times ve}}{2 \times r}$$

$$CD = SE \times 't'$$

and over better part and top part

$$SE = \frac{\sqrt{2 \times ve}}{r}$$

$$CD = SE \times t$$

where, ve = Error mean square in RBD

r = number of replications

CD = critical difference

C. Inheritance of fruit colour, fruit shape (surface) and bitterness and study on linkage if any in bitter gourd

1. Experimental materials

Four parental lines (Priya, MC 49, MC 66 and MC 69) originally included in Set I differing in fruit colour (green/white) and fruit surface (spiny/smooth) were used to develop the six generations of P_1, P_2, F_1, F_2, BC_1 and

BC_2. There were six groups, of which four were with parents differing in fruit colour and four with differing fruit surface. Two groups had parents differing in both fruit colour and surface. These were used to study inheritance of fruit colour and fruit surface and study on linkage if any between fruit colour and surface.

(a) Fruit colour

(i) Group 1

P_1 - Priya (Green, spiny)
P_2 - MC 66 (White, spiny)
F_1 - Priya x MC 66
F_2 - Priya x MC 66
BC_1 - (Priya x MC 66) x Priya
BC_2 - (Priya x MC 66) x MC 66

There were 25 plants each in F_1, P_1 and P_2, 200 in F_2, 80 in BC_1 and 120 in BC_2.

(ii) Group 2

P_1 - Priya (Green, spiny)
P_2 - MC 69 (White, smooth)
F_1 - Priya x MC 69
F_2 - Priya x MC 69
BC_1 - (Priya x MC 69) x Priya
BC_2 - (Priya x MC 69) x MC 69

There were 17 plants in P_1, P_2 and F_1, 180 in F_2, 70 in BC_1 and 140 in BC_2.

(iii) Group 3

P_1 - MC 49 (Green, Smooth)

P_2 - MC 66 (White, spiny)

F_1 - MC 49 x MC 66

F_2 - MC 49 x MC 66

BC_1 - (MC 49 x MC 66) x MC 49

BC_2 - (MC 49 x MC 66) x MC 66

There were 20 plants each in P_1, P_2 and F_1, 190 in F_2, 80 in BC_1 and 165 in BC_2.

(iv) Group 4

P_1 - MC 49 (Green, smooth)

P_2 - MC 69 (White, smooth)

F_1 - MC 49 x MC 69

F_2 - MC 49 x MC 69

BC_1 - (MC 49 x MC 69) x MC 49

BC_2 - (MC 49 x MC 69) x MC 69

There were 15 plants each in P_1, P_2 and F_1 205 in F_2, 65 in BC_1 and 110 in BC_2.

(b) Fruit surface

(i) Group 1

P_1 - Priya (Green, spiny)

P_2 - MC 49 (Green, smooth)

F_1 - Priya x MC 49

F_2 - Priya x MC 49

BC_1 - (Priya x MC 49) x Priya

BC_2 - (Priya x MC 49) x MC 49

The parents, F_1s and segregating generations were grown accomodating 20 plants each in parents and F_1s, 225 in F_2, 95 in BC_1 and 110 in BC_2.

(ii) Group 2

P_1 - Priya (Green, spiny)

P_2 - MC 69 (White, smooth)

F_1 - Priya x MC 69

F_2 - Priya x MC 69

BC_1 - (Priya x MC 69) x Priya

BC_2 - (Priya x MC 69) x MC 69

There were 17 plants in P_1, P_2, F_1 and 180 in F_2 70 in BC_1 and 140 in BC_2.

(iii) Group 3

P_1 - MC 49 (Green, smooth)

P_2 - MC 66 (White, spiny)

F_1 - MC 49 x MC 66

F_2 - MC 49 x MC 66

BC_1 - (MC 49 x MC 66) x MC 49

BC_2 - (MC 49 x MC 66) x MC 66

There were 20 plants each in P_1, P_2, F_1, 190 in F_2 80 in BC_1 and 165 in BC_2.

(iv) Group 4

P_1 - MC 66 (white, spiny)

P_2 - MC 69 (White, smooth)

F_1 - MC 66 x MC 69

F_2 - MC 66 x MC 69

BC_1 - (MC 66 x MC 69) x MC 69

BC_2 - (MC 66 x MC 69) x MC 69

There were 20 plants each in P_1, P_2, F_1, 205 in F_2, 65 in BC_1 and 110 in BC_2.

(c) Detection of linkage between colour and surface

Two crosses, where the populations were segregating simultaneously for fruit colour and surface and their segregation was separately tested, were used for further testing their independance in inheritance.

(i) Group 1

P_1 - Priya (Green, spiny)
P_2 - MC 69 (White, smooth)
F_1 - Priya x MC 69
F_2 - Priya x MC 69
BC_1 - (Priya x MC 69) x Priya
BC_2 - (Priya x MC 69) x MC 69

(ii) Group 2

P_1 - MC 49 (Green, smooth)
P_2 - MC 66 (White, spiny)
F_1 - MC 49 x MC 66
F_2 - MC 49 x MC 66
BC_1 - (MC 49 x MC 66) x MC 49
BC_2 - (MC 49 x MC 66) x MC 66

(d) Bitterness

Three lines, originally included in Set 1 and varying in bitterness as tested by organoleptic methods were used for studies on inheritance of bitterness. The line, MC 79 (P_1) characterised by very small fruits, seeds and thin flesh was adjudged as less bitter. Another line MC 53 (P_2) with spiny dark green fruits was highly bitter. MC 34 (P_2) with moderate bitterness was also used. These three lines were used to develop six generations of P_1, P_2, F_1, F_2, BC_1 and BC_2.

Bitterness was expressed as the percentage of ether extract obtained as per Visratha and Ungsurungsie (1981) which showed a low value in less bitter types and higher value in highly bitter types. Fruits samples from all the plants were dried powdered and extracts obtained and expressed in percentage as a measure of bitterness.

(i) Group 1

P_1	-	MC 53 (Highly bitter)
P_2	-	MC 79 (Less bitter)
F_1	-	MC 53 x MC 79
F_2	-	MC 53 x MC 79
BC_1	-	(MC 53 x MC 79) x MC 53
BC_2	-	(MC 53 x MC 79) x MC 53

There were 15 plants each in P_1, P_2, F_1, 150 in F_2, 90 in BC_1 and 100 in BC_2.

(ii) Group 2

P_1 - MC 53

P_2 - MC 34

F_1 - MC 53 x MC 34

F_2 - MC 53 x MC 34

BC_1 - (MC 53 x MC 34) x MC 34

BC_2 - (MC 53 x MC 34) x MC 34

The plants were grown accomodating 15 each in P_1, P_2 and F_1, 120 in F_2, 90 in BC_1 and 100 in BC_2.

(iii) Group 3

P_1 - MC 79

P_2 - MC 34

F_1 - MC 79 x MC 34

F_2 - MC 79 x MC 34

BC_1 - (MC 79 x MC 34) x MC 79

BC_2 - (MC 79 x MC 34) x MC 34

The parents, F_1s and segregating population were grown accomodating 20 plants each in P_1, P_2 and F_1, 150 in F_2, 100 in BC_1 and 90 in BC_2.

2. Observations

For qualitative characters - colour and shape (Surface), counts of plants with green, white, spiny and smooth and their combinations were recorded. Since the expressivity of fruit surface was not complete in two crosses, the method suggested by Avdeyev (1979) was used to calculate the expected values.

For bitterness, ether extracts as per the methods of Visratha and Ungsurungsie (1981) were taken from the dried and powdered fruits and expressed as percentage.

3. Statistical analysis

(a) Qualitative characters

The agreement of the observed values with the expected values by χ^2 test of 'goodness of fit' with n-1 degrees of freedom, where n is the number of classes and presence of linkage were tested as suggested by Panse and Sukhatme (1954).

(b) Bitterness

The data on percentage of ether extracts obtained from the six generations followed a normal distribution in F_2 generations indicating quantitative inheritance of the character. Therefore scaling tests and generation mean analysis were carried out for this trait.

(i) Scaling tests

The presence of non-allelic interaction was detected by scaling tests (Mather, 1949). Estimates of additive (D) and dominance (H) components of genetic variance were made using the mean and variances of six generations - P_1, P_2, F_1, F_2, BC_1 and BC_2.

$$A = 2\,\bar{B}_1 - \bar{P}_1 - \bar{F}_1$$

$$V(A) = 4\,V(\bar{B}_1) + V(\bar{P}_1) + V(\bar{F}_1)$$

$$B = 2\,\bar{B}_2 - \bar{P}_2 - \bar{F}_1$$

$$V(B) = 4\,V(\bar{B}_2) + V(\bar{P}_2) + V(\bar{F}_1)$$

$$C = 4\,\bar{F}_2 - 2\,\bar{F}_1 - \bar{P}_1 - \bar{P}_2$$

$$V(C) = 16\,V(\bar{F}_2) + 4\,V(\bar{F}_1) + V(\bar{P}_1) + V(\bar{P}_2)$$

$$D = 2\,\bar{F}_2 - \bar{B}_1 - \bar{B}_2$$

$$V(D) = 4\,V(\bar{F}_2) + V(\bar{B}_1) + V(\bar{B}_2)$$

Adequacy of the scale satisfied two conditions namely, additivity of gene effects and independence of heritable components from non-heritable ones.

(ii) Generation mean analysis

Three parameter model as suggested by Jinks and Jones (1958) was applied in the absence of non-allelic interactio

$$m = \tfrac{1}{2}\bar{P}_1 + \tfrac{1}{2}\bar{P}_2 + 4\bar{F}_2 - 2\bar{B}_1 - 2\bar{B}_2$$

$$V(m) = \tfrac{1}{4}V(\bar{P}_1) + \tfrac{1}{4}V(\bar{P}_2) + 16\,V(\bar{F}_2) + 4\,V(\bar{B}_1) + 4\,V(\bar{B}_2)$$

$$d = \tfrac{1}{2}\bar{P}_1 - \tfrac{1}{2}\bar{P}_2$$

$$V(d) = \tfrac{1}{4}V(\bar{P}_1) + \tfrac{1}{4}V(\bar{P}_2)$$

$$h = 6\bar{B}_1 + 6\bar{B}_2 - 8\bar{F}_2 - \bar{F}_1 - 3/2\,\bar{P}_1 - 3/2\,\bar{P}_2$$

$$V(h) = 36\,V(\bar{B}_1) + 36\,V(\bar{B}_2) + 64\,V(\bar{F}_2) + V(\bar{F}_1) - 9/4\,V(\bar{P}_1) + 9/4\,V(\bar{P}_2)$$

In the presence of non-allelic interaction, six - parameter model was used (Hayman, 1958).

$$m = \bar{F}_2$$

$$V(m) = V(\bar{F}_2)$$

$$d = \bar{B}_1 - \bar{B}_2$$

$$V(d) = V\bar{B}_1 + V\bar{B}_2$$

$$h = \bar{F}_1 - 4\bar{F}_2 - \tfrac{1}{2}\bar{P}_1 - \tfrac{1}{2}\bar{P}_2 + 2\bar{B}_1 + 2\bar{B}_2$$

$$V(h) = V(\bar{F}_1) + 16\,V(\bar{F}_2) + \tfrac{1}{4}V(\bar{P}_1) + \tfrac{1}{4}V(\bar{P}_2) + 4\,V(\bar{B}_1) + 4\,V(\bar{B}_2)$$

$$i = 2\bar{B}_1 + 2\bar{B}_2 - 4\bar{F}_2$$

$$V(i) = 4\,V(\bar{B}_1) + 4\,V(\bar{B}_2) + 16\,V(\bar{F}_2)$$

$$j = \bar{B}_1 - \tfrac{1}{2}\bar{P}_1 - \bar{B}_2 + \tfrac{1}{2}\bar{P}_2$$

$$V(j) = V(\bar{B}_1) + \tfrac{1}{4}V(\bar{P}_1) + V\,\bar{B}_2 + \tfrac{1}{4}V(\bar{P}_2)$$

$$l = \bar{P}_1 + \bar{P}_2 + 2\,\bar{F}_1 - 4\,\bar{F}_2 - 4\,\bar{B}_1 - 4\,\bar{B}_2$$

$$V(l) = V(\bar{P}_1) + V(\bar{P}_2) + 4\,V(\bar{F}_1) + 16\,V(\bar{F}_2) + 16\,V(\bar{B}_1) + 16\,V(\bar{B}_2)$$

where , m = mean

d = additive effect

h = dominance effect

i = additive x additive interaction

j = additive x dominance interaction

l = dominance x dominance interaction

The above genetic parameters were tested for significance using 't' test.

(iii) Degree of dominance

The following equations were solved to calculate the proportion between dominance and additive variance.

$$V(F_2) = \tfrac{1}{2} D + \tfrac{1}{4} H + E$$

$$V(B_1) + V(B_2) = \tfrac{1}{2} D + \tfrac{1}{2} H + E$$

$$\text{Degree of dominance} = \sqrt{\frac{H}{D}}$$

(iv) Effective factors

Using the following formulae the number of effective factors were calculated.

$$K_1 = \frac{\left[(\bar{F}_1 - \bar{F}_2)/2\right]^2}{D}$$

$$K_2 \pm \frac{\left[(\bar{F}_1 - (P_1 + P_2)/2\right]^2}{H}$$

D. Crossability studies among the three species of *Momordica* - *charantia*, *dioica* and *cymbalaria*.

1. Experimental materials

Three related species of *Momordica* - *charantia*, *dioica* and *cymbalaria* (Syn: *Momordica tuberosa*, *Luffa tuberosa*) - were used for crossability studies.

(a) *Momordica charantia* L.

Seeds of diverse types of bitter gourd were collected from various parts of Kerala during 1981-'84 and maintained in the research plots of the Department of Olericulture. This included types with small, large, spiny, smooth, ribbed, green and white fruits.

(b) *Momordica dioica* Roxb. (Plate Nos. 11 and 12)

Momordica dioica is cultivated in some parts of South India, Bihar, Assam, Orissa and West Bengal. It is also seen often growing wild.

Plate-11. Momordica dioica

Plant with fruit and female flower

Plate-12. Momordica dioica

Fruits

PLATE-11

PLATE-12

Plate-13. <u>Momordica cymbalaria</u>
Shoot with male and female flowers

Plate-14. <u>Momordica cymbalaria</u>
Fruits

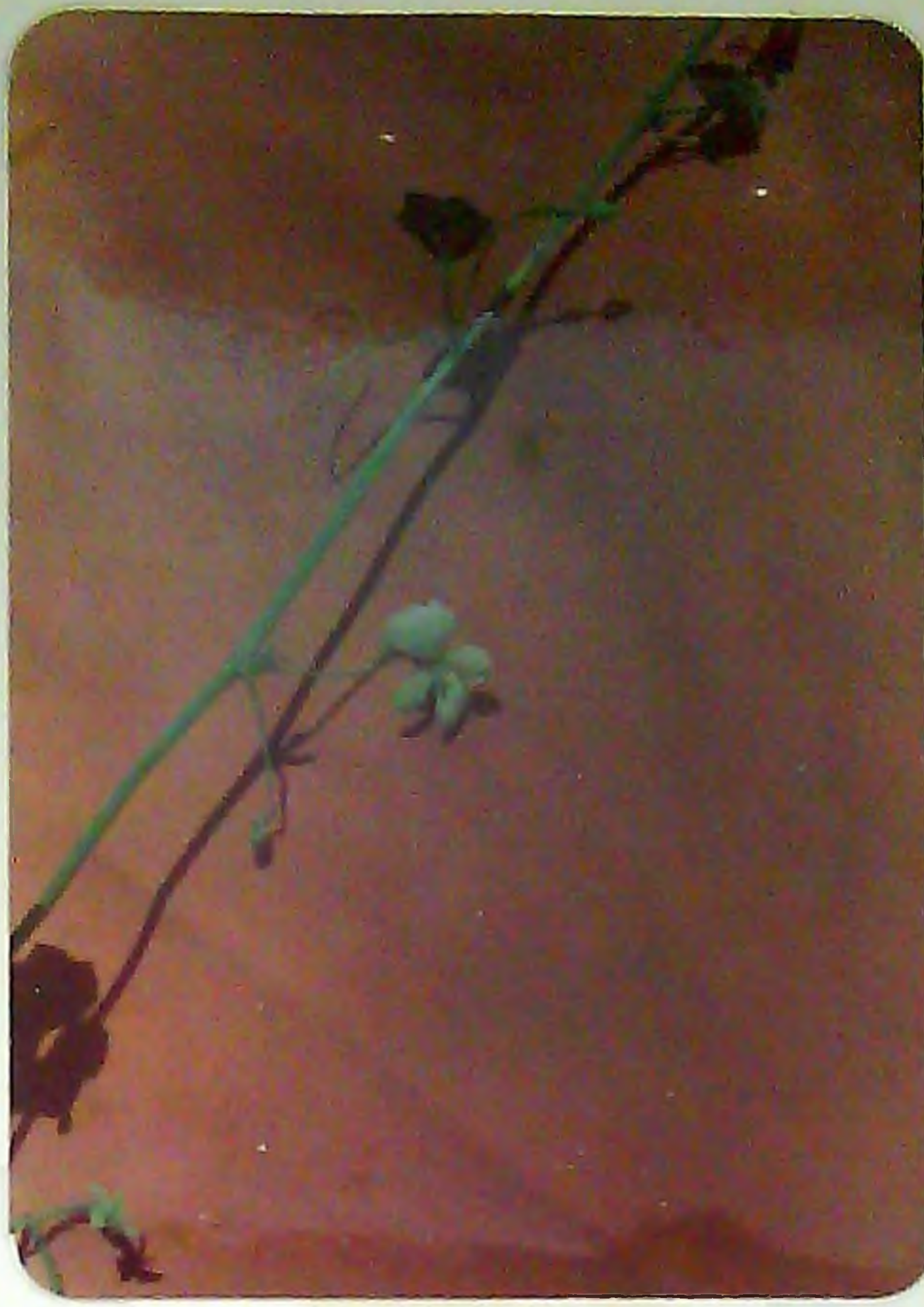


PLATE-13

PLATE-14

Momordica dioica is a perennial dioecious climber with tuberous roots. Fruits are ovoid or ellipsoid, 2.5-6.3 cm long, shortly beaked, densely echinate with soft spines; seeds slightly compressed, 6.00-7.00 mm long and irregularly corrugated. The fruits are bitterless and contain high contents of nutrients - like protein : 3.1 g; fat: 1 g; calcium: 33 mg; iron: 4.6 mg and carotene : 1620 μg per 100 g of edible portion . This is approximately 2.5, 1.5, 3 and 10 times respectively higher than their corresponding values in large fruited *Momordica charantia* (Sheshadri, 1986). It is used as a vegetable.

Rhizomatous tubers which often weigh 500 g were collected from the Parnimalai area of the Anna district in Tamil Nadu during December 1983. The tubers had a dormancy of six months and hence stored for six months beneath soil.

(c) *Momordica cymbalaria* Hook (Syn. *Momordica tuberosa* (Rosb) Cogn; *Luffa tuberosa* Roxb (Plates Nos.13 and 14)

Momordica cymbalaria are seen growing wild in some parts of Tamil Nadu.

It is a perennial monoecious trailing plant with turnip shaped roots. Fruits are pyriform or fusiform, ribbed, 1.8 to 4 cm long; seeds small, 2-4 mm long and smooth.

The fruits are bitterless and are often used as vegetable or sundried chips or after pickling.

Tubers were collected from the Lake area near Viruthunagar of the Kamarajar district in Tamil Nadu in December 1983 and stored for six months beneath soil.

All the three species were grown in the vegetable Research Plots of the Department of Olericulture during June-November in 1984 and 1985.

2. Observations

(a) Anthesis

Observations were made on time of anthesis in all the three species.

(b) Ovary growth

Two hundred crosses each were made in all directions including reciprocally among the three species. Selfings were also done simultaneously in all the three species. Observations were recorded on changes in ovary of both the selfed and crossed flowers every day morning for a week.

Crossability index was worked out as per Marks (1965) as applied to various species of *Solanum*, as under:

$$\text{Crossability Index} = \frac{\text{Crossing efficiency of the cross}}{\text{Selfing efficiency of the female parent}} \times 100$$

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

Where, A = percentage of fruit set

B = average seeds/fruit

C = percentage germination of seeds

D = percentage survival of the germinated seedlings

A^{c} B^{c} C^{c} D^{c} Stands for values in crosses

and A^{s} B^{s} C^{s} D^{s} for values when the mother parent is selfed.

Results

RESULTS

A. Genetic variability and divergence in bitter gourd

1. Variability, heritability and genetic advance

General analysis of variance showed significant differences among the 50 genotypes for all the 18 characters observed (Table 6). Their mean values are given in Appendix-1.

The mean, range, coefficient of variation at genotypic and phenotypic levels, heritability, genetic advance and genetic advance as percent of the mean for all the 18 characters are given in Table 7.

a. Main branches/plant

Branches/plant ranged widely from 20.00 to 43.63 with a general mean of 32.05. MC-79 (Plate 6) a genotype which is wild in nature and perennial in habit and with very small fruits had the maximum branches (43.63). MC-82, a medicinal bitter gourd with very small and highly bitter fruits had the lowest branches/plant (20.0). The phenotypic differences in branches/plant were mainly genetical (pcv, 12.96; gcv, 12.31) as indicated by high estimate of heritability (0.90). The genetic advance as percent of mean was low (24.08) for branches/plant.

Table 6. General analysis of variance for 18 characters in bitter gourd

Sources of variation	df	Mean squares: Main branches/ plant	Main vine length	Node to first female	Days first female flower opening	Female flowers/ plant	Percentage of female flowers	Days to picking maturity	Yield/ plant	Fruits/ plant
Replications	1	0.04	0.21	0.678	0.25	43.50**	0.04	0.04	.47	0.46
Genotypes	49	32.83**	2.31**	5.78**	22.92**	700.91**	3.12**	2.54**	14.57**	600.02**
Error	49	1.69	0.06	0.86	0.61	4.85	0.03	0.18	0.04	2.60

* p = 0.05
** p = 0.01

Contd.

Table 6. Continued

Sources of variation	df	Fruit weight	Fruit length	Fruit girth	Flesh thicknes
Replications	1	14.75**	.04	0.47	0.08
Genotypes	49	9195.98**	148.17**	17.74**	1.89**
Error	49	8.69	0.35	0.05	0.13

Mean square				
Seeds/ fruit	100 seed weight	T.S.S.	Vitamin C content	Protein content
.21	.69	.06	1.84	.56
23.72**	15.82**	0.39**	452.57**	8.04**
1.16	0.39	0.02	3.09	0.44

b. Main vine length

Significant variation among the genotypes was observed for main vine length. It ranged from 1.98 to 7.79 m with a mean of 4.89 m. Here also MC-79 and MC-82 ranked first and last respectively. Heritable variation was much higher than non-heritable variation (pcv, 22.32; gcv, 21.69) and it resulted in a high estimate of heritability (0.94). The genetic advance as per cent of mean was moderate for this character (43.39).

c. Node to first female flower

The node to first female flower ranged from 18.13 to 25.13 with a general mean of 22.28. This character had a comparatively lower estimate of heritability (0.74) and genetic advance as per cent of mean (12.45).

d. days to first female flower opening

The genotypes showed significant variation for days taken for the opening of the first female flower. The genotype MC-34 took the minimum days to opening of the first female flower (33.5) (Plate 10). The differences in the days to opening of the first female flower were

Table 7. Range, mean, pcv, gcv, heritability, percentage of mean for 18 characters

Characters	Range	Mean±sem
1. Primary branches/plant	20.0-43.63	32.05±0.91
2. Main vine length (m)	1.97-7.79	4.89±0.18
3. Node to first female flower	18.13-25.25	22.28±0.05
4. Days to first female flower opening	35.88-47.25	40.92±0.55
5. Female flowers/plant	31.88-120.0	68.73±1.56
6. Percentage of female flowers	2.13-6.75	4.39±0.11
7. Days to picking maturity	10.63-16.12	13.76±0.29
8. Yield/plant(kg)	2.32-12.76	6.78±0.15
9. Fruits/plant	17.25-113.25	54.56±1.14
10. Fruit weight(g)	25.25-311.0	139.09±2.08
11. Fruit length(cm)	6.55-40.52	29.15±0.42
12. Fruit girth (cm)	6.44-24.35	14.41±0.15
13. Flesh thickness(mm)	3.3 -9.4	5.23±0.25
14. Seeds/fruit	12.00-27.75	20.24±0.76
15. 100 seed weight(g)	6.60-23.1	21.48±0.44
16. Total soluble solids (TSS)(%)	2.00-3.57	2.77±0.09
17. Vitamin C content (mg/100 g)	45.5 -122.38	71.25±1.24
18. Protein content(%)	11.37-20.15	14.67±0.46

genetic advance and genetic advance as
in bitter gourd

gcv	pcv	Heritability	Genetic advance	Genetic advance (%)
12.31	12.96	0.90	7.72	24.08
21.69	22.32	0.94	2.12	43.39
7.03	8.18	0.74	2.78	12.45
8.16	8.38	0.95	6.69	16.37
27.14	27.33	0.98	38.16	55.51
28.32	28.56	0.98	2.54	57.87
7.90	8.47	0.87	2.09	15.17
39.77	39.91	0.99	5.53	81.62
31.68	31.82	0.99	35.46	64.95
48.72	48.77	0.99	139.47	100.27
29.48	29.56	0.99	17.66	60.58
20.64	20.70	0.99	6.11	42.43
17.93	19.25	0.86	1.80	34.41
16.59	17.43	0.91	6.58	32.53
12.92	13.25	0.95	5.58	25.99
15.55	16.25	0.92	0.89	30.69
21.04	21.18	0.98	30.66	43.02
13.29	14.04	0.89	3.81	25.94

mainly genetical (pcv, 8.38; gcv, 8.16). Even though the heritability (0.95) was high, genetic advance as per cent of mean was low for this character.

e. Female flowers/plant

Female flowers/plant had a very wide range. This varied from 31.88 in Arka Harit to 120.0 in MC-79. The variation for female flowers/plant was mainly genetical (pcv, 27.33; gcv, 27.14) resulting in a high estimate of heritability (0.98). The genetic advance as per cent of mean was also high (55.51) for this character.

f. Percentage of female flowers

The general mean of the percentage of female flowers in bitter gourd genotypes studied was 4.39 with a range of 2.66 to 6.72. This character was found genetically controlled as evidenced by high estimate of heritability (0.98) with a high value of genetic advance as per cent of mean (57.87).

g. Days to picking maturity

The average days to picking maturity from female flower opening was 13.76. The genotype, MC-34 was the earliest requiring an average of only 10.63 days for maturity. Though this character had a moderate value for heritability (0.87) the genetic advance as per cent of mean was only 15.17.

h. Yield/plant

There were significant differences among the genotypes for yield/plant. The popular variety, Priya (Plate 1) recorded the highest yield/plant (12.76 kg) which was on par with the genotypes MC-84 (12.48 kg), MC-78 (12.25 kg) and MC-66 (12.17 kg). The difference in yield was mainly genetical (pcv, 39.91; gcv, 39.77) as indicated by high heritability (0.99) with a high genetic advance as per cent of mean (81.62).

i. Fruit/plant

Fruits/plant ranged widely from 17.25 in Arka Harit to 113.25 in MC-79, the wild type. Major part of variation in fruits/plant was genetic (pcv, 31.82); gcv, 31.68) as indicated by high heritability (0.99) and genetic advance as per cent of mean (64.95).

j. Fruit weight

Significant variation was observed in fruit weight also. It ranged from 25.25 g in MC-82, the medicinal bitter gourd to 311.00 g in MC-84 (Plate 3) a high yielding type. The differences in fruit weight was also highly genetical (pcv, 48.7; gcv, 48.72) as indicated by high heritability (0.99). The fruit weight had the highest value of genetic advance as per cent of mean (100.27) promising scope for selection for improvement.

k. Fruit length

Fruit length also had a very wide range with 6.55 cm in MC-82 to 40.52 cm in MC-78 (Plate 2). The phenotypic (29.55) and genotypic (29.48) coefficients of variation showed that a major part of the variation was due to genetic effect. The heritability (0.99) and genetic advance (60.58) were high for this character.

l. Fruit girth

The fruit girth averaged 14.41 cm with 6.44 cm in MC-79 to 24.35 cm in MC-84. The high estimate of heritability (0.99) showed that this character also was controlled by genetic factors. The genetic advance as per cent of mean was moderately high (42.47) for this character.

m. Flesh thickness

Flesh thickness ranged from 3.3 mm to 9.4 mm. Arka Harit (Plate 4) was the fleshy type with a thickness of 9.4 mm. The flesh was thinnest in the wild type, MC-79 (3.3 mm). The heritability (0.86) and genetic advance as per cent of mean (34.41) were moderately high for this character.

n. Seeds/fruit

The seeds/fruit averaged 20.24 with a range of 12.00 in MC-82 to 27.75 in MC-49 (Plate 8). Genotypic variation contributed mostly to seeds/plant. The heritability was high (0.91) and the genetic advance as per cent of mean was moderate for this character.

o. 100 seed weight

100 seed weight ranged widely from 6.57 g in MC-79 to 27.1 g in MC-66 (Plate 7) with an average of 21.48 g. Though the estimate of heritability was high 0.95, the genetic advance as per cent of mean was low (25.99).

p. Total soluble solids

The total soluble solids varied from 2.05 to 3.57 with an average of 2.77. It was the highest in Arka Harit and the lowest in MC-90. The variation in T.S.S. is mainly genetical (pcv, 16.25; gcv, 15.55) as indicated by high heritability (0.85). The genetic advance as per cent of mean was moderate (30.69).

q. Vitamin C content

Vitamin C content varied from 45.5 to 122.38 mg/ 100 g. MC-82 (Plate 5) the medicinal bitter gourd had maximum vitamin C content. This also is controlled by genetic factor as evidenced by high estimate of heritab- ility (0.98).

r. Protein content

Protein content on dry weight basis averaged to 14.67% with a range of 11.37% to 20.15%. Here also MC-82 recorded the highest value. Variation in protein content was also genetical as evidenced by high heritability estimate (0.89). The genetic advance as per cent of mean was low for protein content.

2. Genetic divergence among 50 genetypes of bitter grourd

Following Tochers method, 50 bitter gourd genotypes were grouped into five clusters. The clustering pattern in bitter gourd is given in Table 8,

The Cluster III was the biggest with 23 genotypes, followed by Cluster II with 14 genotypes and Cluster I with nine genotypes. Cluster V had only one genotype MC-79, the wild perennial type bitter gourd. There were three genotypes in Cluster IV.

Arka Harit was in the Cluster II along with MC-80 and MC-82, the medicinal bitter gourd.

Cluster III contained high yielders like Priya, MC-66, MC-78 and MC-84.

Cluster I had genotypes with small to medium fruits which were not economically superior.

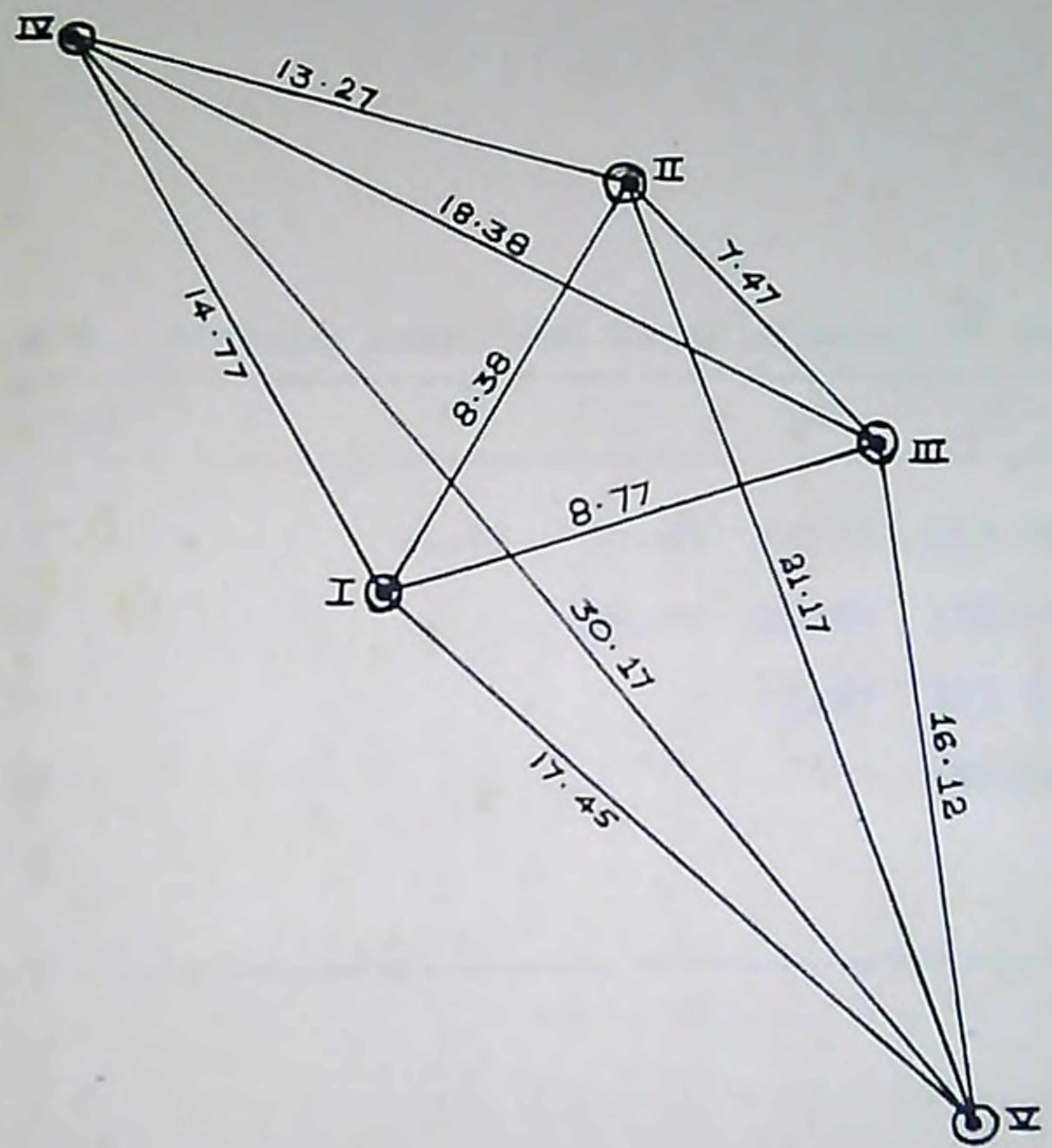
The intra and intercluster genetic distances are presented in Table 9.

The intraculture distance was high in Cluster IV (72.00) followed by Cluster I (31.51). In inter cluster distance was maximum between Cluster IV and V (910.31)

Table 8. Clustering pattern in bitter gourd

Cluster Number	Number of genotypes in each cluster	Genotypes
I	9	MC-83, MC-85, MC-86, MC-87, MC-89, MC-90, MC-91, MC-94 and MC-95.
II	14	MC-4, MC-10, MC-42, MC-48, MC-51, MC-52, MC-57, MC-60, MC-63, MC-67, MC-68, MC-72, MC-73 and MC-88.
III	23	MC-15, Priya, MC-34, MC-49, MC-50, MC-53, MC-54, MC-61, MC-62, MC-64, MC-65, MC-66, MC-69, MC-70, MC-71, MC-74, MC-75, MC-76, MC-77, MC-78, MC-84, MC-92 and MC-93.
IV	3	Arka Harit, MC-80 and MC-82
V	1	MC-79

Fig. 1 DIAGRAMATIC REPRESENTATION OF CLUSTERI[NG]
OF FIFTY GENOTYPES OF BITTERGOURD



* See table 4 for details

Table 9. Average intra and inter cluster D^2 values

Clusters	I	II	III	IV	V
I	31.51	70.22	76.94	218.39	304.74
II		24.70	55.88	176.02	448.51
III			18.39	337.93	259.86
IV				72.00	910.31
V					0.00

followed by II and V (448.51) and III and IV (337.93). The minimum genetic distance was between Cluster II and III (55.88).

With the help of average inter cluster distance values (D) the cluster diagram showing the inter cluster relationship was prepared (Fig.1).

B. Development of F_1 hybrids and their homeostatic analysis

1. Stability analysis

a. Pooled analysis of variance

Pooled analysis of variance was done for all the characters over three environments. Significant genotype x environment interaction was observed for all the characters studied. The genotypes were significantly different in all the three environments. Environments were significantly different among one another.

b. Pooled analysis of variance for stability

The analysis of variance of pooled data for stability as per Eberhart and Russell (1966) is furnished in Table 10. The pooled deviation was highly significant (p = 0.01) when compared to the pooled error for all the characters, except

Table 10. Analysis of variance for stability with respect to yield and its components in bitter gourd

Sources of variation	Mean squares					
	Primary branches/ plant	Main vine length	Node to first female flower	Days to first female flower opening	Female flowers/ plant	Percentage of female flowers
Genotypes	70.72**	4.63**	2.61**	14.61**	926.98**	3.12**
Environments (Linear)	1432.13	29.72	67.23	19.25	3714.61	23.21
Env + (Geno x Env)	16.56	0.42	1.15	4.42	89.77	0.44
Geno x Env (Linear)	4.44*	0.18	0.77**	1.58	84.01**	0.26
Pooled deviation	2.71**	0.13**	0.32**	6.94**	29.51**	0.22**
Pooled Error	0.49	0.02	0.30	0.63	3.34	0.02

* p = 0.05
** p = 0.01

Contd.

Table 10. Continued

Sources of variation
Genotypes
Environments (Linear)
Env + (Geno x Env)
Geno x Env (Linear)
Pooled deviation
Pooled Error

Mean square				
Fruits/ plant	Fruit weight	Fruit length	Fruit girth	Yield/ plant
838.67**	12752.78**	264.00**	44.65**	14.34**
11318.53	9001.10	76.06	2.11	157.05
174.56	654.80	6.23	1.75	2.34
92.91**	287.87	6.27	2.10*	1.27**
52.11**	863.29**	4.91**	1.39**	0.59**
1.75	5.62	1.21	0.06	0.22

p = 0.05
p = 0.01

for node to first female flower. The linear component of genotype x environment interaction was highly significant for node to first female flower, female flowers/plant, fruits/plant and yield/plant and significant for primary branches/plant and fruit girth. It was not significant for vine length, days to opening of first female flower, fruit weight and fruit length.

c. Stability parameters

Stability parameters for yield and yield components were estimated as proposed by Eberhart and Russell (1966) and are presented in Tables 11 to 14.

(i) Primary branches/plant

Based on grand mean over all environments, the cross Arka Harit x MC-79 produced the highest branches/plant (43.83). The genotype MC-82, a small fruited bitter gourd had the lowest branches/plant (17.63). Considering regression coefficient approximately equal to unity ($b(i) \longrightarrow 1$) and deviation from regression not significantly different from zero ($S^2d(i) \longrightarrow 0$), the genotypes, Priya, MC-78, MC-49, MC-84, MC-78 x MC-79, MC-78 x MC-66, MC-82 x MC-34, MC-66 x MC-69 and MC-49 x MC-34 were stable. Priya x MC-84, Priya x MC-66 and MC-49 x MC-69 were above average stable genotypes.

Table 11. Stability parameters for branches/plant, vine length and node to first female flower in bitter gourd

Genotypes	Branches/plant			Length of main vine			Node to first female flower		
	Mean	b(i)	$S^2d(i)$	Mean	b(i)	$S^2d(i)$	Mean	b(i)	$S^2d(i)$
1	2	3	4	5	6	7	8	9	10
Priya	32.08	0.97	-0.97	6.18	0.07	-0.02	22.50	1.12	-0.52
MC-78	31.25	0.98	-0.37	6.06	0.34	-0.08	21.91	0.33	-0.43
MC-84	31.63	1.08	-0.85	5.98	1.36	0.03	22.16	-0.62	-0.40
Arka Harit	21.30	0.82	-0.62	2.35	0.54	-0.02	18.83	0.79	-0.57
MC-82	17.63	0.65	-0.37	2.00	0.18	-0.02	19.04	0.49	-0.44
MC-79	40.50	0.83	-0.92	6.98	1.05	-0.03	19.41	-0.52	-0.20
MC-66	33.42	1.13	-0.58	5.30	0.93	0.03	21.58	0.96	-0.56
MC-49	30.25	1.05	1.00	5.12	0.32	-0.01	21.33	0.19	0.65
MC-69	28.56	1.19	-0.35	4.74	0.74	-0.01	21.00	0.87	-0.55
MC-34	28.88	0.69	-0.39	5.14	0.99	-0.00	22.41	0.65	-0.44
Priya x MC-78	30.88	1.22	5.59	6.29	0.28	-0.02	22.12	1.30	0.15
Priya x MC-84	30.91	1.24	-0.83	6.14	0.47	0.04	21.93	0.47	-0.13
Priya x Arka Harit	25.29	1.40	-0.97	3.80	1.53	0.10	19.91	-0.45	-0.05
Priya x MC-82	23.67	1.50	9.83*	3.43	1.85	0.22	20.66	1.90	-0.51
Priya x MC-79	40.04	0.14	8.39*	6.49	0.65	0.29	21.25	0.80	-0.51
Priya x MC-66	34.38	1.31	0.91	5.58	0.10	0.38	21.83	1.58	-0.36

Contd.

Table 11. Continued

1	2	3	4
Priya x MC-49	31.67	0.55	3.43
Priya x MC-69	29.91	0.96	-0.91
Priya x MC-34	28.25	1.63	-0.94
MC-78 x MC-84	30.83	1.36	1.12
MC-78 x Arka Harit	27.63	1.24	0.82
MC-78 x MC-82	23.13	1.66	0.53
MC-78 x MC-79	36.58	1.03	1.18
MC-78 x MC-66	33.42	1.07	-0.97
MC-78 x MC-49	30.96	0.65	-0.64
MC-78 x MC-69	27.63	0.81	2.75*
MC-78 x MC-34	30.00	0.74	-0.63
MC-84 x Arka Harit	26.42	1.14	-0.97
MC-84 x MC-82	24.83	1.73	15.66*
MC-84 x MC-79	37.08	0.36	8.07*
MC-84 x MC-66	33.87	0.71	-0.95
MC-84 x MC-49	32.25	0.16	9.96*
MC-84 x MC-69	28.92	1.26	-0.49
MC-84 x MC-34	29.08	0.59	-0.77
Arka Harit x MC-82	23.08	1.54	0.52

5	6	7	8	9	10
5.89	0.26	0.06	21.25	0.80	-0.51
5.30	1.64	0.13	21.25	1.40	0.36
5.66	0.95	-0.03	21.62	1.35	-0.54
6.01	1.07	0.15	21.91	1.58	-0.51
4.21	2.13*	0.33	20.58	1.09	-0.01
3.61	2.14*	0.20	20.66	1.73	-0.24
6.67	0.75	-0.00	21.08	0.32	-0.55
5.67	0.70	0.13	20.83	2.39	-0.54
5.69	0.76	-0.03	22.00	0.80	-0.51
5.37	0.90	-0.02	20.91	3.18*	-0.47
5.51	0.80	-0.01	21.25	0.48	-0.51
3.84	2.02	0.02	18.53	0.79	-0.57
3.48	2.19*	0.18	20.16	0.65	-0.44
6.68	0.76	0.03	20.41	1.12	-0.58
5.82	0.70	-0.01	20.79	1.81	0.04
5.58	0.95	-0.02	22.16	1.75	-0.59
5.38	0.98	-0.03	21.37	1.03	-0.55
5.52	1.38	-0.02	21.91	1.58	-0.51
2.26	0.71	-0.03	19.08	1.41	0.00

Contd.

Table 11. Continued

1	2	3	4
Arka Harit x MC-79	43.83	0.61	-9.27*
Arka Harit x MC-66	28.58	0.28	4.93
Arka Harit x MC-49	28.67	0.50	0.46
Arka Harit x MC-69	24.50	0.90	-0.93
Arka Harit x MC-34	24.50	1.38	-0.56
MC-82 x MC-79	33.03	0.58	2.50
MC-82 x MC-66	30.29	0.46	1.80
MC-82 x MC-49	26.67	0.64	0.32
MC-82 x MC-69	24.25	1.14	-0.92
MC-82 x MC-34	23.67	1.12	0.53
MC-79 x MC-66	35.92	0.91	-0.81
MC-79 x MC-49	36.17	1.21	3.86
MC-79 x MC-69	31.79	1.90*	9.82*
MC-79 x MC-34	31.00	1.57	0.82
MC-66 x MC-49	33.08	0.51	0.99
MC-66 x MC-69	29.25	0.97	-0.94
MC-66 x MC-34	29.67	1.46	11.59
MC-49 x MC-69	31.21	1.47	-0.79
MC-49 x MC-34	30.92	0.96	-0.91
MC-69 x MC-34	28.33	0.65	-0.64

5	6	7	8	9	10
6.88	0.67	0.04	19.50	-0.91	1.00
3.63	1.38	0.09	20.62	1.79	0.72
3.69	1.14	-0.00	21.12	0.94	-0.47
3.00	0.43	-0.03	19.70	1.42	-0.37
3.33	0.65	0.00	21.70	1.35	-0.59
3.72	2.31	0.36	20.41	0.65	-0.44
3.73	1.69	0.13	19.75	-0.12	0.26
3.91	1.70	0.02	21.16	1.58	-0.51
3.73	0.76	0.14	20.91	2.05	-0.23
3.15	1.67	-0.03	20.41	0.48	-0.58
5.07	0.93	2.47*	21.08	0.96	-0.56
5.99	0.27	0.31	21.45	0.72	-0.59
5.66	0.81	0.04	21.25	0.80	-0.51
5.93	1.82	-0.00	21.58	0.94	-0.39
5.68	0.97	-0.00	21.08	2.19	0.65
4.97	0.67	-0.03	20.33	0.32	-0.55
4.96	0.53	-0.01	21.08	0.81	-0.36
5.07	0.98	-0.03	21.60	2.02	2.00
5.30	1.20	-0.01	21.25	1.87	1.71
4.80	0.92	-0.01	21.95	-0.21	-2.38

MC-79, a wild genotype, MC-78 x MC-49 and MC-84 and MC-66 were below average stable genotypes. The $S^2d(i)$ values were significant for Priya x MC-82, Priya x MC-79, MC-78 x MC 69, MC-84 x MC-82, MC-84 x MC-79, MC-84 x MC-49, Arka Harit x MC-79, MC-79 x MC-69 indicating unstable nature of these genotypes.

(ii) Main vine length

The wild genotype MC-79 had the longest vine (6.98 m) followed by two crosses Arka Harit x MC-79 (6.88 m) and MC-84 x MC-79 (6.68 m). MC-82 had the shortest vine (2.00m). The genotypes, MC-79, MC-66, MC-34, Priya x MC-34, MC-78 x MC-84, MC-78 x MC-69, MC-84 x MC-49, MC-84 x MC-69, MC-66 x MC-49, MC-49x MC-69 and MC-69 x MC-34 were stable. The above average stable genotypes were MC-84, Priya x Arka Harit, MC-84 x MC-34, and MC-49 x MC-34. The below average stable genotypes are MC-78 x MC-79, MC-78 x MC-66, MC-78 x MC-49, MC-78 x MC-34, MC-84 x MC-79, MC-84 x MC-66, Arka Harit x MC-79, MC-79 x MC-69 and MC-66 x MC-69.

(iii) Node to first female flower

Arka Harit x MC-84, Arka Harit, Arka Harit x MC-82 MC-82 and MC-79 ranked first in producing female flowers on the lower nodes (19th node). MC-78 x Arka Harit was the only stable genotype. MC-84 x Arka Harit is above and Priya x MC-82, MC-78 x MC-82, MC-84 x MC-79, MC-84 x MC-66 and Arka Harit x MC-82 are below average stable $S_d^2(i)$ for MC-78 x MC-69 was significant indicating unstable nature of the genotype.

(iv) Days to first female flower opening

Based on grand mean over all environments, MC-82 x MC-49, MC-66 x MC-49, MC-49 x MC-34 and MC-34 were the earliest in first female flower opening (38 days after sowing). Priya x MC-82, Priya x MC-69, and MC-78 x MC-66, were the stable genotypes. Priya x MC-49, Arka Harit x MC-66, and MC-79 x MC-69 are below and Arka Harit x MC-34 and MC-82 are above average stable genotypes.

(v) Female flowers/plant

MC-79, the wild genotype produced maximum female flowers/plant (107.75) and Arka Harit the minimum (27.20). Priya and Priya x MC-82 are the stable genotypes. MC-84 x MC-82, MC-84 x MC-79, MC-78 x MC-82, MC-78 x MC-66, MC-82 x MC-66, MC-66 x MC-49 and MC-49 x MC-34 are above and MC-78 x MC-79, MC-82 x MC-79, MC-82 x MC-49 and MC-82 x MC-69 are below average stable genotypes.

Table 12. Stability parameters for days to fi
and percentage of female flowers

Genotype	Days to first female flower opening		
	Mean	b(i)	$S^2_{d(i)}$
1	2	3	4
Priya	41.66	0.10	0.28
MC-78	43.66	-0.14	5.03
MC-84	44.83	-0.19	8.02
Arka Harit	44.62	-0.44	6.08
MC-82	40.31	0.43	-0.51
MC-79	46.05	-1.63	7.62
MC-66	43.25	1.02	-1.24
MC-49	39.29	6.12*	31.62*
MC-69	43.00	0.70	-0.55
MC-34	38.16	3.03	2.81
Priya x MC-78	43.95	-0.70	8.26
Priya x MC-84	44.08	-1.37	4.62
Priya x Arka Harit	42.83	-0.74	7.21
Priya x MC-82	41.16	0.98	2.20
Priya x MC-79	43.75	-2.55	11.76
Priya x MC-66	42.50	2.13	-1.21

...female flower opening, female flowers/plant

...ale flowers/plant			Percentage of female flowers		
...n	b(i)	$S^2d(i)$	Mean	b(i)	$S^2d(i)$
	6	7	8	9	10
...00	0.85	-5.40	6.05	0.35	-0.02
...79	0.79	-6.60	5.03	0.79	-0.01
...33	0.63	-6.49	4.39	0.22	-0.00
...20	0.87	-4.87	3.15	0.64	-0.02
...75	2.86	26.04	2.66	0.54	-0.02
...75	-0.35	4.12	2.91	-0.24	0.01
...25	1.97	-5.25	6.01	0.77	-0.01
...33	0.94	-1.32	5.90	1.60	0.00
...00	1.30	-5.47	5.67	2.16	0.04
...08	2.04	50.80	4.30	0.44	-0.03
...75	0.57	-6.25	5.43	1.32	-0.03
...08	-0.26	11.40	5.23	0.72	0.79
...04	0.43	-6.49	4.12	0.96	0.26
...37	1.17	-6.62	3.75	1.42	0.06
...00	3.21*	40.34	5.53	0.57	-0.01
...01	0.43	43.98	6.01	0.62	-0.02

Contd.

Table 12. Continued

1	2	3	4
Priya x MC-49	39.58	1.46	0.03
Priya x MC-69	41.16	0.98	2.20
Priya x MC-34	39.33	1.71	-1.23
MC-78 x MC-84	44.25	-3.80	15.05
MC-78 x Arka Harit	43.74	0.48	-0.03
MC-78 x MC-82	41.75	-1.26	0.55
MC-78 x MC-79	43.62	-2.78	24.94*
MC-78 x MC-66	41.00	0.94	-1.06
MC-78 x MC-49	40.54	2.59	1.39
MC-78 x MC-69	41.54	-0.64	1.18
MC-78 x MC-34	39.54	3.07	2.14
MC-84 x Arka Harit	42.08	-0.27	6.01
MC-84 x MC-82	40.29	-0.13	0.56
MC-84 x MC-79	44.25	-0.30	12.58
MC-84 x MC-66	41.58	2.02	-0.15
MC-84 x MC-49	38.87	3.24	7.83
MC-84 x MC-69	43.70	-0.42	-0.55
MC-84 x MC-34	40.83	4.01	13.77
Arka Harit x MC-82	45.45	0.28	1.54
Arka Harit x MC-79	44.37	-1.59	10.45

	6	7	8	9	10
5	0.32	-0.60	6.33	0.57	0.14
5	0.21	0.54	5.80	0.94	-0.02
3	0.67	72.57	5.17	1.27	0.20
3	-0.25	-1.84	4.74	0.97	0.01
7	0.30	42.88	3.83	0.42	0.34
5	1.78	10.46	3.45	-0.01	0.34
1	0.32	96.09	3.90	0.40	-0.00
2	1.61	-6.17	5.68	0.20	0.01
1	1.68	-3.46	5.90	1.15	0.04
3	0.41	-1.41	5.66	1.69	0.06
3	1.71	4.82	4.87	1.31	-0.01
3	-0.12	-6.44	3.56	0.77	-0.03
0	1.29	-5.80	3.31	0.14	0.00
3	1.39	-6.13	3.73	-0.16	0.05
2	0.88	-5.35	5.36	1.20	-0.03
9	0.55	-6.68	5.62	0.47	0.05
0	-0.24	1.86	5.22	1.61	0.67
1	0.19	-6.63	4.42	0.07	-0.03
0	2.29	29.07	2.87	0.76	0.47
5	5.22*	50.88	3.08	0.20	-0.02

Contd.

Table 12. Continued

1	2	3	4
Arka Harit x MC-66	40.12	1.26	1.21
Arka Harit x MC-49	38.75	0.39	-0.93
Arka Harit x MC-69	42.29	-1.35	-0.88
Arka Harit x MC-34	39.83	0.52	-0.68
MC-82 x MC-79	41.37	-1.59	10.45
MC-82 x MC-66	42.45	-0.10	-1.24
MC-82 x MC-49	37.54	3.66	5.98
MC-82 x MC-69	41.91	0.97	-1.04
MC-82 x MC-34	39.58	4.25	25.20*
MC-79 x MC-66	43.87	-0.40	1.72
MC-79 x MC-49	39.16	3.11	1.52
MC-79 x MC-69	41.50	1.89	-0.51
MC-79 x MC-34	38.79	4.73	12.84
MC-66 x MC-49	38.00	4.43	11.36
MC-66 x MC-69	42.33	3.37	2.92
MC-66 x MC-34	39.41	3.27	9.53
MC-49 x MC-69	38.25	3.16	3.61
MC-49 x MC-34	38.04	3.91	38.13*
MC-69 x MC-34	39.12	2.77	6.58

6	7	8	9	10
0.77	88.64	5.10	1.41	0.58
-0.56	3.27	5.38	1.32	0.39
-0.63	7.46	4.39	3.11*	-0.02
1.20	12.57	3.57	-0.01	0.24
0.54	23.60	2.97	-0.28	0.01
1.25	140.10*	4.25	2.07	-0.02
0.62	-2.35	4.37	2.23	1.42
0.67	-5.17	3.92	1.78	2.00
2.73	1.62	3.65	1.50	0.15
0.27	63.47	3.78	-0.43	0.26
-0.63	384.37*	4.40	1.50	0.06
2.30	99.31	4.04	1.40	0.71
3.71*	-4.33	3.69	0.93	-0.00
1.22	-1.26	5.99	1.20	0.14
0.53	-5.98	5.50	1.99	0.31
0.62	-2.60	4.94	2.08	0.09
-0.00	-5.24	5.55	2.35	-0.03
1.50	15.43	5.82	2.26	0.30
1.02	62.13	4.94	1.48	0.11

(vi) Percentage of female flowers/plant

The highest percentage (6.33) was observed in Priya x MC-49, followed closely by Priya x MC-66 (6.01) and Priya (6.05). It was lowest in MC-82. Priya x MC-69, MC-78 x MC-84, MC-78 x MC-49 are the stable genotypes. MC-49, Priya x MC-78, Priya x MC-34, MC-78 x MC-69, MC-78 x MC-34, MC-84 x MC-66, MC-84 x MC-69, Arka Harit x MC-66, Arka Harit x MC-49, MC-66 x MC-49 and MC-69 x MC-34 are above average stable genotypes. MC-78, MC-66, Priya x MC-84, Priya x MC-79, Priya x MC-66 and Priya x MC-49 are below average stable.

(vii) Fruits/plant

MC-79, the wild genotype recorded the highest number of fruits/plant (103.08) followed by MC-82 x MC-79 (91.08) MC-82 (77.33) and Arka Harit x MC-79 (77.33). Priya x MC-66, MC-78 x MC-79 and MC-49 x MC-34 were stable genotypes. Priya x MC-82, MC-78 x MC-82, MC-78 x MC-66, MC-84 x MC-82, MC-84 x MC-79, MC-82 x MC-66, MC-82 x MC-49, MC-82 x MC-34, MC-79 x MC-66, MC-79 x MC-49 and MC-66 x MC-49 were above average stable genotypes. Below average stable genotypes are MC-79, MC-66, MC-69, MC-82 x MC-69 and MC-66 x MC-34. The $S^2d(i)$ values in MC-82, Arka Harit x

Table 13. Stability parameters for fruits/plant, fruit weight and fruit length in bitter gourd

Genotypes	Fruits/plant			Fruit weight			Fruit length		
	Mean	b(i)	$S^2d(i)$	Mean (g)	b(i)	$S^2d(i)$	Mean (cm)	b(i)	$S^2d(i)$
1	2	3	4	5	6	7	8	9	10
Priya	46.08	0.49	4.07	223.08	0.74	42.66	36.76	-2.21	-2.37
MC-78	41.12	0.23	28.83	219.66	0.55	135.29	35.83	-1.11	-2.28
MC-84	35.08	0.06	2.17	267.00	0.76	2494.32	29.85	-0.43	-2.12
Arka Harit	16.91	0.14	-3.31	201.25	0.35	-7.86	28.71	1.38	-0.54
MC-82	77.33	1.29	250.14*	30.41	0.19	120.39	6.60	-0.18	-2.36
MC-79	103.08	0.76	-2.09	30.25	0.17	-10.67	7.65	0.30	-2.14
MC-66	54.83	0.78	75.25	201.41	0.45	-5.87	29.48	0.32	-1.97
MC-49	41.37	0.43	-1.30	208.50	0.67	37.97	24.31	0.64	-2.19
MC-69	43.37	0.66	23.60	207.33	1.35	18.75	33.71	0.54	-2.21
MC-34	50.33	1.15	128.50	147.70	1.22	4777.51*	25.91	0.52	-2.37
Priya x MC-78	45.66	0.60	15.88	223.58	0.72	-5.48	37.06	-3.14	-2.28
Priya x MC-84	40.50	0.53	0.86	246.08	0.39*	286.07	31.96	0.27	-0.54
Priya x Arka Harit	29.91	0.39	0.44	191.41	-0.13	1453.07	31.10	0.37	1.80
Priya x MC-82	57.00	1.62	-1.30	107.41	-0.28	280.02	11.76	2.48	-0.59
Priya x MC-79	73.83	2.41*	3.83	99.66	0.35	91.18	13.47	2.95	8.06

Contd.

Table 13. Continued

1	2	3	4
Priya x MC-66	52.58	1.04	3.39
Priya x MC-49	49.00	1.05	9.42
Priya x MC-69	43.16	0.72	-2.27
Priya x MC-34	45.08	1.00	28.46
MC-78 x MC-84	38.16	0.39	-2.96
MC-78 x Arka Harit	25.83	0.21	-3.45
MC-78 x MC-82	59.25	1.55	-2.42
MC-78 x MC-79	75.58	1.05	174.90
MC-78 x MC-66	55.25	1.47	36.08
MC-78 x MC-49	48.75	1.37	0.03
MC-78 x MC-69	42.79	0.75	1.31
MC-78 x MC-34	46.75	1.39	39.53
MC-84 x Arka Harit	27.08	-0.01	31.75
MC-84 x MC-82	54.33	1.24	115.19
MC-84 x MC-79	67.16	1.21	45.24
MC-84 x MC-66	46.91	1.20	50.18
MC-84 x MC-49	42.16	0.80	10.00
MC-84 x MC-69	38.50	0.56	-1.93
MC-84 x MC-34	41.75	0.86	0.23
Arka Harit x MC-82	42.16	1.15	-2.83
Arka Harit x MC-79	77.33	3.77*	510.34*

6	7	8	9	10
0.67	34.43	32.33	0.83	0.37
0.55	164.07	29.91	2.57	-1.38
1.10	-4.05	36.01	-1.20	-2.31
3.70	1924.53	28.07	0.33	-0.98
2.06	14.59	32.76	0.96	-0.72
-0.42	455.60	31.14	0.60	7.16
0.91	75.45	12.02	1.56	-2.40
1.96	428.75	14.24	2.50	1.50
0.55	-10.89	32.35	1.50	5.93
0.77	-4.39	28.35	-0.39	3.86
1.11	75.42	36.56	0.26	-0.95
3.74*	3568.33*	28.06	0.52	1.49
1.66	6115.73*	29.74	-0.18	-1.72
2.27	-11.19	14.97	3.32	5.54
3.25	28.08	15.05	4.06	23.87*
1.21	1448.55	30.08	0.53	-1.23
3.00	5.10	29.05	-1.95	1.05
1.38	465.95	32.30	1.93	-1.39
0.68	1078.44	27.64	0.29	-0.99
-0.13	97.67	11.06	2.26	2.29
-0.84	772.26	12.58	3.05	11.41

Table 13. Continued

1	2	3	4
Arka Harit x MC-66	35.00	1.24	69.44
Arka Harit x MC-49	27.58	0.45	-1.89
Arka Harit x MC-69	32.83	-0.36	47.95
Arka Harit x MC-38	35.08	0.68	170.89
MC-82 x MC-79	91.08	1.03	265.64*
MC-82 x MC-66	65.75	1.37	27.03
MC-82 x MC-49	52.50	1.23	1.19
MC-82 x MC-69	58.91	0.73	-2.29
MC-82 x MC-34	62.66	1.73	4.01
MC-79 x MC-66	76.16	1.65	7.76
MC-79 x MC-49	72.75	1.31	327.04*
MC-79 x MC-69	66.66	1.83	0.23
MC-79 x MC-34	67.50	2.49*	64.94
MC-66 x MC-49	59.41	1.26	37.79
MC-66 x MC-69	49.08	0.66	-0.91
MC-66 x MC-34	52.16	0.75	16.30
MC-49 x MC-69	50.33	0.57	73.00
MC-49 x MC-34	59.16	1.08	2.31
MC-69 x MC-74	47.08	0.77	-3.48

6	7	8	9	10
-0.52	2221.68	29.45	1.26	0.73
0.84	21.20	27.66	-0.35	-1.52
-0.47	7712.38*	31.05	2.13	-2.31
2.58	946.41	27.55	1.29	-2.00
0.26	79.55	8.55	-1.23	-2.14
2.40	131.67	10.07	-0.91	8.57
2.14	54.32	10.60	-0.28	10.76
3.82*	62.13	10.30	-0.59	-0.63
3.29	94.76	10.04	-1.46	-1.45
1.43	165.30	13.46	3.53	27.02*
-0.11	242.01	14.77	4.14	17.58*
1.17	76.56	15.10	5.05	29.86*
1.16	614.56	13.75	3.81	17.74*
0.38	1832.16	25.26	6.00*	-0.46
0.02	554.67	28.84	8.31*	0.97
-0.62	1358.50	27.61	0.50	-0.82
-0.28	2341.10	31.63	1.98	2.97
-3.06	-5.27	26.10	-0.39	-1.46
0.47	1894.19	29.99	1.10	-2.04

MC-79 and MC-79 x MC-49 were found significant indicating their unstable nature.

(viii) Fruit weight

MC-84 had the highest fruit weight (267.00 g) followed by Priya x MC-84 (246.08 g), Priya x MC-78 (223.58 g) and Priya (223.08 g). MC-82 had the lowest fruit weight (30.25 g). Priya x MC-69 and MC-78 x MC-69 were the only two stable genotypes. MC-69, MC-84 x Arka Harit, MC-84 x MC-66 and MC-84 x MC-69 were above average stable genotypes. Priya, MC-78, MC-84, MC-49, Priya x MC-78, Priya x MC-66, MC-78 x MC-49, MC-84 x MC-34 and Arka Harit x MC-49 were below average stable.

(ix) Fruit length

The longest fruit (37.06 cm) was observed in Priya x MC-78 followed by Priya (36.76 cm) and Priya x MC-34 (36.01 cm). MC-82 had the shortest fruits (6.6 cm). MC-78 x MC-84 and MC-69 x MC-34 were the stable genotypes. Arka Harit, MC-78 x MC-66, MC-84 x MC-69, Arka Harit x MC-66, Arka Harit x MC-34 and MC-49 x MC-69 were above average stable. Priya, MC-78, MC-84, MC-69, MC-34, Priya x MC-78 (Plate 15). Priya x MC-84, Priya x Arka Harit, Plate-15. Priya x MC 66, stable F_1 hybrid for fruit length in low environment

Plate-16. MC 78 x MC 84, stable F_1 hybrid for fruit girth in high environment

PLATE-15

Table 14. Stability parameters for fruit girth and yield/plant in bitter gourd

Genotypes	Fruit girth			Yield/plant		
	Mean	d(i)	$S^2_d(i)$	Mean	d(i)	$S^2_d(i)$
1	2	3	4	5	6	7
Priya	16.50	0.88	0.25	9.64	0.34	0.07
MC-78	14.56	-1.09	0.28	8.95	0.44	0.26
MC-84	22.50	3.80	2.22	9.46	0.71	0.09
Arka Harit	22.55	6.05	2.83	3.21	-0.01	0.00
MC-82	8.16	0.83	-0.11	2.30	0.13	0.00
MC-79	6.53	-0.52	-0.11	3.18	0.23	-0.04
MC-66	15.90	0.96	0.09	9.68	0.36	1.25
MC-49	17.81	1.49	0.12	8.25	0.28	0.32
MC-69	16.58	0.41	-0.10	7.95	0.64	0.08
MC-34	15.11	-0.11	-0.08	7.07	0.27	-0.01
Priya x MC-78	15.25	-3.27	1.71	9.64	0.55	0.74
Priya x MC-84	17.63	2.87	0.14	9.00	1.07	0.47
Priya x Arka Harit	17.40	-10.24	0.48	6.13	1.64	0.05
Priya x MC-82	11.91	-8.53	-0.11	5.38	0.56	0.55
Priya x MC-79	10.85	-9.79	2.33	6.09	2.07	0.44
Priya x MC-66	16.46	-2.01	0.16	9.75	0.47	0.86

Contd.

Table 14. Continued

1	2
Priya x MC-49	17.31
Priya x MC-69	16.70
Priya x MC-34	15.92
MC-78 x MC-84	19.73
MC-78 x Arka Harit	19.68
MC-78 x MC-82	11.73
MC-78 x MC-79	10.35
MC-78 x MC-66	15.98
MC-78 x MC-49	17.35
MC-78 x MC-69	16.21
MC-78 x MC-34	14.95
MC-84 x Arka Harit	22.23
MC-84 x MC-82	12.60
MC-84 x MC-79	10.93
MC-84 x MC-66	18.01
MC-84 x MC-49	19.36
MC-84 x MC-69	18.66
MC-84 x MC-34	16.01
Arka Harit x MC-82	11.55
Arka Harit x MC-79	10.61

3	4	5	6	7
-1.38	0.09	9.47	0.23	0.61
0.32	-0.05	8.53	1.13	0.00
-2.00	-0.01	7.84	1.62	0.26
2.31	0.06	9.03	1.13	0.05
9.07	9.62*	5.75	1.19	0.11
3.95	1.75	5.02	1.72	0.01
-7.56	9.92*	5.80	2.90*	0.07
0.76	0.16	10.33	0.46	3.03*
-0.55	0.73	8.98	0.80	-0.04
-2.94	0.06	8.55	0.87	0.02
-4.76	0.04	7.70	1.32	0.04
6.80	4.01*	5.67	1.79	-0.04
-6.62	0.63	4.54	1.84	0.65
-1.50	0.28	5.47	1.96	0.75
13.87	0.68	8.77	0.89	-0.04
7.36	0.00	9.00	1.06	0.99
16.38*	0.46	8.33	1.02	0.26
7.76	0.69	8.03	0.72	0.71
10.48	2.63	2.77	0.37	-0.01
3.82	2.80	5.06	1.82	0.76

Contd.

Table 14. Continued

1	2
Arka Harit x MC-66	16.85
Arka Harit x MC-49	20.11
Arka Harit x MC-69	17.07
Arka Harit x MC-34	15.45
MC-82 x MC-79	8.81
MC-82 x MC-66	10.46
MC-82 x MC-49	10.37
MC-82 x MC-69	10.55
MC-82 x MC-34	10.03
MC-79 x MC-66	9.46
MC-79 x MC-49	10.38
MC-79 x MC-69	10.83
MC-79 x MC-34	9.35
MC-66 x MC-49	16.95
MC-66 x MC-69	16.59
MC-66 x MC-34	15.18
MC-49 x MC-69	17.59
MC-49 x MC-34	16.40
MC-69 x MC-34	15.08

5	6	7
5.01	0.75	0.05
6.28	2.48*	0.78
5.41	0.54	0.20
5.69	0.34	1.34
3.18	-0.09	-0.01
4.76	1.33	1.04
3.95	0.57	0.09
4.23	2.02	2.09
4.11	1.75	2.01
5.70	1.73	-0.02
4.65	0.67	0.77
5.64	1.70	-0.04
4.90	1.52	0.37
9.29	0.33	0.90
8.66	0.86	0.88
7.79	1.05	-0.01
8.15	0.83	0.14
8.79	0.99	1.55
7.12	0.73	1.17

Priya x MC-66, Priya x MC-49, Priya x MC-69, Priya x MC-34, MC-78 x Arka Harit, MC-78 x MC-49, MC-78 x MC-69, MC-78 x MC-34, MC-84 x Arka Harit, MC-84 x MC-66, MC-84 x MC-34 and Arka Harit x MC-49 were below average stable.

(x) Fruit girth

Arka Harit had maximum fruit girth (22.55 cm) closely followed by MC-84 (22.5 cm), MC-84 x Arka Harit (22.23 cm) and MC-79 the minimum (6.53 cm). Priya and MC-66 are the only two stable genotypes. MC-49, MC-84, Arka Harit, Priya x MC-84, MC-78 x MC-84 (Plate 16), Arka Harit x MC-69, Arka Harit x MC-34 and MC-66 x MC-69 were above average stable. The below average stable genotypes are MC-69, MC-34, Priya x MC-78, Priya x Arka Harit, Priya x MC-66, Priya x MC-49, Priya x MC-69, Priya x MC-34 and Arka Harit x MC-66.

(xi) Yield/plant

The highest overall mean yield/plant was recorded by MC-78 x MC-66 (10.33 kg) followed by Priya x MC-66 (9.75 kg), MC-66 (9.68 kg) and Priya (9.64 kg) (Fig. 2). The stable genotypes are Priya x MC-84 (Plate 17), MC-78 x MC-69 (Plate 18), MC-84 x MC-66 (Plate 19), MC-84 x MC-49, Fig 2: PARAMETERS OF STABILITY (bi) PLOTTED AGAINST MEAN YIELD OF INDIVIDUAL VARIETIES

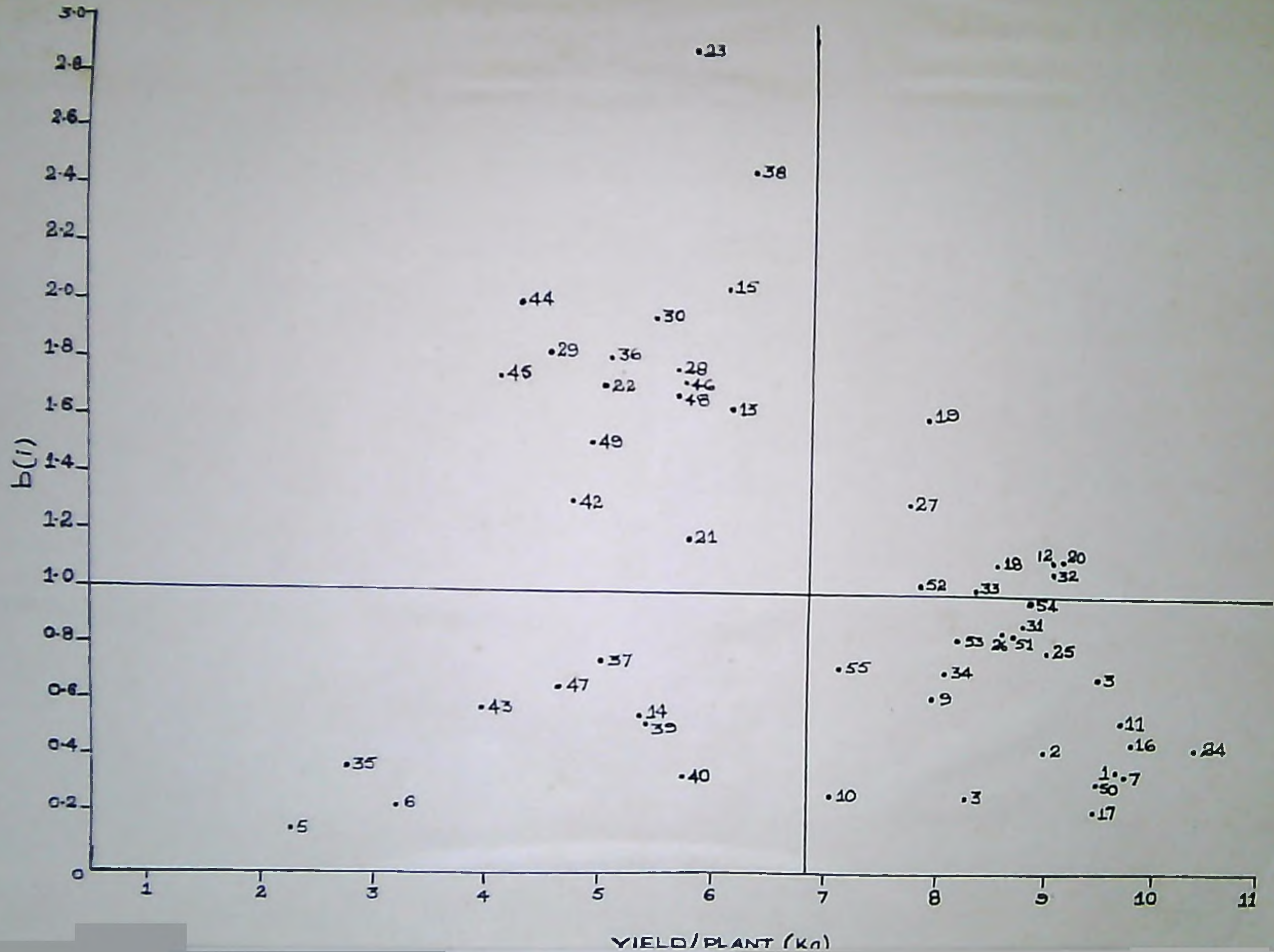


Plate-17. Priya x MC 84, stable F_1 hybrid for yield in medium environment

Plate-18. MC 78 x MC 69, stable F_1 hybrid for yield in medium environment

PLATE-17

Plate-19. MC 84 x MC 66, stable F_1 hybrid for yield in medium environment

Plate-20. MC 66 x MC 34, stable F_1 hybrid for yield in medium environment

PLATE-19

Plate-21. Priya x MC 69, stable F_1 hybrid for yield in high environment

Plate-22. MC 78 x MC 34, stable F_1 hybrid for yield in high environment

PLATE-21

Plate-23. Priya x MC 78, stable F_1 hybrid for yield in low environment

Plate-24. Priya x MC 49, stable F_1 hybrid for yield in low environment

PLATE 23

Plate-25. MC 49 x MC 69, stable F_1 hybrid for yield in low environment

Plate-26. MC 69 x MC 34, stable F_1 hybrid for yield in low environment

PLATE-25

PLATE-26

MC-84 x MC-69, MC-66 x MC-34 (Plate 20) and MC-49 x MC-34. Priya x MC-69 (Plate 21), Priya x MC-34, MC-78 x MC-84 and MC-78 x MC-34 (Plate 22) are above average stable genotypes. Priya, MC-78, MC-84, MC-66, MC-49, MC-69, MC-34, Priya x MC-78 (Plate 23), Priya x MC-66, Priya x MC-49 (Plate 24), MC-78 x MC-49, MC-84 x MC-34, MC-66 x MC-49, MC-49 x MC-69 (Plate 25) and MC-69 x MC-34 (Plate 26) are below average stable genotypes. The $S^2_{d(i)}$ for the genotype MC-78 x MC-66, which yielded the highest mean yield was significant indicating the unstable nature of the genotype.

2. Combining ability analysis

Analysis of variance for combining ability for all the characters were carried out during all the three seasons seperately and the results are presented in Table 16. The analysis of variance for combining ability over three environments was also carried out (Table 17). General combining ability effects were estimated for the three environments separately and presented in Tables 18 and 19. The corresponding sca effects were presented in Tables 20 to 25. The pooled analysis of variance for combining ability shows that the gca variances were highly significant for all the characters. The sca variance were highly

Table 15. General analysis of variance for 55 genotypes of bitter gourd in three environments

Sources of variation	df	Environments	Mean square: Branches per plant	Main vine length	Node to first female flower	Days to first female flower opening	Female flowers/ plant	Percentage of female flowers	Days to picking maturity
		E_1	10.13**	0.06	0.18	1.56	50.78*	0.003	1.11*
Replication	1	E_2	7.39*	0.22	0.03	0.02	70.00**	0.01	0.55
		E_3	11.78**	0.03	0.18	0.66	32.16*	0.001	0.004
		E_1	41.73**	2.97**	2.17**	21.56**	904.44**	2.89**	0.32**
Genotypes	54	E_2	69.82**	4.25**	3.47**	4.65**	588.43**	1.76**	0.38**
		E_3	42.21**	2.76**	1.77**	20.29**	589.97**	2.55**	0.47
		E_1	0.78	0.02	0.55	1.21	9.08	0.02	0.18
Error	54	E_2	1.17	0.09	0.57	1.28	6.39	0.04	0.24
		E_3	0.95	0.07	0.64	1.28	4.56	0.03	0.40

* $p = 0.05$ ** $p = 0.01$

Table 15. Continued

Sources of variation	df	Environments	Yield/ plant	Fruits/ plant
		E_1	0.38**	101.25**
Replication	1	E_2	0.11	20.95**
		E_3	0.03	43.61**
		E_1	9.89**	1006.38**
Genotypes	54	E_2	9.55**	421.13**
		E_3	12.98**	541.84**
		E_1	0.03	4.63
Error	54	E_2	0.09	1.87
		E_3	0.01	4.09

Mean squares					
Fruit weight	Fruit length	Fruit girth	Flesh Thickness	Seeds/ fruit	100 seed weight
96.25**	1.44**	1.49**	0.01	0.07	0.48
4.75	0.16	0.41	0.003	15.47*	0.45
38.00*	0.53	0.03	0.01	0.96	0.05
0071.51**	195.76**	41.75**	1.58**	16.00**	79.24**
8304.02**	202.44**	22.95**	0.93**	16.59**	55.26**
9463.74**	154.83**	31.64**	1.66**	8.28**	53.04**
25.96	0.11	0.03	0.03	0.85	0.46
1.44	0.08	0.28	0.03	2.54	1.301
6.38	0.19	0.03	0.04	0.80	0.69

significant for 13 characters. It was significant for yield/plant and not significant for days to picking maturity. In general the variances due to gca were higher than sca variances. The interaction of gca with environments was highly significant for all the characters except node to first female flower and days to picking maturity. The interaction of sca with location were highly significant for all the characters.

a. Branches/plant

The gca and sca variances were highly significant during all the three seasons. Positive values of gca and sca effects indicated increase and negative values, decrease in branches/plant. MC-84 had the maximum value of gca effect (35.93) during the first season. MC-79 had the highest value during the second (6.92) and third (5.97) seasons. MC-82 had the lowest value of gca effect for all the three seasons. The crosses MC-82 x MC-79 (37.13) and Arka Harit x MC-34 (33.53) had the maximum values of sca effects during the first season. Arka Harit x MC-79 possessed the highest values in the second and third seasons (12.36 and 8.64 respectively).

Table 16. Analysis of variance for combining ability in a 10 x 10 diallel in bitter gourd for three environments

Source of variation	df	Environments	Mean squares						
			Main branches per plant	Main vine length	Node to first female flower	Days to first female flower opening	Female flowers/ plant	Percentage of female flowers	Days to picking maturity
gca	9	E_1	107.93**	8.04**	4.06**	51.44**	2191**	7.54**	1.11**
		E_2	136.67**	10.48**	5.04**	1.79**	1527.52**	4.44**	0.34**
		E_3	105.26**	6.69**	2.89**	47.74**	1608.99**	0.49**	0.46**
sca	45	E_1	4.65**	0.17**	0.49*	2.69**	104.39**	0.23**	0.32**
		E_2	14.56**	0.46**	1.07**	2.43**	47.55**	0.17**	0.16
		E_3	4.28**	0.29**	0.48	2.63**	32.19**	0.23**	0.19
Error	54	E_1	0.39	0.10	0.28	0.61	4.54	0.01	0.09
		E_2	0.59	0.05	0.29	0.64	3.19	0.02	0.12
		E_3	0.47	0.04	0.32	0.64	2.28	0.02	0.30

* $p = 0.05$
** $p = 0.01$

Table 16. Continued

Sources of variation	df	Environ-ments	Mean squares							
			Yield/ plant	Fruits/ plant	Fruit weight	Fruit length	Fruit girth	Flesh thickness	Seeds/ fruit	100 seed weight
		E_1	24.86**	2555.26**	28022.61**	536.68**	110.21**	3.90**	34.3**	212.27**
gca	9	E_2	25.27**	1066.67**	21004.22**	539.44**	63.28**	2.4**	23.94**	194.09**
		E_3	32.61**	1456.08**	25855.61**	425.32**	79.26**	3.89**	15.58**	108.92**
		E_1	0.96**	92.78**	438.39**	9.92**	3.01**	0.17**	2.74**	5.09**
sca	45	E_2	0.67**	39.34**	781.57**	13.58**	1.11	0.08**	5.17**	50.27**
		E_3	1.27**	33.87**	501.12**	7.84**	3.13**	0.22**	1.65**	10.05**
		E_1	0.02	2.32	12.98	0.06	0.01	0.02	0.42	0.23
Error	54	E_2	0.04	0.93	0.72	0.04	0.14	0.01	1.27	45.11
		E_3	0.01	2.05	3.19	0.10	0.01	0.02	0.40	0.34

Table 17. Analysis of variance for combining ability over three environments in a 10 x 10 diallel in bitter gourd

Sources of variation	df	Branches per plant	Vine length	Node to first female vlower	Days to first female flower opening	Female flowers/ plant	Percentage of female flowers	Days to picking maturity
General combining ability (G)	9	345.93**	25.38**	11.0**	62.78**	5150.17**	16.59**	1.34**
Specific combining ability (S)	45	15.50**	0.24**	2.58**	5.02**	81.82**	0.44**	0.167
Environment (L)	2	716.07**	14.58**	33.30**	9.425**	1845.7**	11.605**	0.895**
Interaction (G x L)	18	178.41**	0.172**	0.574	19.20**	90.53**	0.497**	0.258
Interaction (S x L)	90	3.71**	0.33**	0.711**	1.33**	50.28**	0.164**	0.355**
Error	162	0.48	0.063	0.30	0.63	3.34	0.017	0.17

* p = 0.05
** p = 0.01

Table 17. Continued

Sources of variation	df	Yield/ plant	Fruits/ plant	Fruit weight	Fruit length	Fruit girth	Flesh thickness	Seeds/ fruit	100 seed weight
General combining ability (G)	9	88.78^{**}	4750.87^{**}	71855.0^{**}	1480.44^{**}	246.22^{**}	9.81^{**}	67.78^{**}	457.34^{**}
Specific combining ability (S)	45	1.53^{*}	56.52^{**}	932.31^{**}	26.29^{**}	4.41^{**}	0.352^{**}	5.83^{**}	9.54^{**}
Environment (L)	2	77.97^{**}	5660.41^{**}	4498.59^{**}	29.80^{**}	1.415^{**}	0.605^{**}	113.63^{**}	56.48^{**}
Interaction (G x L)	18	1.004^{**}	162.86^{**}	1532.03^{**}	9.48^{**}	3.28^{**}	0.203^{**}	3.74^{**}	5.67^{**}
Interaction (S x L)	90	3.49^{**}	54.9^{**}	394.31^{**}	2.78^{**}	1.49^{**}	0.08^{**}	1.87^{**}	4.64^{**}
Error	162	0.023	1.77	5.63	0.037	0.053	0.017	0.70	0.28

Table 18. Estimates of gca effects of ten bitter gourd lines for vegetative characters, Female flowers and earliness for three environments

Parental lines	Environ-ments	Branches/ plant	Main vine length	Node to first female flower	Days to first female flower opening	Female flowers/ plant	Percentage of female flowers	Days to picking maturity
1	2	3	4	5	6	7	8	9
	E_1	34.51	0.43	0.60	0.90	-3.95	0.68	-0.10
Priya	E_2	0.34	0.73	0.49	-0.45	-1.73	0.85	-0.05
	E_3	0.88	0.51	0.43	0.85	-0.39	0.60	-0.04
	E_1	34.23	0.54	0.39	1.58	-6.32	0.10	-0.18
MC-78	E_2	0.02	0.51	0.53	-0.38	-5.12	0.23	0.14
	E_3	0.37	0.56	0.19	1.51	-5.73	0.32	-0.25
	E_1	35.93	0.60	0.29	1.51	-9.92	-0.25	-0.14
MC-84	E_2	0.63	0.44	0.13	0.16	-3.85	0.12	-0.08
	E_3	0.63	0.48	0.34	1.61	-6.30	-0.12	0.04
	E_1	-3.42	-1.26	-1.16	1.66	-18.86	-0.83	-0.04
Arka harit	E_2	-2.66	-1.30	-1.08	-0.11	-18.30	-0.81	0.05
	E_3	-3.27	-1.16	-0.84	1.52	-21.08	-0.56	0.00

Contd.

Table 18. Continued

1	2	3	4	5	6	7	8	9
	E_1	-77.73	-1.51	-0.78	-0.25	14.0	-1.02	0.47
MC-82	E_2	-5.59	-1.93	-0.76	-0.40	7.04	-0.95	0.33
	E_3	-4.84	-1.40	-0.79	-0.50	11.22	-1.32	0.38
	E_1	-72.88	1.12	-0.08	2.07	29.46	-1.08	0.59
MC-79	E_2	6.92	1.15	-0.89	-0.13	25.29	-0.49	0.08
	E_3	5.97	0.93	-0.01	2.14	23.17	-0.94	0.27
	E_1	7.19	0.09	-0.12	-0.30	4.15	0.60	0.11
MC-66	E_2	2.36	0.26	0.23	0.80	3.57	0.49	-0.27
	E_3	2.08	0.02	-0.15	-0.18	4.05	0.83	-0.15
	E_1	13.10	0.15	0.39	-3.81	-1.41	1.07	-0.20
MC-49	E_2	1.75	0.21	0.57	0.01	3.07	0.68	0.02
	E_3	0.75	0.17	0.29	-3.49	-2.25	0.78	-0.02

Contd.

Table 18. Continued

1	2	3	4	5	6	7	8	9
	E_1	7.90	-0.22	0.09	0.002	-7.1	0.84	-0.14
MC-69	E_2	-2.03	-0.08	0.30	0.26	-3.34	0.09	-0.05
	E_3	-1.26	-0.06	-0.08	-0.20	-2.33	0.42	-0.02
	E_1	21.16	-0.06	0.57	-3.36	-0.05	-0.11	-0.37
MC-34	E_2	-1.74	0.02	0.51	0.24	-6.03	-0.20	-0.17
	E_3	-1.20	-0.03	0.63	-3.29	-0.37	-0.01	-0.21
	E_1	0.05	0.001	0.02	0.05	0.34	0.001	-0.01
SE (gi)	E_2	0.04	0.004	0.02	0.05	0.24	0.002	0.01
	E_3	0.04	0.003	0.02	0.05	0.17	0.001	0.02
	E_1	0.49	0.01	0.19	0.41	3.09	0.007	-0.06
SE (gi-gj)	E_2	0.40	0.03	0.20	0.44	2.18	0.02	0.08
	E_3	0.32	0.02	0.22	0.44	1.55	0.01	0.14

Table 19. Estimates of gca effects of ten bitter gourd lines for yield and fruit characters in three environments

Parental lines	Environments	Yield/ plant	Fruit/ plant	Fruit weight	Fruit length	Fruit girth	Flesh thickness	Seeds/ fruit	100 seed weight
1	2	3	4	5	6	7	8	9	10
	E_1	1.27	-4.13	30.76	4.79	0.14	0.19	1.38	1.95
Priya	E_2	1.39	-3.70	34.51	6.00	1.26	0.04	0.74	0.75
	E_3	1.43	-2.11	30.58	4.23	0.75	0.26	1.43	1.55
	E_1	1.26	-5.9	30.99	5.31	0.32	0.17	1.07	1.95
MC-78	E_2	0.9	-3.67	34.23	5.35	0.30	0.07	0.49	5.67
	E_3	1.34	-2.52	29.54	4.10	1.01	0.11	0.23	1.38
	E_1	1.23	-11.80	61.33	3.17	3.64	0.27	0.88	3.26
MC-84	E_2	1.17	-3.87	35.93	3.20	2.58	0.27	0.78	1.04
	E_3	0.61	-9.72	43.04	3.14	2.88	0.19	0.87	1.52
	E_1	-1.72	-19.38	16.64	2.49	3.30	1.00	-0.04	0.54
Arka Harit	E_2	-1.88	-13.15	-3.42	1.55	2.13	0.51	-0.66	-0.29
	E_3	-1.53	-17.96	23.11	1.85	2.63	0.99	-0.85	0.54

Contd.

Table 19. Continued

1	2	3	4	5	6	7	8	9	10
	E_1	-2.75	13.76	-82.03	-12.56	-4.21	-0.84	-3.46	-1.54
MC-82	E_2	-2.27	6.99	-77.73	-12.44	-3.54	-0.82	-3.62	1.95
	E_3	-3.33	13.04	-86.77	-13.14	-4.63	-0.87	-2.22	-1.27
	E_1	-1.39	32.95	-83.07	-12.17	-5.95	-1.05	-1.62	-11.27
MC-79	E_2	-2.00	22.37	-72.88	-12.07	-4.51	-0.78	-0.77	-10.34
	E_3	-2.09	21.08	-78.21	-8.06	-4.34	-1.01	-1.40	-8.24
	E_1	0.95	3.77	16.37	2.91	0.38	0.03	1.09	3.15
MC-66	E_2	1.00	1.14	7.19	2.33	0.46	0.23	0.82	0.90
	E_3	1.72	3.46	20.61	2.13	0.14	-0.01	0.58	1.38
	E_1	0.58	-1.88	17.10	0.84	1.95	0.16	0.34	0.89
MC-49	E_2	0.92	1.18	13.10	1.19	1.13	0.31	0.88	0.08
	E_3	1.08	-4.11	23.46	0.24	1.33	0.20	0.20	1.34

Contd.

Table 19. Continued

1	2	3	4	5	6	7	8	9	10
	E_1	0.49	-7.53	16.56	4.49	1.00	0.05	-1.54	0.64
MC-69	E_2	0.48	-1.84	7.9	4.47	0.49	0.12	0.44	0.32
	E_3	0.48	-3.76	14.43	5.38	0.66	0.04	-0.11	0.94
	E_1	0.08	0.16	-24.67	0.73	-0.58	0.03	1.92	0.41
MC-34	E_2	0.27	-5.45	21.16	0.42	-0.30	0.05	0.90	-0.08
	E_3	0.001	2.60	-19.79	0.11	-0.43	0.10	1.27	0.86
	E_1	0.001	0.17	0.97	0.004	0.001	0.001	0.03	0.02
SE (gi)	E_2	0.003	0.07	0.05	0.003	0.01	0.001	0.10	3.38
	E_3	0.001	0.15	0.24	0.01	0.001	0.001	0.03	0.03
	E_1	0.01	1.58	8.85	0.04	0.01	0.01	0.29	0.16
SE (gi-gj)	E_2	0.03	0.64	0.49	0.03	0.10	0.01	0.87	30.76
	E_3	0.01	1.39	2.18	0.07	0.01	0.01	0.27	0.23

b. Main vine length

Vine length also had highly significant variances due to gca and sca consistently. MC-79 had the highest values of gca for all the three seasons (1.12, 1.15 and 0.93 respectively). MC-82 was the lowest in gca effect for this character also. Arka Harit x MC-79 was the highest in sca effects throught the three seasons (2.0, 2.41 and 1.95).

c. Node to first female flower

The gca variances were highly significant for all the three seasons. Sca variance was highly significant during the second season. It was significant during first and not significant during second season. Arka Harit and MC-82 had negative values of gca effects which favoured production of female flowers in the lower nodes. Priya and MC-34, in general, had higher and positive values which favoured female flower production in the upper nodes. Higher and negative values were recorded by Arka Harit x MC-84 consistently for the three seasons. Arka Harit x Priya, Arka Harit x MC-79, MC-82 x MC-66 and MC-66 x MC-69 had higher and negative values of sca in the second season. In general, crosses involving Arka Harit as one of the parents had negative values of sca effects.

d. Days to first female flower opening

The gca and sca variances were highly significant for days to first female flower opening during the three seasons. MC-49 and MC-34 had the highest negative gca effect during first and third seasons indicating earlier female flower production. The crosses with higher and negative sca effects are Arka Harit x MC-66 and MC-79 x MC-69 during the first and third seasons and Priya x MC-49 and Arka Harit x MC-49 during the second season.

e. Female flowers/plant

Highly significant and consistent gca and sca variances were observed for this trait. MC-79 had the highest gca effect through out the three seasons (29.46, 25.29 and 23.17). The crosse MC-49 x MC-34 had higher sca effect consistently (11.70, 8.14 and 3.89). Higher sca effects were observed in Priya x MC-79, MC-78 x MC-66 in the first MC-79 x MC-66 and MC-82 x MC-79 in the second and Arka Harit x MC-79 and MC-82 x MC-66 in the third seasons. The cross Arka Harit x MC-79 recorded the highest sca effect (48.69) in the first season.

Table 20. Estimates of sca effects of 45 F_1 hybrids for vegetative characters, female flowers and earliness during first season

F_1 hybrids	Branches/ plant	Main vine length	Node to first female flower	Days to first female flower opening	Female flowers/ plant	Percentage of female flowers	Days to picking maturity
1	2	3	4	5	6	7	8
Priya x MC-78	-0.64	0.02	0.87	1.12	-1.48	0.18	-0.56
Priya x MC-84	0.23	-0.02	0.63	1.56	-3.88	0.32	0.65
Priya x Arka Harit	-1.28	-0.16	0.04	-0.09	-6.44	-0.55	0.55
Priya x MC-82	-1.25	-0.15	-0.33	-1.18	-1.43	-0.24	0.05
Priya x MC-79	0.55	0.02	-0.04	1.50	9.74	1.13	-0.58
Priya x MC-66	2.31	-0.13	0.00	-0.13	-3.95	-0.12	-1.09
Priya x MC-49	-0.70	0.08	-0.51	0.88	2.61	-0.13	-0.28
Priya x MC-69	0.22	0.35	-1.03	-1.43	-2.20	-0.39	-0.85
Priya x MC-34	1.07	0.20	-0.69	-0.07	-6.76	0.26	-0.62
MC-78 x MC-84	0.25	0.13	0.08	2.38	-5.52	0.17	-0.51
MC-78 x Arka Harit	0.49	0.38	-0.25	-0.64	-12.58	-0.55	0.38
MC-78 x MC-82	-0.23	0.09	-0.37	0.14	6.06	-0.96	-0.37
MC-78 x MC-79	0.45	0.01	-0.08	0.82	-2.90	0.00	-0.51
MC-78 x MC-66	1.46	-0.21	-0.54	-1.81	10.04	0.02	-0.01
MC-78 x MC-49	-1.05	-0.05	0.45	0.33	7.35	0.25	-0.45

Contd.

Table 20. Continued

1	2	3	4	5	6	7	8
MC-78 x MC-69	-1.82	0.09	-0.57	-0.61	-0.34	0.34	0.49
MC-78 x MC-34	0.09	-0.09	-0.48	-1.37	2.61	0.44	0.97
MC-84 x Arka Harit	-0.65	0.02	-1.61	-1.70	-6.97	-0.09	0.59
MC-84 x MC-82	0.76	-0.07	0.01	-1.79	2.16	-0.41	-0.41
MC-84 x MC-79	-1.07	-0.20	-0.70	-0.11	-3.05	-0.05	-0.53
MC-84 x MC-66	0.57	-0.03	-0.91	-1.75	3.89	-0.47	0.45
MC-84 x MC-49	-0.69	-0.12	0.58	-1.73	2.70	0.00	-0.24
MC-84 x MC-69	0.29	-0.03	0.06	1.45	-3.23	0.04	-0.81
MC-84 x MC-34	-1.42	0.10	-0.09	-0.68	-3.29	-0.31	-0.08
Arka Harit x MC-82	2.62	-0.07	-0.57	3.06	3.10	0.20	-0.51
Arka Harit x MC-79	10.05	2.00	0.72	0.74	4.86	-0.06	0.36
Arka Harit x MC-66	-2.19	-0.71	0.01	-2.89	-2.55	0.66	-0.16
Arka Harit x MC-49	-0.33	-0.14	0.63	-0.38	-11.48	0.38	-0.35
Arka Harit x MC-69	-1.84	-0.71	-0.40	0.18	-9.79	0.82	-0.41
Arka Harit x MC-34	-0.05	-0.55	1.32	0.17	-3.85	-0.78	-0.18
MC-82 x MC-79	1.46	-0.34	0.60	-0.36	-7.22	-0.08	-0.14
MC-82 x MC-66	2.09	0.44	0.39	2.01	-5.91	0.54	0.34
MC-82 x MC-49	0.33	0.63	0.38	-1.48	-5.85	0.67	-0.10
MC-82 x MC-69	0.81	0.25	0.36	0.71	-4.14	0.30	1.09
MC-82 x MC-34	0.10	0.01	-0.30	-0.42	2.79	0.26	0.07

Contd.

Table 20. Continued

1	2	3	4	5	6	7	8
MC-79 x MC-66	-2.36	-0.54	0.43	1.45	-3.74	-1.25	-0.03
MC-79 x MC-49	-0.49	-0.41	0.17	-1.79	-2.81	0.13	0.28
MC-79 x MC-69	-1.14	-0.38	0.65	-2.60	0.88	0.12	0.22
MC-79 x MC-34	-2.22	-0.19	-0.26	-3.61	2.33	0.27	-0.56
MC-66 x MC-49	-0.48	0.42	-0.04	-1.42	7.76	-0.35	0.01
MC-66 x MC-69	-1.50	-0.01	-0.31	-0.23	-5.31	-0.27	0.45
MC-66 x MC-34	-0.21	-0.34	0.03	0.13	-9.61	0.24	-0.33
MC-49 x MC-69	3.49	0.18	0.18	-0.72	-1.62	-0.34	0.51
MC-49 x MC-34	1.65	0.30	-1.73	1.64	11.70	0.67	-0.01
MC-69 x MC-34	0.37	-0.08	1.00	-0.17	-2.11	-0.30	0.92
SE (sij)	0.26	0.04	0.22	0.32	0.87	0.04	0.14
SE (sij-sik)	0.84	0.14	0.71	1.05	2.88	0.14	0.41
SE (sij-ske)	0.81	0.14	0.68	1.00	2.75	0.14	0.39

Table 21. Estimates of sca effects of 45 F_1 hybrids for vegetative characters, female flowers and earlines during second season

F_1 hybrids	Branches per plant	Main vine length	Node to first female flower	Days to first female flower opening	Female flowers	Percentage of female flowers	Days to picking maturity
1	2	3	4	5	6	7	8
Priya x MC-78	-1.48	0.53	-0.01	0.66	-0.08	-0.41	-0.38
Priya x MC-84	-1.10	0.45	-0.36	0.61	2.91	0.19	0.47
Priya x Arka Harit	-3.81	-0.97	-1.90	-0.61	-2.76	-0.80	0.59
Priya x MC-82	-4.63	0.94	0.79	1.93	1.27	-0.81	0.56
Priya x MC-79	7.11	0.13	0.41	-0.59	-14.73	0.78	0.06
Priya x MC-66	-0.08	0.42	0.81	-0.73	0.24	0.15	-0.08
Priya x MC-49	2.03	0.55	-1.05	-2.24	3.99	0.56	-0.13
Priya x MC-69	1.56	-0.77	0.22	1.27	0.65	0.22	-0.05
Priya x MC-34	-2.48	0.02	0.12	-1.71	0.44	0.01	-0.06
MC-78 x MC-84	-1.78	0.32	0.85	-0.94	1.55	-0.34	0.15
MC-78 x Arka Harit	-1.23	-0.74	0.56	1.83	-7.00	-0.28	-0.11
MC-78 x MC-82	-4.18	-0.66	0.74	-0.38	3.15	-0.34	-0.14
MC-78 x MC-79	0.18	0.31	-0.13	-1.90	8.90	-0.15	0.11
MC-78 x MC-66	0.75	-0.04	0.27	-0.59	2.37	0.77	0.72
MC-78 x MC-49	0.60	-1.29	-0.34	0.95	-6.13	0.43	0.18

Contd.

Table 21. Continued

1	2	3	4
MC-78 x MC-69	1.13	0.12	0.93
MC-78 x MC-34	2.84	0.24	-1.28
MC-84 x Arka harit	-2.10	-0.82	-1.55
MC-84 x MC-82	-4.67	-0.74	-0.61
MC-84 x MC-79	3.07	0.18	0.27
MC-84 x MC-66	1.88	0.30	0.41
MC-84 x MC-49	4.24	0.08	1.06
MC-84 x MC-69	-0.98	0.11	0.08
MC-84 x MC-34	1.72	-0.06	0.87
Arka Harit x MC-82	-1.13	0.73	0.60
Arka Harit x MC-79	12.36	2.41	-1.53
Arka Harit x MC-66	2.46	-0.59	1.62
Arka Harit x MC-49	1.78	-0.27	0.77
Arka Harit x MC-69	-0.44	-0.19	0.04
Arka Harit x MC-34	-2.73	-0.04	1.58
MC-82 x MC-79	4.54	-1.35	0.66
MC-82 x MC-66	6.10	-0.03	-1.94
MC-82 x MC-49	2.20	-0.23	0.95

5	6	7	8
-1.29	1.29	0.27	-0.25
-0.03	-0.67	0.13	0.36
-1.71	-0.51	-0.27	-0.14
-2.17	-0.58	-0.04	-0.42
-0.19	-9.61	0.11	0.08
0.12	-0.14	0.03	0.19
-0.09	-2.64	0.56	0.15
0.91	1.03	-0.31	0.22
2.43	6.57	0.24	-0.67
3.10	-4.91	0.45	-0.29

0.08	4.09	0.04	-0.04
-1.86	1.06	0.24	-0.69
-2.32	1.93	0.35	0.02
0.68	5.48	-0.37	0.47
-1.30	0.27	0.12	-0.04
-2.63	9.75	0.50	-0.57
0.43	-2.54	-0.40	-0.22
-1.03	1.22	0.08	-0.01

Contd.

Table 21. Continued

1	2	3	4	5	6	7	8
MC-82 x MC-69	1.24	-0.76	1.47	0.22	2.63	0.52	-0.44
MC-82 x MC-34	-0.06	-0.19	-0.74	2.74	-4.08	-0.27	0.18
MC-79 x MC-66	-2.91	-0.49	0.68	0.16	10.22	-0.51	0.03
MC-79 x MC-49	-4.31	0.35	0.58	-0.55	17.84	-0.47	0.24
MC-79 x MC-69	-7.78	-0.36	0.60	0.70	-14.87	0.06	-0.19
MC-79 x MC-34	-6.82	-0.64	1.14	0.72	-18.58	-0.15	-0.32
MC-66 x MC-49	1.26	0.25	0.72	-0.99	1.43	-0.10	-0.16
MC-66 x MC-69	-0.96	0.06	-1.76	1.77	-3.15	-0.42	-0.58
MC-66 x MC-34	-4.26	0.07	-0.96	-0.21	1.64	-0.61	-0.53
MC-49 x MC-69	-0.36	0.04	0.64	-1.44	1.85	-0.43	-0.63
MC-49 x MC-34	-0.85	0.13	0.43	1.58	8.14	-0.11	0.49
MC-69 x MC-34	3.51	-0.08	-1.05	-0.42	-0.44	0.02	0.56
SE (sij)	0.32	0.10	0.22	0.33	0.73	0.20	0.14
SE (sij-sik)	1.03	0.30	0.72	1.08	2.42	0.80	0.47
SE (sij-skl)	0.31	0.28	0.69	1.03	2.31	0.80	0.14

Table 22. Estimates of SCA effects of 45 F_1 hybrids for vegetative characters and earliness during 3rd season

F_1 hybrids	Branches/ plant	Main vine length	Node to first female flower	Days to first female flower opening	Female flowers/ plant	Percentage of female flowers	Days to picking maturity
1	2	3	4	5	6	7	8
1. Priya x MC-78	1.70	0.25	-0.05	1.60	-2.11	-0.14	0.63
2. Priya x MC-84	-0.41	0.01	0.35	0.99	-7.78	-0.60	-0.41
3. Priya x Arka Harit	-2.51	-0.20	0.22	0.34	-3.50	-0.11	0.13
4. Priya x MC-82	0.06	-0.24	-0.57	-1.95	-3.05	-0.46	0.01
5. Priya x MC-79	1.00	-0.34	-0.10	0.45	5.99	1.16	0.36
6. Priya x MC-66	2.38	-0.38	0.29	0.78	4.61	0.05	-0.22
7. Priya x MC-49	-1.53	0.04	-0.40	1.59	1.42	-0.00	0.15
8. Priya x MC-69	0.48	0.20	-0.03	-2.20	-2.25	0.21	-0.10
9. Priya x MC-34	-1.84	0.25	-0.62	0.40	2.54	-0.46	-0.41
10. MC-78 x MC-84	0.95	-0.32	0.05	0.84	1.05	0.08	0.55
11. MC-78 x Arka Harit	1.59	0.32	0.45	-0.22	1.83	-0.02	0.09
12. MC-78 x MC-82	-1.59	-0.14	-0.08	-0.60	-1.72	0.38	-0.28
13. MC-78 x MC-79	-0.90	0.10	0.39	0.68	-4.67	-0.20	0.32
14. MC-78 x MC-66	0.99	0.49	-1.22	-2.12	4.76	-0.22	-0.01
15. MC-78 x MC-49	-0.43	-0.01	0.60	0.44	1.00	-0.07	-0.89

Contd.

Table 22. Continued

1	2	3
16. MC-78 x MC-69	-2.92	-0.15
17. MC-78 X MC-34	0.52	-0.06
18. MC-84 x Arka Harit	-1.01	-0.28
19. MC-84 x MC-82	2.06	-0.21
20. MC-84 x MC-79	-1.75	0.56
21. MC-84 x MC-66	1.13	0.50
22. MC-84 x MC-49	-1.53	-0.08
23. MC-84 x MC-69	-0.02	0.05
24. MC-84 x MC-34	-0.59	0.17
25. Arka Harit x MC-82	1.96	-0.12
26. Arka Harit x MC-79	8.64	1.95
27. Arka Harit x MC-66	-1.97	0.11
28. Arka Harit x MC-49	0.36	-0.14
29. Arka Harit x MC-69	-1.13	-0.64
30. Arka Harit x MC-34	-0.69	-0.56
31. MC-82 x MC-79	1.09	-0.29
32. MC-82 x MC-66	1.85	0.48
33. MC-82 x MC-49	-0.07	0.38
34. MC-82 x MC-69	0.45	0.61
35. MC-82 x MC-34	0.63	-0.37

5	6	7	8
-0.73	0.83	0.49	0.36
-0.76	1.37	-0.18	0.05
-1.18	-1.60	-0.39	-0.20
-1.83	0.48	0.01	-0.33
1.20	-2.10	-0.02	-0.03
-1.73	-0.22	0.02	-0.31
-2.04	2.82	0.12	-0.18
0.92	-0.10	0.93	0.07
-0.62	-1.05	0.01	0.76
3.76	-7.37	-0.44	-0.53
0.67	20.69	0.08	-0.18
-2.76	-10.19	0.82	-0.26
-1.32	-1.90	0.96	0.11
-1.61	-5.81	-0.32	-0.64
-0.52	-7.73	0.01	0.30
-0.36	-1.62	0.38	-0.06
1.21	9.51	0.07	-0.14
-0.98	-2.20	-0.79	0.24
1.10	-2.62	-1.02	0.49
-0.55	-2.08	0.66	-0.08

Contd.

Table 22. Continued

1	2	3	4	5	6	7	8
36. MC-79 x MC-66	-2.46	-2.10	0.23	1.11	-2.44	-0.21	-0.03
37. MC-79 x MC-49	1.12	-0.51	0.42	-1.45	-8.15	-0.37	0.34
38. MC-79 x MC-69	-0.62	0.08	0.41	-2.24	5.94	-0.80	-0.41
39. MC-79 x MC-34	-2.93	0.20	0.20	-2.90	-7.02	-0.12	-0.97
40. MC-66 x MC-49	-0.99	0.68	-0.57	-1.13	4.48	0.07	0.76
41. MC-66 x MC-69	-1.73	0.07	0.04	0.58	-5.94	0.03	0.01
42. MC-66 x MC-34	1.45	-0.06	-0.42	-0.07	-4.40	-0.29	0.45
43. MC-49 x MC-69	1.85	0.03	-0.32	-0.36	-0.39	-0.37	0.38
44. MC-49 x MC-34	1.54	0.11	-0.85	0.11	3.89	0.81	0.32
45. MC-69 x MC-34	0.42	0.07	1.14	-0.18	2.98	0.17	0.57
SE (sij)	0.28	0.10	0.22	0.33	0.62	0.05	0.17
SE (sij-sik)	0.93	0.24	0.77	1.09	2.04	0.17	0.61
SE (sij-skl)	0.89	0.24	0.73	1.03	1.95	0.17	0.57

f. Percentage of female flowers

The general analysis of variance for combining ability showed highly significant gca and sca variances for percentage of female flowers. Considering all the three seasons, MC-49 had higher values of gca effects (1.07, 0.68 and 0.78) followed by Priya (0.68, 0.85 and 0.6) and MC-66 (0.60, 0.49 and 0.83). Priya x MC-79 possessed higher and consistant value of sca effects (1.13, 0.78 and 1.16).

g. Days to picking maturity

Analysis of variance showed that only the gca variances were significant for days to picking maturity in all the three seasons. Sca variance was significant only for the first season. In general gca and sca effects were comparatively low for this character.

h. Yield/plant

Mean square due to gca and sca were highly significant for yield/plant in all the three seasons. Considering the three seasons, Priya (1.27, 1.39 and 1.43) ranked first in gca effect followed closely by MC-66 (0.95, 1.00 and 1.72) and MC-78 (1.26, 0.90 and 1.34). The crosses Arka

Harit x MC-49 (2.60), Arka Harit x MC-79 (2.53), MC-78 x MC-79 (1.75) and MC-49 x MC-34 (1.31) had higher values of sca effects during the first season. Arka Harit x MC-79 (2.19), MC-82 x MC-79 (1.55) and Priya x MC-49 (1.50) in the second and MC-82 x MC-79 (2.12), MC-78 x MC-66 (2.09), MC-49 x MC-34 (1.83), Arka Harit x MC-34 (1.71) and Priya x MC-78 (1.01) in the third season had higher values of sca effects.

i. Fruits/plant

The gca and sca variances were highly significant for fruits/plant. MC-79 had the highest and consistent values of gca effects (32.95, 22.37 and 21.08) followed by MC-82 (13.76, 6.99 and 13.04) and MC-66 (3.77, 1.14 and 3.46). The cross Arka Harit x MC-79 recorded the highest sca effect in the first season (47.81). Other crosses with higher sca effects are MC-49 x MC-34 (10.6), MC-78 x MC-66 (10.02) and MC-78 x MC_49 (9.42) in the first, MC78 x MC-79 (12.79), Arka Harit x MC-79 (11.57), Arka Harit x MC-69 (11.24) and MC-49 x MC-34 (7.90) in the second and MC-82 x MC-79 (17.92) and Arka Harit x MC-34 (10.15) in the third seasons.

j. Fruit weight

Fruit weight also recorded highly significant gca and sca variances consistently. Considering the three seasons MC-84 had the highest gca effect (61.33, 35.93 and 43.04) followed by Priya (30.76, 34.51 and 30.58) and MC-78 (30.99, 34.23 and to 29.54). MC-79 recorded the lowest gca effects followed by MC-82. However the crosses between these small fruited lines recorded the highest sca effects consistently (34.56, 37.13 and 50.18) indicating the higher sca effects in crosses between small fruited x small fruited than in crosses between large fruited x small fruited or large fruited x large fruited lines.

k. Fruit length

The gca and sca variances were highly significant for all the three seasons. Priya (4.79, 6.00 and 4.23), MC-78 (5.31, 5.35, 4.1) and MC-69 (4.49, 4.47 and 5.38) possessed higher values of gca effects. The two small fruited lines MC-79 and MC-82 recorded negative effects. The sca effects were similar to those for fruit weight, MC-82 x MC-79 having the highest values (8.86, 10.82 and 4.09).

l. Fruit girth

There were highly significant differences among the variances due to gca and sca for fruit girth. In all the three environments, the parent MC-84 had the highest values of gca effects (3.64, 2.58 and 2.88) followed by Arka Harit (3.3, 2.13 and 2.63). The sca effects showed similarity to those for fruit length and weight, the highest being shown by MC-82 x MC-79 (4.05, 2.78 and 2.10).

m. Flesh thickness

The mean square due to gca and sca showed highly significant variances for all the seasons. MC-84 (3.64, 0.27 and 0.19) and Arka Harit (3.3, 0.51 and 0.99) were good general combiners for fruit flesh thickness. Here also, MC-82 and MC-79 registered negative values indicating poor combining ability. Priya x Arka Harit (1.07) and MC-82 x MC-79 (0.80) possessed higher sca effects in the first, MC-79 x MC-34 (0.69), MC-79 x MC-69 (0.50), MC-79 x MC-66 (0.30) and Priya x Arka Harit (0.34) in the second and Priya x Arka Harit (1.06), MC-82 x MC-79 (0.94), MC-82 x MC-66 (0.44) and MC-79 x MC-34 (0.47) in the third seasons.

n. Seeds/fruit

There were significant gca and sca variances for this trait. MC-34 (1.92, 0.90 and 1.27), Priya (1.38, 0.74 and 1.43), MC-78 (1.07, 0.49 and 0.23) and MC.84 (0.88, 0.78 and 0.87) were in general, good combiners for seeds/fruit. Arka Harit, MC-79 and MC-82 possessed negative values indicating their poor combining ability for this trait. MC-82 x MC-69 (2.91, 4.61 and 2.68) and MC-82 x MC-34 (4.45, 4.16 and 1.56) possessed higher sca effects consistently.

o. 100 seed weight

Mean square due to gca and sca were highly significant for all the three seasons. Estimates of gca effects revealed that the parents MC-78 (1.95, 5.67 and 1.38), MC_84 (3.26, 1.04 and 1.52), MC-66 (3.15, 0.9 and 1.38) and Priya (1.95, 0.75 and 1.55) possessed higher values in general. The small fruited type MC-79 possessed negative values for seed weight also. Arka Harit x MC-69 (2.75), MC-78 x MC-84 (2.71), MC-84 x MC-82 (2.22) and MC-78 x MC-66 (2.07) in the first, Priya x MC-49 (2.93), Priya x MC-69 (2.68) and Priya x MC-34 (2.58) in the second and Priya x Arka Harit (3.77), Priya x MC-66 (3.19)

Table 23. Estimates of sca effects of 45 F_1 hybrids for yield and fruit characters during first Season

F_1 hybrids	Yield/ plant	Fruits/ plant	Fruit weight	Fruit length	Fruit girth	Flesh thickness	seeds/ fruit	100 seed weight
1	2	3	4	5	6	7	8	9
Priya x MC-78	-0.31	-1.34	0.21	1.17	-0.77	-0.12	0.47	0.77
Priya x MC-84	-0.18	-0.19	23.88	0.76	-0.74	-0.06	-0.34	-0.29
Priya x Arka Harit	0.68	-4.86	-2.44	1.14	-2.75	1.07	-0.43	-1.32
Priya x MC-82	-0.55	2.50	-18.77	-4.95	0.45	-0.01	-2.01	-0.98
Priya x MC-79	0.89	9.06	-16.73	-4.89	-0.05	0.03	1.16	-2.01
Priya x MC-66	0.01	1.25	5.84	1.83	-0.57	0.04	1.45	1.32
Priya x MC-49	-0.23	4.64	-2.89	-0.26	-0.05	0.06	-1.30	1.08
Priya x MC-69	0.17	-0.21	3.15	1.70	0.55	-0.88	-0.43	1.33
Priya x MC-34	0.58	-3.65	12.88	-0.79	0.98	-0.10	-1.38	0.56
MC-78 x MC-84	-0.07	-2.92	4.40	1.24	1.08	-0.14	-2.03	2.71
MC-78 x Arka Harit	-0.31	-9.59	3.84	1.52	2.42	0.02	-1.11	0.43
MC-78 x MC-82	0.71	6.27	-13.50	-4.47	1.18	-0.09	-0.19	-0.48
MC-78 x MC-79	1.75	-0.17	2.04	-3.86	-0.33	0.07	0.97	-3.01
MC-78 x MC-66	0.57	10.02	7.61	2.51	0.34	0.14	0.76	2.07
MC-78 x MC-49	0.81	9.42	4.88	-0.43	-0.08	-0.07	0.51	0.33
MC-78 x MC-69	-0.17	1.31	1.42	1.58	-0.63	0.21	0.39	-0.67

Contd.

Table 23. Continued

1	2	3	4	5	6	7	8	9
MC-78 x MC-34	0.04	4.12	10.15	-0.66	-0.60	-0.06	-0.07	-0.31
MC-78 x Arka Harit	0.46	-3.94	13.50	0.26	1.31	-0.00	0.07	1.38
MC-84 x MC-82	0.41	5.92	-34.33	-0.93	-2.94	0.06	-3.51	2.22
MC-84 x MC-79	0.18	-2.02	-20.29	-2.72	-2.05	-0.22	1.66	-4.19
MC-84 x MC-66	-0.36	6.41	11.27	0.65	1.17	0.02	0.95	1.77
MC-84 x MC-49	0.51	2.56	8.04	1.36	-0.10	-0.11	2.70	0.78
MC-84 x MC-69	-0.15	0.96	-31.42	0.22	1.61	-0.07	-2.43	-2.97
MC-84 x MC-34	-0.44	-0.23	2.31	0.38	-0.87	0.15	0.12	-1.24
Arka Harit x MC-82	-0.41	-2.00	-34.14	-4.05	-0.10	-0.78	0.41	-0.07
Arka Harit x MC-79	2.53	47.81	-46.60	-3.84	-1.15	-1.06	0.57	-2.09
Arka Harit x MC-66	-1.35	3.25	2.46	1.48	-2.49	-0.52	0.87	0.24
Arka Harit x MC-49	2.66	-9.36	15.23	0.54	3.64	-0.32	0.62	0.50
Arka Harit x MC-69	-0.79	-6.21	9.77	0.25	-1.70	-0.11	0.49	2.75
Arka Harit x MC-34	-0.38	-3.40	27.00	0.91	-2.07	-0.67	0.03	-0.02
MC-82 x MC-79	-0.99	-9.84	34.56	8.86	4.05	0.80	1.99	1.49
MC-82 x MC-66	0.24	-0.15	-13.87	-2.47	-0.63	-0.48	-0.22	-3.43
MC-82 x MC-49	-1.26	-3.00	-0.10	0.59	-1.70	-0.01	-1.47	-0.17
MC-82 x MC-69	1.13	-1.86	3.94	-5.19	-0.40	0.15	2.91	0.08
MC-82 x MC-34	1.05	4.96	28.67	-2.29	-1.52	0.02	4.45	-0.19

Contd.

Table 23. Continued

1	2	3	4	5	6	7	8	9
MC-79 x MC-66	0.36	-5.34	-9.83	-4.45	-2.39	0.09	-2.05	-4.21
MC-79 x MC-49	-1.77	-3.19	-29.56	-0.14	-2.96	-0.22	0.20	-2.20
MC-79 x MC-69	0.72	-0.54	-0.52	-4.03	-0.85	-0.21	2.07	-1.70
MC-79 x MC-34	0.14	-1.73	22.71	-1.17	-0.97	-0.04	-0.88	-0.97
MC-66 x MC-49	0.04	9.99	18.00	0.38	-0.96	0.32	-2.01	0.88
MC-66 x MC-69	0.24	-2.39	3.54	1.49	0.61	0.23	-2.13	0.13
MC-66 x MC-34	0.05	-7.05	-39.97	0.75	1.39	0.06	-1.09	-1.64
MC-49 x MC-69	0.05	4.79	7.81	0.90	1.24	-0.05	0.12	0.39
MC-49 x MC-34	1.31	10.60	-40.96	0.76	0.87	0.25	-0.34	1.62
MC-69 x MC-34	-0.59	0.25	-29.42	1.27	0.38	0.19	-1.47	-0.19
SE (sij)	0.05	0.93	1.47	0.10	0.04	0.05	0.26	0.20
SE (sij-sik)	0.17	2.06	4.87	0.32	0.17	0.17	0.88	0.65
SE (sij-ske)	0.17	1.96	4.65	0.30	0.14	0.17	0.84	0.62

Table 24. Estimates of sca effects of 45 F_1 hybrids for yield and fruit characters during second season

F_1 hybrids	Yield/ plant	Fruits/ plant	Fruit weight	Fruit length	Fruit girth	Flesh thickness	seeds/ fruit	100 seed weight
1	2	3	4	5	6	7	8	9
Priya x MC-78	0.25	1.85	-1.97	5.40	0.10	-0.28	1.72	-3.92
Priya x MC-84	0.09	1.31	8.57	-1.00	-0.90	0.03	0.43	-0.54
Priya x Arka Harit	-0.85	1.09	-30.83	-0.38	-0.51	0.34	-1.89	0.29
Priya x MC-82	0.29	-3.81	3.49	-7.36	0.05	-0.13	-0.93	-3.70
Priya x MC-79	-1.36	-9.43	-13.37	-6.26	1.18	-0.17	-1.03	-2.41
Priya x MC-66	0.27	1.55	3.56	-0.33	0.47	0.06	1.88	1.10
Priya x MC-49	1.50	1.51	17.65	1.71	0.55	0.02	1.32	2.93
Priya x MC-69	-0.39	-1.47	3.84	3.38	-0.07	0.18	-2.99	2.68
Priya x MC-34	-0.25	-0.87	6.59	-2.15	0.10	-0.03	1.55	2.58
MC-78 x MC-84	0.29	-1.60	13.61	-0.21	1.56	-0.01	2.68	-2.71
MC-78 x Arka Harit	-0.48	-2.94	-0.04	-0.03	-0.49	-0.15	-1.39	-3.39
MC-78 x MC-82	-1.09	0.41	-32.97	-5.74	-1.13	0.19	-3.43	2.38
MC-78 x MC-79	-1.48	12.79	-45.08	-4.57	-1.86	-0.20	1.22	-5.82
MC-78 x MC-66	0.79	-1.48	15.35	-0.46	-0.02	0.03	2.63	-2.81
MC-78 x MC-49	0.47	-2.27	3.44	-1.45	0.51	0.05	1.07	-1.74

Contd.

Table 24. Continued

1	2	3	4	5	6	7	8	9
MC-78 x MC-69	0.29	-2.75	18.64	3.27	1.15	0.02	-0.49	-3.24
MC-78 x MC-34	0.25	-2.90	25.38	-1.78	0.81	-0.04	1.05	-4.09
MC-84 x Arka Harit	-0.96	4.02	-49.74	1.72	0.73	0.28	-2.68	-0.75
MC-84 x MC-82	1.17	4.62	-20.93	-1.99	-0.10	0.19	-2.72	-5.00
MC-84 x MC-79	-0.57	0.50	-26.54	-2.74	-1.38	-0.40	0.43	-0.20
MC-84 x MC-66	-0.14	0.73	-6.61	0.57	-0.35	-0.17	1.34	0.06
MC-84 x MC-49	1.04	-3.07	31.24	2.96	-0.49	0.10	0.78	-0.37
MC-84 x MC-69	0.26	-4.80	29.43	-0.45	-0.03	-0.13	-0.53	1.38
MC-84 x MC-34	0.59	-0.69	28.17	0.25	-2.34	-0.23	-0.24	0.79
Arka Harit x MC-82	0.69	-4.10	2.17	-3.32	-1.56	-0.32	-1.78	-1.91
Arka Harit x MC-79	2.19	8.03	11.57	-2.97	-0.94	-0.64	2.86	0.13
Arka Harit x MC-66	-0.96	-1.49	-22.76	0.81	0.85	-0.03	3.28	2.15
Arka Harit x MC-49	-1.26	-8.54	32.59	1.80	0.18	0.14	2.72	0.97
Arka Harit x MC-69	-0.01	11.24	-70.71	-0.33	-0.81	-0.29	0.16	0.47
Arka Harit x MC-34	0.15	-3.41	33.53	0.92	-1.02	-0.47	1.20	-0.63
MC-82 x MC-79	1.55	-0.12	37.13	10.82	2.78	0.07	0.82	-3.61
MC-82 x MC-66	0.27	-0.39	-1.07	-2.67	-0.48	-0.32	-2.26	-4.85
MC-82 x MC-49	-0.94	-2.93	-17.85	-1.63	-1.53	0.10	1.68	-4.15

Contd.

Table 24. Continued

1	2	3	4	5	6	7	8	9
MC-82 x MC-69	-0.48	-4.84	-19.53	-4.66	-0.27	-0.21	4.61	-3.53
MC-82 x MC-34	-0.22	-1.95	-20.91	-0.01	1.52	0.23	4.16	-3.82
MC-79 x MC-66	-0.72	-6.26	4.54	-2.92	0.24	0.39	-3.62	-2.05
MC-79 x MC-49	-0.22	5.95	-7.95	-1.16	-0.68	-0.19	-2.18	-0.23
MC-79 x MC-69	-0.17	-11.03	9.49	-4.69	-1.17	0.50	2.76	-1.10
MC-79 x MC-34	-0.99	-17.93	-0.77	-1.84	0.24	0.69	2.30	-0.83
MC-66 x MC-49	0.36	7.17	-22.78	0.97	-0.15	0.12	-2.26	-0.72
MC-66 x MC-69	-0.19	1.70	-4.83	1.29	0.61	0.21	2.18	1.53
MC-66 x MC-34	-0.21	4.05	-17.09	0.29	-0.72	0.03	-0.28	1.68
MC-49 x MC-69	-0.24	7.90	-38.48	-0.34	-0.06	-0.15	1.14	1.10
MC-49 x MC-34	-0.08	12.51	-55.99	1.11	0.11	0.17	-1.10	3.01
MC-69 x MC-34	0.54	4.53	-4.80	0.83	-0.76	0.17	-1.91	1.51
SE (sij)	0.10	0.40	0.35	0.10	0.14	0.04	0.46	2.74
SE (sij-sik)	0.28	1.31	1.15	0.28	0.51	0.17	1.53	9.09
SE (sij-skl)	0.26	1.25	1.10	0.26	0.48	0.14	1.46	8.67

Table 25. Estimates of sca effect of 45 F_1 hybrids for yield and fruit characters during third season

F_1 hybrids	Yield/ plant	Fruits/ plant	Fruit weight	Fruit length	Fruit girth	Flesh thickness	Seeds/ fruit	100 Seed weight
1	2	3	4	5	6	7	8	9
1. Priya x MC-78	1.01	3.42	7.34	2.52	-2.03	-0.13	0.94	0.44
2. Priya x MC 84	-0.39	0.62	-4.91	-0.71	-1.39	0.19	0.56	2.04
3. Priya x Arka Harit	-0.76	-1.14	0.78	-0.68	0.56	1.06	-0.72	3.77
4. Priya x MC-82	-0.10	-6.64	13.65	-1.59	1.67	-0.48	-1.61	0.08
5. Priya x MC-79	-0.27	0.32	-7.16	-3.47	-0.72	0.06	1.08	-6.08
6. Priya x MC-66	0.84	1.44	4.03	0.79	0.54	-0.17	-0.40	3.19
7. Priya x MC-49	0.10	0.51	2.42	-1.32	0.21	0.53	-0.28	0.23
8. Priya x MC-69	-0.11	-0.84	2.83	1.30	0.63	-0.21	-1.71	-3.19
9. Priya x MC-34	-1.61	-2.70	-27.58	-1.44	1.16	0.08	-0.84	-1.05
10. MC-78 x MC-84	-0.01	1.41	3.87	0.67	1.14	-0.06	-1.25	1.72
11. MC-78 x Arka Harit	-0.69	-2.47	18.06	-1.05	2.74	0.21	0.60	0.20
12. MC-78 x MC-82	-0.38	-5.72	-8.32	-2.66	1.20	0.25	-0.16	-1.74
13. MC-78 x MC-79	-1.28	-5.27	-24.38	-3.64	1.71	-0.29	-0.22	-5.27
14. MC-78 x MC-66	2.09	5.86	12.56	0.57	0.33	-0.04	1.55	0.86
15. MC-78 x MC-49	-0.06	0.92	3.45	-2.44	0.89	0.26	0.92	1.90

Contd.

Table 25. Continued

1	2	3	4	5	6	7	8	9
16. MC-78 x MC-69	0.21	-0.05	5.48	3.43	-0.34	-0.08	-0.27	-1.20
17. MC-78 x MC-34	-1.39	-1.29	-25.29	-1.71	-0.36	-0.27	0.11	1.88
18. MC-84 x Arka Harit	-0.75	1.97	-8.19	-0.48	2.83	-0.12	-0.41	0.30
19. MC-84 x MC-82	-0.98	-9.53	-34.07	4.15	-0.56	-0.26	-2.05	-0.64
20. MC-84 x MC-79	-1.13	-2.07	-48.63	0.82	-2.75	-0.62	-0.61	-4.67
21. MC-84 x MC-66	-0.27	-4.94	10.81	-0.16	-1.53	0.26	0.91	-0.78
22. MC-84 x MC-49	-0.53	2.12	-14.55	-1.28	-0.47	-0.02	-0.46	-2.74
23. MC-84 x MC-69	0.04	2.78	-11.77	0.99	-1.51	0.01	1.60	-1.10
24. MC-84 x MC-34	0.19	-0.84	31.20	-0.74	-1.22	-0.05	-1.28	-2.26
25. Arka Harit x MC-82	0.84	-5.79	-12.88	0.49	-3.27	-1.06	1.92	-0.41
26. Arka Harit x MC-79	0.69	-4.83	-17.44	-1.64	-4.01	-1.30	0.86	-4.44
27. Arka Harit x MC-66	-1.59	-9.70	5.74	0.47	-1.54	-0.92	0.38	0.45
28. Arka Harit x MC-49	-0.41	0.86	3.64	0.16	-0.63	-0.13	0.75	-3.01
29. Arka Harit x MC-69	0.33	2.02	7.17	0.68	-1.16	-0.09	-2.43	-0.37
30. Arka Harit x MC-34	1.71	10.15	-3.86	1.34	-1.97	0.22	2.19	0.47
31. MC-82 x MC-79	2.12	17.92	50.18	4.09	2.10	0.94	1.47	-2.63
32. MC-82 x MC-66	-1.69	0.55	-34.89	-6.19	-0.78	0.44	-0.76	1.01
33. MC-82 x MC-49	-0.87	-5.64	-24.24	-3.60	-2.37	0.11	-0.13	-0.70
34. MC-82 x MC-69	-1.74	-1.98	-41.70	-7.74	-2.15	-0.11	2.68	0.70
35. MC-82 x MC-34	-1.18	-5.09	-9.24	-3.02	-0.50	-0.17	1.56	2.03

Contd.

Table 25. Continued

1	2	3	4	5	6	7	8	9
36. MC-79 x MC-66	-1.12	0.26	-22.94	0.38	-0.32	0.08	-2.32	-5.27
37. MC-79 x MC-49	-1.57	-11.18	-16.55	3.32	0.49	0.25	-0.44	-2.77
38. MC-79 x MC-69	0.00	-6.78	-3.77	-0.16	2.46	0.28	0.87	-0.96
39. MC-79 x MC-34	0.31	-6.64	16.95	2.25	0.20	0.47	0.49	-0.75
40. MC-66 x MC-49	0.84	2.44	6.39	0.93	-0.04	-0.18	0.08	0.40
41. MC-66 x MC-69	0.44	-2.40	12.17	0.45	0.73	0.21	0.89	-2.20
42. MC-66 x MC-34	-0.89	-1.27	-9.86	0.27	0.52	-0.08	-0.74	-0.37
43. MC-49 x MC-69	0.22	1.16	9.32	4.09	0.34	-0.05	1.27	0.09
44. MC-49 x MC-34	1.83	6.80	20.54	0.30	0.43	-0.36	0.39	0.17
45. MC-69 x MC-34	-0.76	-2.79	-10.43	0.17	0.09	0.30	-1.55	-1.43
SE (sij)	0.03	0.58	0.73	0.14	0.04	0.05	0.26	0.24
SE (sij-sik)	0.10	1.94	2.42	0.42	0.14	0.17	0.85	0.79
SE (sij-skl)	0.10	1.84	2.31	0.04	0.14	0.17	0.82	0.75

and MC-82 x MC-34 (2.03) in the third seasons had the higher sca effects.

3. Heterosis in bitter gourd

General analysis of variance for 10 parents and 45 hybrids indicated significant differences among the genotypes in all the three seasons for all the characters, except days to picking maturity in the third season (Table 15). The Relative Heterosis (RH), heterobeltiosis (HB) and standard heterosis (SH) calculated are presented in Table 26 to 40.

a. Branches/plant

Out of 45 F_1 hybrids significant relative heterosis was shown by 16 in first, 12 in second and 22 in third seasons. Arka Harit x MC-79 recorded the highest heterosis of 37.9%, 53.09% and 33.33% in first, second and third seasons respectively. Other crosses like Arka Harit x MC-82 (26.67%) in first, MC-82 x MC-66 (31.11%), MC-84 x MC-49 (23.72%) and Priya x MC-79 (23.31%) in second and Arka Harit x MC-82 (26.17%) in third seasons had higher values of relative heterosis.

Significant heterobeltiosis was recorded by three hybrids in first, seven in second and four in third seasons. Arka Harit x MC-82 in first and third (15.15% and 14.63%) and MC-84 x MC-49 (19.82%) in second seasons recorded highest values of heterobeltiosis for this trait.

Standard heterosis was significant for eight hybrids in first, ten in second and nine in third seasons. Arka Harit x MC-79 recorded consistently higher standard heterosis in all the three seasons (32.17%, 50.43% and 35.54%). Other crosses with higher standard heterosis are Priya x MC-79 in first (16.78%) and second (42.61%) seasons.

b. Main vine length

Fifteen hybrids in first, one in second and ten in third seasons recorded significant relative heterosis for vine length. Arka Harit x MC-79 had the highest and consistent relative heterosis (44.42%, 57.58% and 42.29%).

None of the hybrids showed significant heterobeltiosis in first and second seasons. However, in the third season it was significant for the crosses Priya x MC-79 (8.63%) and MC-66 x MC-49 (14.35%).

Significant standard heterosis was observed in five crosses in first and three in third seasons. It was not significant in second season. The crosses MC-78 x MC-79 (14.4%) and Priya x MC-79 (23.27%) recorded the highest values for the first and third seasons respectively.

c. Node to first female flower

Significant and negative relative heterosis was observed for seven hybrids in first, five in second and six in third seasons. MC-49 x MC-34 (-10.0%) and MC-84 x Arka Harit (-10.3%) in first, Priya x Arka Harit (-9.94%) in second and MC-78 x MC-69 (-11.9%) and MC-84 x Arka Harit (-11.66%) in third seasons recorded highest negative heterosis for node of first female flower formation.

Heterobeltiosis was significant for four hybrids in first and three in third seasons. There was no significant heterobeltiosis in the second season. The hybrids MC-49 x MC-34 (-8.99%) and MC-78 x MC-69 (-9.76%) possessad highest and negative values in first and third seasons respectively.

Considerable standard heterosis was observed in all the three seasons for many hybrids. The hybrids with highest standard heterosis observed were Arka Harit x MC-82 (-18.68%), MC-84 x Arka Harit (-18.68%), MC-78 x MC-82

Table 26. Mean performance of parents and F_1 hybrids and extent of heterosis for branches/plant, vine length and node to first female flower during first season

Parents/crosses	Branches/plant				Main vine length (m)				Node to first female flower			
	Mean	RH (%)	HB (%)	SH (%)	Mean (m)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	37.75				6.25				22.75			
MC 78	35.25				6.38				22.25			
MC 84	35.63				6.77				22.50			
Arka Harit	24.63				2.63				18.75			
MC 82	20.38				2.08				19.38			
MC 79	43.75				7.55				20.13			
MC 66	37.50				5.90				21.75			
MC 49	33.75				5.35				22.25			
MC 69	32.75				5.19				20.75			
MC 34	31.75				5.75				22.75			
Priya x MC 78	34.63	-2.11	-2.79	-2.79	6.48	2.61	1.57	3.60	22.75	1.11	2.22	0.00
Priya x MC 84	35.50	-0.35	-0.69	-0.69	6.50	0.75	3.92	4.00	22.50	-0.55	0.00	-1.09
Priya x Arka Harit	30.63	1.65	-13.99	-13.99	4.50	1.40	-28.00	-28.00	20.50	-1.20	-9.33	-9.90**
Priya x MC 82	28.50	1.78	-7.48	-7.47	4.25	2.10	-32.00	-32.00	20.50	-2.94	5.12	-9.90**
Priya x MC 79	41.63	5.03**	-4.57	16.78**	7.05	2.17	-6.62	12.80**	21.50	0.00	6.17	-5.49*
Priya x MC 66	38.88	4.02*	3.33	8.39**	5.88	-3.29	-6.00	-6.00	21.50	-2.80	-1.15	-5.49*
Priya x MC 49	34.50	-0.72	-3.50	-3.50	6.15	6.03**	-1.60	-1.60	21.50	-4.40	-3.37	-5.49*
Priya x MC 69	33.50	-2.23	-6.29	-6.29	6.05	5.76**	-3.20	-3.20	20.50	-5.74*	-1.20	-9.90**

Contd.

Table 26. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Priya x MC 34	34.50	2.22	-3.49	-3.49	6.18	2.96	-1.20	-1.20	21.50	-5.49	-5.49*	-5.49*
MC 78 x MC 84	35.50	0.35	0.00	-0.69	6.75	2.74	-0.22	8.00**	21.75	-2.79	-2.25	-4.40
MC 78 x Arka Harit	31.80	4.47*	-9.22	-10.49	5.15	14.44**	-19.21	-17.60	20.00	-2.44	6.67	-12.09**
MC 78 x MC 82	29.00	4.50*	-17.73	-18.88	4.60	0.89	-27.80	-26.40	20.25	-2.76	-3.85	-10.99**
MC 78 x MC 79	41.00	3.80*	-6.29	14.69**	7.19	2.69	-5.30	14.40	21.25	0.31	4.94	-6.60**
MC 78 x MC 66	37.50	3.09	0.00	4.90**	5.90	-3.87	-7.45	-5.60	20.75	-5.68*	-4.60	-8.80**
MC 78 x MC 49	37.63	-2.54	-4.25	-5.60	6.13	4.48**	-3.92	-2.00	22.25	0.00	0.00	-2.20
MC 78 x MC 69	31.38	-7.79	-10.61	-11.89	5.90	2.03	-7.45	-5.60	20.75	3.60	0.00	-8.80**
MC 78 x MC 34	33.00	-1.49	-6.38	-7.69	5.99	-1.07	-5.96	-4.00	21.50	-4.40	-3.37	-5.49*
MC 84 xArka Harit	30.75	2.07	-13.38	-13.97	4.85	3.30	-28.31	-2.40	18.50	-10.30**	-1.33	-18.68**
MC 84 x MC 82	30.00	7.62**	-15.49	-16.08	4.50	1.81	-33.81	-28.00	20.50	-2.95	5.12	-9.90**
MC 84 x MC 79	39.50	-3.10	-9.71	10.49**	7.00	-2.20	-7.28	12.00**	20.50	-3.80	1.23	-9.90**
MC 84 x MC 66	36.63	0.68	-2.00	2.80	6.15	-2.88	-9.09	-1.60	20.25	-8.40**	-6.90**	-10.99**
MC 84 x MC 49	34.00	1.81	-4.23	-4.90	6.13	1.11	-9.64	-2.00	22.25	-0.56	-0.00	-2.20
MC 84 x MC 69	33.50	-1.90	-5.60	-6.29	5.90	-1.30	-12.79	-5.60	21.25	-1.85	2.41	-6.60**
MC 84 x MC 34	31.50	-6.32	-11.20	-11.89	6.25	-0.08	-7.61	0.00	21.75	-3.87	-3.33	-4.40
Arka Harit x MC 82	28.50	26.67**	15.15**	-20.28	2.65	12.77**	0.95	-57.60	18.50	-3.01	-1.33	-18.68**
Arka Harit x MC 79	47.25	-37.96**	8.00**	32.17**	7.35	44.42**	-2.65	-17.60	20.50	5.48	9.33	-9.90**
Arka Harit x MC 66	30.50	-2.00	-18.67	-14.69	4.25	-0.29	-27.97	-32.00	19.75	-2.47	5.33	-13.19**

Contd.

Table 26. Continued

1	2	3	4	5	6
Arka Harit x MC 49	31.00	5.98*	-8.75	-13.29	4.25
Arka Harit x MC 69	28.00	-2.69	-14.63	-21.68	3.30
Arka Harit x MC 34	29.50	4.42	-10.00	-70.48	3.75
MC 82 x MC 79	36.50	14.96**	-16.57	2.86	4.75
MC 82 x MC 66	32.63	13.00**	-2.67	-8.81	4.50
MC 82 x MC 49	29.50	9.26**	-12.59	-17.48	4.75
MC 82 x MC 69	28.50	7.45**	-13.11	-20.28	4.00
MC 82 x MC 34	27.50	5.76*	-13.38	-23.08	4.05
MC 79 x MC 66	39.50	-2.77	-9.77	10.49**	6.15
MC 79 x MC 49	40.00	3.22	-8.57	11.89**	6.35
MC 79 x MC 69	37.88	-1.24	-13.60	5.73*	6.00
MC 79 x MC 34	36.50	-3.31	-16.57	2.10	6.85
MC 66 x MC 49	35.50	-0.35	-5.33	-0.69	6.15
MC 66 x MC 69	33.00	-6.12	-12.00	-7.69	5.35
MC 66 x MC 34	34.00	-1.81	-9.33	-4.90	5.30
MC 49 x MC 69	36.63	10.48**	8.89**	2.80	5.60
MC 49 x MC 34	34.50	5.34*	2.22	-3.49	6.00
MC 69 x MC 34	31.00	-3.95	-5.49	-13.29	5.15
CD (p=0.05)	1.73	1.49	1.73	1.73	0.28
CD (p=0.01)	2.28	1.96	2.28	2.28	0.36

7	8	9	10	11	12	13
6.58*	-20.56	-32.00	20.88	1.46	10.67	-8.86**
-15.55	-36.41	-47.20	19.38	-1.90	4.00	-14.29**
-10.39	-34.73	-40.00	21.75	4.82	0.16	-4.40
-1.30	-37.09	-24.00	20.75	4.40	6.41	-8.80**
12.85**	-23.73	-28.00	20.50	-0.61	5.13	-9.90**
27.95**	-11.12	-24.00	21.00	0.60	7.69	-7.70**
10.12**	-22.93	-36.00	20.50	1.86	5.12	-9.90**
3.58	-29.50	-35.20	20.50	-3.96	5.12	-9.90**
-8.55	-18.54	-1.60	21.25	1.19	4.94	-6.60**
-1.55	-15.89	1.60	21.25	1.18	6.17	-5.49*
-5.80	-20.05	-4.00	21.50	4.89	6.17	-5.49*
3.01	-9.27	9.60**	21.25	-1.16	4.94	-6.60**
9.33**	4.23	-1.60	20.25	-6.90**	-6.89**	-10.09**
-3.52	-9.32	-14.40	20.50	-3.53	-1.20	-9.90**
-8.90	-10.17	-15.20	21.50	-3.33	-1.15	-5.49*
-6.26	4.67	-10.40	21.50	0.00	3.61	-5.49*
8.16**	4.44	-4.00	20.25	-10.00**	-8.99**	-10.09**
-3.98	1.16	-16.00	22.50	3.45	8.43	-1.05
0.24	0.28	0.28	1.04	1.25	1.04	1.04
0.31	0.36	0.36	1.36	1.65	1.36	1.36

Table 27. Mean performance of parents and F_1 hybrids and extend of heterosis for branches/plant, vine length and node to first female flower in bitter gourd during second season

Parents/Crosses	Primary branches/plant				Main vine length				Node to first female flower			
	Mean	RH (%)	HB (%)	SH (%)	Mean (m)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	28.75				6.18				23.25			
MC 78	28.25				6.05				22.00			
MC 84	27.75				5.38				21.50			
Arka Harit	18.75				2.05				19.50			
MC 82	15.75				1.88				19.25			
MC 79	37.75				6.45				18.50			
MC 66	29.25				4.95				22.25			
MC 49	26.00				5.03				21.00			
MC 69	24.13				4.43				21.75			
MC 34	26.88				4.73				22.75			
Priya x MC 78	25.50	-10.53	-11.30	-11.30	6.18	1.19	0.16	0.16	22.75	0.55	3.40	-2.15
Priya x MC 84	26.50	-6.19	-7.82	-7.82	6.03	4.42	-2.30	-2.30	22.00	-1.68	2.33	-5.38*
Priya x Arka Harit	20.50	-13.68	-28.69	-28.69	2.88	-30.21	-53.52	-53.52	19.25	-9.94**	-1.28	-17.20**
Priya x MC 82	16.75	-24.72	-41.74	-41.74	2.28	-43.48	-63.16	-63.16	22.25	4.71	15.50	-4.30
Priya x MC 79	41.00	23.31**	8.61**	42.61**	6.43	1.78	-0.39	4.01	21.75	4.19	17.57	-6.45*
Priya x MC 66	29.25	0.86	0.00	1.74	5.83	4.72	-5.71	-5.67	23.25	2.20	4.49	0.00
Priya x MC 49	30.75	12.33**	6.95**	6.95**	5.90	5.36	-4.45	-4.45	21.75	-1.70	3.57	-6.45*
Priya x MC 69	26.50	-4.07	-7.83	-7.83	4.30	-18.87	-30.36	-30.36	22.75	1.11	4.60	-2.15

Table 27. Continued

1	2	3	4	5
Priya x MC 34	22.75	-4.50	-20.86	-20.86
MC 78 x MC 84	25.50	-8.93	-9.73	-11.30
MC 78 x Arka Harit	22.75	-4.26	-19.46	-20.87
MC 78 x MC 82	16.88	-23.64	-40.50	-41.56
MC 78 x MC 79	33.75	2.27	-10.60	17.39**
MC 78 x MC 66	29.75	3.49	1.71	3.48
MC 78 x MC 49	29.00	6.91*	2.65	0.87
MC 78 x MC 69	25.75	-1.45	-8.85	-10.43
MC 78 x MC 34	27.75	-0.91	-1.77	-3.48
MC 84 x Arka Harit	22.50	-3.22	-18.92	-21.74
MC 84 x MC 82	17.00	-21.84	-38.74	-40.87
MC 84 x MC 79	32.25	15.27**	-1.32	29.57**
MC 84 x MC 66	31.50	10.53**	7.69**	9.57**
MC 84 x MC 49	33.25	23.72	19.82	15.65
MC 84 x MC 69	24.25	-6.28	-12.61	-15.65
MC 84 x MC 34	27.25	0.00	-1.80	-5.22
Arka Harit x MC 82	17.25	0.00	-8.00	-40.00
Arka Harit x MC 79	43.25	53.09**	14.56**	50.43**
Arka Harit x MC 66	28.75	19.79**	-1.71	0.00

6	7	8	9	10	11	12	13
5.18	-4.86	-16.03	-16.03	22.75	-1.01	0.00	-2.15
5.68	-0.56	-6.12	-8.02	23.25	6.90	8.13	0.00
2.88	-28.89	-52.40	-53.36	21.75	4.82	11.54	-6.45*
2.32	-41.30	-61.57	-62.35	22.25	7.88	15.58	-4.30
6.38	2.00	-1.08	3.32	21.25	4.94	14.86	-8.60**
5.13	-6.64	-15.12	-16.84	22.75	2.80	3.41	-2.15
5.33	-3.66	-11.82	-13.60	22.50	4.65	7.14	-3.23
4.97	-5.11	-17.85	-19.51	23.50	7.43	8.04	1.08
5.18	-3.94	-14.46	-16.19	21.50	-3.50	2.27	-7.53**
2.72	-26.60	-49.30	-55.87	19.25	-6.10*	-1.28	-17.20**
2.18	-39.86	-59.44	-64.70	20.50	0.61	6.40	-11.83**
6.18	4.61	-4.11	1.00	21.25	6.25	14.86	-8.60**
5.41	4.79	-4.37	-12.39	22.50	2.86	4.65	-3.23
5.14	-1.15	-4.37	-16.76	23.50	10.59	11.90	1.08
4.88	-0.41	-9.21	-20.97	22.25	2.89	3.48	-4.30
4.81	-4.75	-10.51	-22.11	23.25	5.08	8.14	0.00
1.91	-2.90	-7.07	-69.50	20.50	5.80	6.49	-11.83**
6.67	57.58**	-3.49	8.10	18.25	3.94	-1.35	-21.50**
2.78	-20.57	-43.84	-54.98	22.50	7.78	15.38	-3.23

Contd.

Table 27. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Arka Harit x MC 49	27.50	22.90**	5.77*	-4.35	3.05	-13.81	39.30	-50.61	22.00	8.64	12.82	-5.38*
Arka Harit x MC 69	21.50	0.58	-10.42	-25.21	2.84	-12.12	-35.71	-53.93	21.00	1.82	7.69	-9.68**
Arka Harit x MC 34	19.50	-14.28	-27.10	-32.17	3.09	-8.78	-34.60	-49.86	22.75	7.69	16.67	-2.15
MC 82 x MC 79	32.50	21.49**	-13.91	-13.04**	2.28	-45.11	-64.57	-62.30	20.75	9.93	12.16	-10.75**
MC 82 x MC 66	29.50	31.11**	0.85	2.61	2.70	-20.73	-45.35	-66.19	19.25	-7.23*	0.00	-17.20**
MC 82 x MC 49	25.00	19.70**	-3.81	-13.04	2.96	-14.35	-41.19	-52.15	22.50	11.80	16.88	-3.23
MC 82 x MC 69	20.25	1.89	-3.75	-29.57	3.16	0.48	-28.47	-48.74	22.75	10.98	18.18	-2.15
MC 82 x MC 34	19.25	-9.41	-28.04	-33.04	2.31	-30.00	-51.11	-62.59	20.75	-1.15	7.79	-10.75**
MC 79 x MC 66	33.00	1.49	-12.58	14.78**	5.33	-6.49	-17.36	-13.68	21.75	6.75	17.57	-6.45*
MC 79 x MC 49	31.00	-2.70	-17.88	7.83**	6.13	6.75	-5.04	-0.81	22.00	11.39	18.92	-5.38*
MC 79 x MC 69	23.75	-23.70	-37.09	-17.39	5.10	-5.66	-20.47	-16.92	21.75	-8.07	17.57	-6.45*
MC 79 x MC 34	25.00	-22.48	-33.77	-13.04	4.94	-11.59	-23.41	-20.00	22.50	9.09	21.63	-3.23
MC 66 x MC 49	32.00	15.83**	9.40**	11.30**	5.13	2.76	-1.79	-17.00	23.25	7.51	10.70	0.00
MC 66 x MC 69	26.00	-2.34	-11.11	9.57	4.65	-0.69	-6.00	-24.62	20.50	-6.82*	-5.75	-11.83**
MC 66 x MC 34	23.00	-17.85	-21.37	-20.00	4.76	-1.71	-3.94	-23.00	21.50	-4.44	-3.37	-7.53**
MC 49 x MC 69	26.00	4.00	0.00	-9.57	4.58	-3.07	-8.86	-25.83	23.25	8.77	10.31	0.00
MC 49 x MC 34	27.50	4.27	2.80	-4.35	4.76	-2.26	-5.17	-22.84	23.25	6.29	10.71	0.00
MC 69 x MC 34	26.38	4.04	-1.30	-8.17	4.28	-6.56	-9.52	-30.77	21.50	-3.37	-1.15	-7.53*
CD (p=0.05)	2.12	1.84	2.12	2.12	0.62	0.51	0.62	0.62	1.48	1.27	1.48	1.27
CD (p0.01)	2.79	2.42	2.79	2.79	0.81	1.31	0.81	0.81	1.94	1.67	1.67	1.67

Table 28. Mean performance of parents and F_1 hybrids and extent of heterosis for branches/plant, vine length and node to first female flower during third season

Parents/Crosses	Primary branches/plant				Main vine length				Node to first female flower			
	Mean	RH (%)	HB (%)	SH (%)	Mean (m)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
	2	3	4	5	6	7	8	9	10	11	12	13
Priya	31.75				6.13				21.50			
MC 78	30.25				5.78				21.50			
MC 84	31.50				5.68				22.50			
Arka Harit	20.50				2.38				18.25			
MC 82	16.75				2.05				18.50			
MC 79	40.50				6.95				19.50			
MC 66	33.50				5.05				20.75			
MC 49	31.50				5.00				20.75			
MC 69	28.75				4.63				20.38			
MC 34	28.00				4.98				21.75			
Priya x MC 78	32.50	4.83**	2.36*	2.30	6.23	4.62	1.63	1.63	20.75	-3.49	-3.49	-3.49
Priya x MC 84	30.75	-2.77	-3.15	-3.15	5.90	0.00	3.67	3.67	21.30	-3.18	-0.93	-0.93
Priya x Arka Harit	24.75	-5.26	-22.05	-22.05	5.05	-4.70	-33.87	-33.87	20.00	0.63	9.50	-6.97
Priya x MC 82	25.75	6.18**	-18.90	-18.90	3.78	-7.64	-38.36	-38.36	19.25	-5.53	4.05	-10.46**
Priya x MC 79	37.50	4.52**	-6.66	18.11**	7.55	15.48**	8.63**	23.27**	20.50	0.00	51.28	-4.65
Priya x MC 66	35.00	7.27**	4.48**	10.23**	5.05	-9.61	-17.55	-17.55	20.75	-1.78	0.00	-3.49
Priya x MC 49	29.75	-5.17	-6.29	-6.29	5.63	1.12	-8.16	-8.16	20.50	-2.96	-12.05**	-4.65
Priya x MC 69	29.75	-1.65	-6.29	-6.29	5.55	3.25	-9.38	-9.38	20.50	-2.38	0.00	-4.65

Contd...

Table 28. Continued

1	2	3	4	5	6
Priya x MC 34	27.50	-7.95	-13.38	-13.38	5.63
MC 78 x MC 84	31.50	2.02	0.00	3.14	5.63
MC 78 x Arka Harit	28.25	11.33**	-6.61	-11.02	4.63
MC 78 x MC 82	23.50	0.00	-23.31	-25.98	3.93
MC 78 x MC 79	35.00	-0.35	-12.50	10.23**	6.50
MC 78 x MC 66	33.00	3.52**	-1.49	3.94	5.98
MC 78 x MC 49	30.25	-1.22	-2.42	-4.96	5.63
MC 78 x MC 69	25.75	-12.71	-14.87	-18.90	5.25
MC 78 x MC 34	29.25	0.43	-3.30	-3.31	5.38
MC 84 x Arka Harit	26.00	0.00	-17.46	-14.05	3.95
MC 84 x MC 82	27.50	13.99**	-12.69	-13.38	3.78
MC 84 x MC 79	34.50	-3.49	-13.79	14.05**	6.88
MC 84 x MC 66	33.50	3.07*	0.00	10.74**	5.90
MC 84 x MC 49	29.50	-5.60	-6.34	-2.48	5.48
MC 84 x MC 69	29.00	-3.73	-7.93	-4.13	5.38
MC 84 x MC 34	28.50	-4.20	-9.52	-5.79	5.53
Arka Harit x MC 82	23.50	26.17**	14.63**	-22.31	2.23
Arka Harit x MC 79	41.00	33.33**	2.50*	35.54**	6.63
Arka Harit x MC 66	26.50	-1.85	-20.89	-12.40	3.88

7	8	9	10	11	12	13
1.35	-8.16	-8.16	20.63	-5.20	-3.48	-4.49
-1.74	-2.50	-8.16	20.75	-5.68	-3.49	-3.49
13.49**	-19.91	-24.49	20.00	0.63	9.58	-6.97
0.31	-32.03	-55.92	19.50	-2.50	5.40	-9.30**
2.16	-6.47	-6.12	20.75	1.22	6.41	-3.49
10.39**	3.46	-2.45	19.00	-10.06**	-8.43**	-11.63**
4.40	-2.60	-8.16	21.25	0.59	2.41	-1.16
0.96	-9.09	-14.29	28.50	-11.90**	-9.76**	-13.95**
0.00	-6.93	-12.24	20.75	-4.05	-3.40	-3.49
-1.86	-30.40	-35.50	18.00	-11.66**	-1.37	-16.27**
-2.26	-33.48	-38.37	19.50	-4.88	5.40	-9.30**
8.19**	-1.07	12.24**	19.50	-7.14**	0.00	-9.30**
10.02**	2.16	3.67	29.63	-9.83**	6.02	-9.30**
2.57	-5.19	-10.61	20.75	-4.05	0.00	-3.49
4.37	-5.19	-12.24	20.63	-4.65	0.00	-4.65
3.75	-4.32	-9.78	20.75	-6.21*	-4.60	-3.49
0.56	-6.31	-63.67	18.25	-0.68	0.00	-15.12**
42.09**	-4.67	8.18*	19.75	4.64	8.22	-8.14*
4.37	-23.26	-36.73	29.50	0.00	6.84	-9.30**

Contd.

Table 28. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Arka Harit x MC-49	27.50	-6.78	-11.29	-13.38	3.78	2.37	-24.50	-38.37	20.50	5.13	12.33	-4.65
Arka harit x MC-69	24.00	-2.53	-16.52	-20.66	3.05	-12.85	-34.05	-50.20	18.75	-3.22	2.74	-12.80**
Arka Harit x MC-34	24.50	1.03	-12.50	-19.00	3.15	-14.28	-36.60	-48.57	20.63	2.50	12.33	-4.62
MC-82 x MC-79	31.88	12.33**	-20.06	5.35	4.15	-7.78	-40.28	-32.24	19.75	3.95	6.76	-8.14*
MC-82 x MC-66	28.75	14.42**	-14.17	-4.96	4.00	12.67**	-20.79	-34.70	19.50	0.64	5.41	-9.30**
MC-82 x MC-49	25.50	6.80**	-17.74	-15.70	4.05	14.89**	-19.00	-33.87	20.00	1.91	8.10	-6.97
MC-82 x MC-69	24.00	5.49**	-16.52	-20.66	4.05	21.35**	-12.43	-33.87	19.50	0.00	5.41	-9.30**
MC-82 x MC-34	24.25	8.37**	-13.39	-19.83	3.10	-11.76	-37.68	-49.38	20.00	-0.62	8.10	-6.97
MC-79 x MC-66	35.25	-4.08	-11.87	16.53**	3.75	-37.50	-46.07	-38.00	20.25	0.62	3.85	-5.80
MC-79 x MC-49	37.50	5.63**	-6.25	18.11**	5.50	-7.94	-20.80	-10.20	21.00	4.34	7.69	-2.33
MC-79 x MC-69	33.75	14.89**	-15.65	11.57**	5.85	1.07	-15.82	-4.49	20.50	2.50	-5.13	-4.65
MC-79 x MC-34	31.50	8.62**	-21.25	4.13	6.00	0.62	-13.66	-2.04	21.00	1.82	7.61	-2.33
MC-66 x MC-49	31.75	-1.55	-5.22	4.96	5.78	14.92**	14.35**	5.71	19.75	-4.82	-4.82	-8.14*
MC-66 x MC-69	28.75	-7.63	-14.17	-4.96	4.93	1.80	-2.48	-19.60	20.00	-3.03	-2.44	-6.97
MC-66 x MC-34	32.00	4.06**	-4.48	5.79	4.83	-3.74	-3.46	-21.22	20.25	-4.71	-2.41	-5.80
MC-49 x MC-69	31.00	3.76**	0.00	2.48	5.05	4.90	1.00	-17.55	20.00	-3.03	-2.44	-6.97
MC-49 x MC-34	37.75	4.23**	-0.81	1.65	5.15	3.25	3.00	-15.92	20.25	-4.71	-2.41	-5.80
MC-69 x MC-34	27.50	-0.06	-3.91	-8.76	4.88	1.56	-2.00	-20.41	21.88	2.95	6.10	1.16
CD (p=0.05)	1.91	1.65	1.91	1.91	0.52	0.45	0.52	0.52	1.57	1.35	1.57	1.57
CD (p=0.01)	2.51	2.16	2.51	2.51	0.68	0.59	0.68	0.68	2.08	1.77	2.06	2.06

(-10.99%) and MC-84 x MC-66 (-10.99%) in first, Arka Harit x MC-79 (-21.5%), MC-84 x Arka Harit (-17.2%), Priya x Arka Harit (-17.2%) in second and MC-84 x Arka Harit (1-6.27%) and Arka Harit x MC-82 (-15.12%) in third sesons.

d. Days to first female flower opening

Out of 45 hybrids, 16 in first, 10 in second and 28 in third seasons showed significant and negative heterosis over mid parents. Hybrids with higher and negative relative heterosis were MC-79 x MC-34 (-13.17%), Arka Harit x MC-66 (-9.97%), MC-79 x MC-69 (-9.75%) and MC-79 x MC-49 (-9.37%) in first, Arka Harit x MC-49 (-10.03%) and Priya x MC-49 (-8.77%) in second and MC-49 x MC-34 (-14.11%), MC-79 x MC-34 (-11.49%) and Arka Harit x MC-66 (-10.02%) in third seasons.

Heterobeltiosis was significant for five hybrids in first, nine in second and ten in third seasons. Arka Harit x MC-66 (-7.6%) and MC-84 x Arka Harit (-5.56%) in first, Arka Harit x MC-49 (-7.65%) and MC-84 x Arka Harit (-5.88%) in second and Arka Harit x MC-66 (-7.47%) and MC-49 x MC-34 (-7.25%) in third seasons.

Standard heterosis was significant for 17 hybrids in first, one in second and 27 in third seasons. During the first season, MC-66 x MC-49 (-14.97%) (Plate 27), MC-49 x MC-34 (-13.28%) and MC-79 x MC-34 (-13.17%) had highest negative standard heterosis. MC-49 x MC-34 (-17.65%), MC-82 x MC-49 (-13.53%), MC-82 x MC-34 (-11.76%), MC-66 x MC-49 (12.44), MC-84 x MC-49 (-11.18%) and MC-79 x MC-34 (-11.18%) recorded maximum standard heterosis in the third season.

e. Female flowers/plant

Relative heterosis was significant and positive in nine crosses each in first and third and 13 in second season. It was maximum in Arka Harit x MC-79 (19.25%) and MC-49 x MC-34 (19.25%) in first, MC-79 x MC-49 (28.77%) followed by MC-49 x MC-34 (27.65%) and Arka Harit x MC-49 (23.51%) in second and Arka Harit x MC-79 (27.69%) followed by MC-82 x MC-79 (14.97%) in the third seasons.

Out of 45 hybrids, 17 in first, 16 in second and 17 in third seasons exhibited significant standard heterosis. Highest values were shown by Arka Harit x MC-79 (88.92%) followed by MC-82 x MC-79 (54.98%) and [illegible] in first, MC-79 x MC-49 (79.22%),

Table 27. Mean performance of parents and F_1 hybrids and extent of heterosis for female flower characters during first season

Parents/Crosses	Days to opening of first Female flowers				Female flowers/plant				Percentage of female flower			
	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	41.75				67.75				6.26			
MC 78	44.00				54.50				5.38			
MC 84	45.25				57.50				4.55			
Arka Harit	45.00				32.00				3.45			
MC 82	40.00				102.00				2.96			
MC 79	47.00				106.75				2.86			
MC 66	42.75				81.75				6.36			
MC 49	35.75				60.75				6.63			
MC 69	42.75				68.50				6.65			
MC 34	36.50				71.50				4.55			
Priya x MC 78	44.63	3.79	6.58	6.58	57.00	-6.75	-15.87	-15.87	6.08	4.50**	-2.79	-2.79
Priya x MC 84	45.00	3.44	7.78	7.78	51.00	-18.56	-24.72	-24.72	5.88	8.75**	-6.08	-6.08
Priya x Arka Harit	43.50	0.29	4.19	4.19	39.50	-20.80	-41.70	-41.70	4.43	-8.81	-29.26	-29.26
Priya x MC 82	40.50	-1.16	1.25	-3.00	77.50	-8.69	-24.02	14.39**	4.55	-0.01	-27.26	-27.26
Priya x MC 79	45.50	2.36	8.98	8.98	104.00	19.20**	-2.76	53.50**	5.85	28.36**	-6.47	-6.47
Priya x MC 66	41.50	-1.78	-0.60	-0.60	65.00	-13.04	-20.49	-4.06	6.29	-2.24	-1.02	0.56
Priya x MC 49	39.00	0.65	9.90	-6.59**	66.00	-11.71	-2.58	-2.58	6.75	4.81**	1.89	7.91**
Priya x MC 69	40.50	-4.14	-3.00	-3.00	55.50	-18.53	-18.98	-18.08	6.25	-3.14	-6.02	-0.08

Contd.

Table 27. Continued

1	2	3	4	5
Priya x MC 34	38.50	-1.60	5.48	-7.78
MC 78 x MC 84	46.50	4.49	5.68	11.38
MC 78 x Arka Harit	43.63	-1.69	-0.57	4.79
MC 78 x MC 82	42.50	1.19	6.25	1.80
MC 78 x MC 79	45.50	0.00	3.41	8.98
MC 78 x MC 66	40.50	-6.63**	-5.26**	-3.00
MC 78 x MC 49	39.13	-2.19	9.09	-6.59**
MC 78 x MC 69	42.00	-3.17	-1.75	-0.60
MC 78 x MC 34	37.75	-6.21**	3.42	-9.52**
MC 84 x Arka Harit	42.50	-5.82**	-5.56**	1.80
MC 84 x MC 82	40.50	-4.99**	1.25	-3.00
MC 84 x MC 79	44.50	-3.52	1.66	6.59
MC 84 x MC 66	40.50	-7.95**	-5.26**	-3.00
MC 84 x MC 49	37.00	-8.64**	3.50	-11.38**
MC 84 x MC 69	44.00	0.00	2.92	5.38
MC 84 x MC 34	38.50	-5.81**	5.47	-7.78**
Arka Harit x MC 82	45.50	7.06	13.75	8.98
Arka Harit x MC 79	45.50	1.09	1.11	8.98
Arka Harit x MC 66	39.50	-9.97**	7.60**	-5.39**

6	7	8	9	10	11	12	13
58.00	-16.85	-19.16	-14.39	5.95	10.34	-4.88	-4.88
47.00	-16.07	-18.26	-30.63	5.15	3.73	-4.28	-17.67
31.00	-28.32	-46.09	-54.24	3.85	-12.79	-28.44	-38.45
81.50	5.43	-9.12	21.77**	3.25	-22.02	-39.59	-48.04
89.50	13.74**	-16.63	31.37**	4.15	0.73	-22.86	-33.66
76.63	12.66**	-6.12	13.29**	5.85	-0.30	-7.94	-6.47
68.63	18.87**	12.76**	1.11	6.55	9.12**	-1.13	4.72**
55.00	-10.57	-19.71	-18.82	6.40	6.40**	-3.76	2.32
65.00	2.97	-9.41	-4.06	5.55	12.00**	3.16	-11.27
33.00	-26.26	-42.61	-51.29	3.95	-0.01	-13.19	-36.85
75.00	-5.96	-26.47	-10.70	3.45	-8.06	-24.18	-44.84
85.25	3.81	-20.14	25.83**	3.75	1.21	-17.58	-40.00
66.75	-4.13	-18.35	-1.48	5.95	9.12**	-6.37	-4.88
60.25	1.90	-0.82	-11.07	5.95	6.49**	-10.19	-4.88
48.50	-23.01	-29.20	-28.41	5.75	2.68	-13.53	-8.07
85.50	-14.12	-22.65	-18.08	4.45	-2.20	-2.20	-28.85
67.00	0.00	-34.43	-1.10	3.48	8.51**	0.73	-44.44
128.00	84.50**	19.91**	88.92**	3.15	0.00	-8.69	-49.60
51.50	-9.45	-37.00	-23.99	5.55	13.21**	-12.67	-11.27

Contd.

Table 27. Continued

1	2	3	4	5	6
Arka Harit x MC 49	38.50	-4.64*	7.69	-7.78**	37.
Arka Harit x MC 69	42.75	-2.56	0.00	2.40	33.
Arka Harit x MC 34	39.50	-3.07	8.22	-5.39**	46.
MC 82 x MC 79	42.50	-2.30	6.25	1.80	105.
MC 82 x MC 66	42.50	2.72	6.25	1.80	81.
MC 82 x MC 49	45.50	20.13	27.27	8.98	75.
MC 82 x MC 69	41.50	0.30	3.75	0.60	71.
MC 82 x MC 34	37.00	-3.27	21.23	-11.38**	85.
MC 79 x MC 66	44.25	-1.39	3.50	5.98	98.
MC 79 x MC 49	37.50	-9.37**	4.90	-10.18**	94.
MC 79 x MC 69	40.50	-9.75**	-5.26**	-3.00	92.
MC 79 x MC 34	36.25	-13.17**	-2.74	-13.17**	100.
MC 66 x MC 49	35.50	-9.55**	-0.92	-14.97**	79.
MC 66 x MC 69	40.50	-5.26	-2.60	-3.00	60.
MC 66 x MC 34	37.50	-5.36*	2.74	-10.18**	63.
MC 49 x MC 69	36.50	-7.00**	2.10	-12.57**	58.
MC 49 x MC 34	35.50	-1.73	0.69	-13.28**	79.
MC 69 x MC 34	37.50	-5.36*	2.74	-10.18**	59.
CD (p=0.05)	1.53	1.86	1.53	1.53	5.
CD (p=0.01)	2.01	2.45	2.01	2.01	7.

	7	8	9	10	11	12	13
00	-20.28	-39.09	-45.39	5.75	14.14**	-13.21	-8.07
25	-33.83	-51.46	-50.92	5.95	17.82**	-10.53	-4.88
00	-11.33	-35.89	-32.10	3.40	-15.00	-25.27	-45.64
00	0.60	-1.63	54.98**	2.95	1.46	-0.50	-52.84
00	-11.84	-20.59	19.56**	5.25	12.78**	-17.39	-16.07
50	-7.22	-25.98	10.70**	5.85	22.13**	-11.70	-6.47
50	-16.13	-29.90	5.54	5.25	9.32**	-21.05	-16.07
50	-1.58	16.18**	26.20**	4.25	13.26**	-0.07	-32.05
63	4.78	-7.49	45.79**	3.40	-26.20	-46.49	-45.64
00	12.24**	-11.94	38.95**	5.25	10.70**	-20.75	-16.07
00	5.00	-13.81	35.79**	5.00	5.15**	-24.81	-20.06
50	12.61**	-5.85	48.34**	4.20	13.36**	-7.69	-32.85
25	11.23**	-3.06	16.97**	6.45	-0.62	-2.64	-3.12
50	-19.47	-25.99	-10.70	6.30	3.11	-5.26	0.72
25	-17.59	-22.63	-6.64	5.85	7.30**	-7.95	-6.47
63	-9.09	-14.23	-13.28	6.70	0.94	0.75	7.10**
00	19.25**	10.10**	16.60**	6.75	20.81**	1.89	7.91**
50	-15.15	-17.07	-12.17	5.55	-8.93	-16.54	-11.27
91	5.12	5.91	5.91	0.28	0.24	0.28	0.28
76	6.72	7.76	7.76	0.36	0.31	0.36	0.36

Table 30. Mean performance of parents and F_1 hybrids and extent of heterosis for female flower characters during second season

Parents/Crosses	Days to first female flower opening				Female flowers/plant				Percentage of female flowers			
	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	40.75				57.75				5.95			
MC 78	41.75				45.25				4.62			
MC 84	42.50				50.13				4.37			
Arka Harit	42.50				21.75				2.85			
MC 82	39.75				68.25				2.47			
MC 79	43.50				111.25				3.12			
MC 66	43.50				58.75				5.62			
MC 49	44.75				49.50				5.12			
MC 69	42.50				53.25				4.62			
MC 34	40.25				47.25				4.12			
Priya x MC 78	41.50	0.61	1.84	1.84	58.25	-2.43	-12.90	-12.90	4.87	-7.80	-18.07	-18.07
Priya x MC 84	42.00	0.91	3.07	3.07	54.50	1.16	-5.63	-5.63	5.37	0.04	-9.66	-9.66
Priya x Arka Harit	40.50	-2.70	-0.61	-0.61	34.38	13.21	-40.26	-40.26	3.45	-21.59	-42.02	-42.02
Priya x MC 82	42.75	6.21	7.56	4.91	63.75	1.19	-6.59	10.38**	3.30	-21.66	-44.54	-44.54
Priya x MC 79	40.50	-3.86	-0.61	-0.61	66.00	-21.89	-40.67	14.29**	5.35	17.91**	-10.08	-10.08
Priya x MC 66	42.75	1.48	4.91	4.91	59.25	1.72	0.85	2.60	5.70	-1.51	-4.20	-4.20
Priya x MC 49	39.00	-8.77**	-4.29*	-4.29*	62.50	16.55**	8.23*	8.23*	6.30	13.77**	5.88**	5.88**
Priya x MC 69	42.75	2.70	4.90	4.90	52.75	-4.95	-8.66	-8.66	5.37	1.65	-9.66	-9.66

Contd.

Table 30. Continued

1	2	3	4	5	6
Priya x MC 34	39.75	-1.85	-1.23	-2.45	49.
MC 78 x MC 84	40.50	-3.86	-3.00	-0.61	49.
MC 78 x Arka Harit	43.00	2.08	3.00	5.52	26.
MC 78 x MC 82	40.50	-0.61	1.88	-0.61	62.
MC 78 x MC 79	39.25	-7.92**	-5.99**	-3.68	86.
MC 78 x MC 66	41.50	-2.30	-0.59	1.84	58.
MC 78 x MC 49	42.15	0.30	1.19	3.68	49.
MC 78 x MC 69	40.25	-4.48	-3.50*	-1.23	50.
MC 78 x MC 34	41.50	1.22	3.11	1.84	44.
MC 84 x Arka Harit	40.00	-5.88*	-5.88**	-1.84	34.
MC 84 x MC 82	31.25	-4.56	-1.26	-3.68	59.
MC 84 x MC 79	41.50	-3.49	-2.35	1.84	69.
MC 84 x MC 66	42.75	-0.58	-0.59	4.90	56.
MC 84 x MC 49	41.75	-4.30	-1.76	2.45	53.
MC 84 x MC 69	43.00	1.18	1.18	5.52	57.
MC 84 x MC 34	44.50	7.55	1.06	9.20	53.
Arka Harit x MC 82	44.50	7.60	11.32	8.59	41.
Arka Harit x MC 79	41.50	-3.49	-2.35	1.84	68.
Arka Harit x MC 66	40.50	-5.81*	-4.70**	-0.61	43.

	7	8	9	10	11	12	13
25	-6.64	-14.71	-14.71	4.87	-3.22	-18.07	-18.07
75	4.46	-0.50	-13.86	4.22	-6.11	-8.65	-28.99
75	-20.15	-46.50	-53.68	3.35	-10.37	-27.57	-43.69
25	9.69*	-8.79	7.79*	3.15	-11.27	-31.89	-47.06
25	10.22**	-22.47	49.35**	3.80	-1.94	-17.84	-36.13
00	11.54**	-1.28	0.43	5.70	11.22**	1.33	-4.20
00	3.43	-1.01	-15.15	5.55	13.85**	8.29**	-6.72
00	1.52	-6.10	-13.42	4.80	0.38	3.89**	-19.32
75	-3.76	-5.29	-22.51	4.37	0.00	-5.41	-26.47
50	-3.83	-31.00	-40.26	3.25	-10.03	-25.71	-45.37
88	1.48	-12.09	3.90	3.35	-2.19	-23.43	-43.69
00	-0.17	-37.91	19.48**	3.95	5.33*	-9.71	-33.61
75	4.37	-3.40	-1.73	4.85	-0.03	-13.78	-18.49
75	8.04	7.50*	-6.93	5.57	17.37**	8.75**	-6.36
00	1.21	-4.23	-11.69	4.12	-8.33	-10.81	-30.67
25	9.51*	6.50	-7.79	4.37	2.94	0.00	-26.47
00	-8.89	-39.93	-29.00	2.90	8.92**	1.75	-51.26
25	2.63	-31.65	18.18**	2.95	-1.26	-5.60	-50.42
50	8.07	-25.96	-24.68	4.12	-2.65	-26.67	-30.67

Contd.

Table 30. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Arka Harit x MC 49	39.25	-10.03**	-7.65**	-3.68	43.88	23.51**	-11.11	-23.80	4.42	10.97**	-13.66	-25.63
Arka Harit x MC 69	42.50	0.00	0.00	1.75	41.00	9.33	-23.00	-29.00	3.12	-16.39	-32.43	-47.48
Arka Harit x MC 34	40.50	-2.11	0.62	-0.61	32.50	5.78	-31.22	-43.72	3.32	-4.66	-19.39	-44.12
MC 82 x MC 79	38.50	-7.50**	-3.14	-5.52*	99.25	10.58**	-10.79	71.86**	3.27	16.96**	4.80**	-44.96
MC 82 x MC 66	42.50	2.10	6.92	1.75	65.25	2.75	-4.40	12.99**	3.35	-17.28	-40.44	-43.70
MC 82 x MC 49	40.25	-4.73*	1.26	-1.23	68.50	16.35**	0.37	18.61**	4.02	5.92*	-21.46	-32.35
MC 82 x MC 69	41.75	1.52	5.03	2.45	63.50	4.53	-6.96	10.00*	3.87	9.15**	-16.22	-34.87
MC 82 x MC 34	44.25	10.63	11.32	8.59	53.50	-7.35	-21.61	-7.36	2.80	-15.15	-32.12	-52.90
MC 79 x MC 66	42.50	-2.30	-2.30	1.75	96.25	13.24**	-13.48	66.67**	3.70	-15.42	-34.22	-37.82
MC 79 x MC 49	41.00	-7.08**	-5.75**	0.61	103.38	28.77**	-6.97	79.22**	3.92	-4.85	-23.41	-34.03
MC 79 x MC 69	42.50	-1.16	0.00	1.75	64.25	-21.88	-42.25	11.26**	3.87	0.00	-16.22	-34.87
MC 79 x MC 34	42.50	1.49	5.59	1.75	57.25	-27.76	-48.50	-0.87	3.37	-6.90	-18.18	-43.28
MC 66 x MC 49	41.50	-5.95**	-4.60**	1.84	65.25	20.55**	11.06**	12.99**	5.27	-1.86	-6.22	-11.34
MC 66 x MC 69	44.50	3.49	4.70	9.20	54.25	-3.13	-7.66	-6.06	4.37	-14.63	-22.22	-26.47
MC 66 x MC 34	42.50	1.49	5.59	1.75	55.75	5.19	-5.11	-3.46	3.89	-20.20	-30.84	-34.02
MC 49 x MC 69	40.50	-7.16**	-4.71**	-0.61	58.75	14.08**	10.33**	1.73	4.55	-6.67	-11.22	-23.53
MC 49 x MC 34	43.75	2.94	8.70	7.36	61.75	27.65**	-48.08	6.93*	4.58	20.76**	-10.54	-22.94
MC 69 x MC 34	41.75	0.91	3.73	2.45	46.75	-6.97	-12.21	-19.05	4.12	-5.71	-10.81	-30.67
CD (p=0.05)	2.22	1.92	2.22	2.22	4.95	4.29	4.95	4.95	0.39	0.33	0.39	0.39
CD (p=0.01)	2.91	2.52	2.91	2.91	6.51	5.26	6.51	6.51	0.52	0.44	0.52	0.52

Table 3. Mean performance of parents and F_1 hybrids and extent of heterosis for female flower characters during third season

Parents/Crosses	Days to first female flower opening				Female flowers/plant				Percentage of female flowers			
	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	42.50				63.50				5.95			
MC-78	45.25				49.63				5.10			
MC-84	46.75				53.88				4.25			
Arka Harit	46.25				27.88				3.15			
MC-82	41.00				90.00				2.55			
MC-79	47.50				105.25				2.75			
MC-66	43.50				70.25				6.05			
MC-49	37.50				57.25				5.95			
MC-69	43.75				61.25				5.75			
MC-34	37.75				67.25				4.25			
Priya x MC-78	45.75	4.27	7.64	7.65	54.00	-4.53	-14.96	-14.96	5.35	4.40	-10.00	-10.00
Priya x MC-84	45.25	1.40	6.47	6.47	47.75	-18.63	-24.80	-24.80	4.45	-0.13	-25.25	-25.21
Priya x Arka Harit	44.50	-0.28	4.71	4.71	37.25	-18.46	-41.50	-41.50	4.50	-1.09	-24.57	-24.37
Priya x MC-82	40.25	3.59**	-1.82	-5.29**	70.00	4.87	-22.00	10.24**	3.40	-0.20	-42.85	-42.85
Priya x MC-79	45.25	0.55	6.47	6.47	91.00	7.85**	-13.30	43.30**	5.40	24.10**	-9.24	-9.24
Priya x MC-66	43.25	0.58	1.75	1.76	70.50	5.40*	0.35	11.00**	6.05	0.83	0.00	1.68
Priya x MC-49	40.75	2.03	8.67	-4.12**	61.00	0.83	-3.93	-3.93	5.95	0.00	0.00	0.00
Priya x MC-69	40.25	-6.09**	-5.29**	-5.29**	57.25	8.21**	-9.84	-9.84	5.80	-0.85	-2.52	-2.52

Contd.

Table 31. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Priya x MC-34	39.75	-0.93	5.30	-6.47**	64.00	2.10	-4.80	0.78	4.70	-7.80	-21.00	-21.00
MC-78 x MC-84	45.75	-0.54	1.10	7.05	51.25	0.97	-4.87	-19.29	4.85	3.70	-4.90	-18.49
MC-78 x Arka Harit	44.50	-2.51*	1.44	4.70	37.25	3.87	-24.90	-41.13	4.30	4.20	-15.68	-27.73
MC-78 x MC-82	42.25	1.50	3.05	-0.58	66.00	-0.05	-26.67	3.94	3.95	3.27	-22.55	-33.61
MC-78 x MC-79	46.00	-0.54	1.66	8.20	75.00	-0.03	-28.74	18.10**	3.75	-4.45	-26.47	-36.97
MC-78 x MC-66	41.00	-7.60**	-5.75**	-3.53**	65.25	8.86**	-7.12	2.75	5.50	-1.34	-9.09	-7.56
MC-78 x MC-49	40.25	-2.57*	7.33	-5.29**	55.25	3.39	-3.50	-12.90	5.60	1.36	-5.85	-5.88
MC-78 x MC-69	42.38	-4.78**	-3.42*	-0.58	55.00	-0.79	-10.20	-13.30	5.80	6.90*	0.88	-2.52
MC-78 x MC-34	39.25	-5.42**	3.97	-7.64**	57.75	-1.18	-14.12	9.00**	4.70	0.53	-7.80	-2.10
MC-84 x Arka Harit	43.75	-5.91**	-5.42**	-2.94**	33.25	-18.65	-38.20	-47.60	3.50	-5.40	-17.65	-4.12
MC-84 x MC-82	41.13	-6.26**	0.00	-3.52**	67.63	-5.60	-24.90	5.90	3.15	-7.35	-25.85	-47.05
MC-84 x MC-79	46.75	-0.79	0.00	10.00**	77.00	-3.22	-26.84	21.25**	3.50	0.00	-17.64	-41.11
MC-84 x MC-66	41.50	-7.52**	-4.60**	-2.35**	59.75	-3.73	-14.90	-5.90	5.30	2.90	-12.40	-10.92
MC-84 x MC-49	37.88	-9.96**	0.67	-11.18**	56.50	2.38	-1.31	-11.02	5.35	4.90	-10.08	-10.00
MC-84 x MC-69	44.13	-2.48*	0.57	3.53	53.50	-7.05	-12.65	-15.70	5.80	16.00**	0.87	-2.52
MC-84 x MC-34	39.50	-6.50**	4.64	-7.06**	54.50	-1.00	-18.95	-14.10	4.45	4.70	4.70**	-25.21
Arka Harit x MC-82	46.63	6.87	13.41	9.41	45.00	-23.64	-50.00	-29.10	2.25	-21.00	-28.57	-62.18
Arka Harit x MC-79	46.00	-1.60	0.54	8.23	85.00	27.69**	-19.24	33.84**	3.15	6.78	0.00	-47.06
Arka Harit x MC-66	40.25	-10.02**	-7.47**	-5.29**	35.00	-28.66	-50.17	-44.80	5.65	22.80**	-6.61	-5.04

Contd.

Table 3[illegible]. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Arka Harit x MC-49	38.50	-7.92**	2.67	-9.41**	37.00	-13.07	-35.37	-41.70	5.75	26.37**	-3.36	-3.36
Arka Harit x MC-69	49.50	-7.78**	-5.14**	-2.35**	33.00	-25.95	-46.10	-48.00	4.10	-9.90	-28.69	-31.09
Arka Harit x MC-34	39.50	-5.95**	4.64	-7.06**	33.00	-30.62	-50.90	-48.00	4.00	8.10*	-5.88	-32.77
MC-82 x MC-79	43.13	-2.50*	4.88	1.18	95.00	14.87**	-9.70	49.60**	2.70	1.10	-1.82	-54.60
MC-82 x MC-66	42.25	0.29	3.05	-0.58	87.00	8.58**	-3.30	37.00**	4.15	-3.40	-31.40	-30.25
MC-82 x MC-49	36.88	-5.90**	-2.00	-13.53**	69.00	-6.28	-23.30	8.70**	3.25	-23.50	-45.38	-45.38
MC-82 x MC-69	42.50	0.29	3.60	0.00	68.50	-9.42	-23.80	7.80**	2.65	-36.14	-53.91	-55.46
MC-82 x MC-34	37.50	-4.70**	-0.66	-11.76**	71.00	-9.70	-21.10	11.80**	3.90	14.30**	-8.24	-34.45
MC-79 x MC-66	44.88	-1.37	2.87	5.29	87.00	-0.85	-17.33	37.00**	4.25	-3.40	-29.75	-28.57
MC-79 x MC-49	39.00	-8.10**	4.00	-8.24**	75.00	-7.69	-28.70	18.10**	4.05	-6.89	-31.93	-31.93
MC-79 x MC-69	41.50	-9.04**	-5.14**	-2.35**	89.00	6.90**	-15.40	40.10**	3.25	-23.52	-43.48	-45.38
MC-79 x MC-34	37.75	-11.44**	0.00	-11.18**	78.00	-9.56	-25.90	22.80**	3.50	0.00	-17.65	-41.11
MC-66 x MC-49	37.00	-8.50**	-1.33	-12.94**	78.50	7.45**	-2.50	7.87**	6.25	4.17	3.31*	5.00*
MC-66 x MC-69	42.00	-3.72**	-3.45*	-1.18**	58.00	-11.78	-17.43	-8.71	5.85	-0.85	-3.30	-1.68
MC-66 x MC-34	38.25	-5.85**	1.32	-10.00**	61.50	-10.56	-12.50	3.10	5.10	-0.97	-15.70	-14.28
MC-49 x MC-69	37.75	-6.93**	0.67	-11.17**	57.25	-3.37	-6.50	-9.80	5.40	-7.69	-9.24	-9.20
MC-49 x MC-34	35.13	-14.10**	-17.25**	-17.25**	63.50	2.00	-5.57	0.00	6.15	20.58**	3.36*	3.36*
MC-69 x MC-34	38.13	-6.44**	0.66	-10.59**	62.50	-2.70	-7.06	-1.57	5.15	3.00	-10.43	-13.44
CD (p=0.05)	2.22	1.92	2.22	2.22	4.18	3.63	4.18	4.18	0.34	0.29	0.34	0.34
CD (p=0.01)	2.91	2.52	2.91	2.91	5.50	4.77	5.50	5.50	0.45	0.39	0.45	0.45

Plate-27. MC 60 x MC 49, an early flowering standard heterotic F_1 hybrid

Plate-28. MC 84 x MC 69, an early maturing standard heterotic F_1 hybrid

PLATE-27

MC-82 x MC-79 (71.86%) and MC-79 x MC-66 (66.67%) in second and MC-82 x MC-79 (49.6%), Priya x MC-79 (43.3%) and MC-79 x MC-69 (40.1%) in third seasons.

f. Percentage of female flowers

Significant relative heterosis was observed in 23 hybrids in first, 12 in second and eight in third seasons. The highest values were recorded by Priya x MC-79 (28.36%) followed by MC-82 x MC-49 (22.13%), MC-49 x MC-34 (20.81%) and Arka Harit x MC-69 (17.82%) in first MC-49 x MC-34 (20.76%) followed by Priya x MC-79 (17.91%), MC-84 x MC-49 (17.37%) and MC-82 x MC-79 (16.96%) in second and Arka Harit x MC-49 (26.37%), Priya x MC-79 (24.14%), Arka Harit x MC-66 (22.8%) and MC-49 x MC-34 (20.58%) in the third seasons.

Significant heterobeltiosis for percentage of female flowers was observed in five hybrids in the second and three in the third seasons. MC-78 x MC-49 (13.85%) and MC-84 x MC-49 (8.75%) during second season possessed considerable heterobeltiosis. It was not significant in the third season.

Standard heterosis was significant in 4 crosses in the first, one in second and two in the third seasons. Priya x MC-49 (7.91%), MC-49 x MC-34 (7.91%), MC-49 x MC-69 (7.1%) and MC-78 x MC-49 (4.72%) in first, Priya x MC-49 (5.88%) in second and MC-66 x MC-49 (5.00%) and MC-49 x MC-34 (3.36%) in the third seasons were the crosses possessing significant standard heterosis.

g. Days to picking maturity

Relative heterosis was observed only for 12 crosses in first and four crosses in second season. The hybrids showed comparatively poor heterosis for maturity.

Heterobeltiosis was observed in five crosses in first and only one in the second season.

Standard heterosis for maturity was observed in 27 crosses in the first season. Higher values of standard heterosis (-15.78%) were observed in Priya x MC-69, Priya x MC-34 and MC-84 x MC-69 (Plate 28) in the first season. None of the crosses had shown significant standard heterosis in the second season.

The 55 genotypes did not differed significantly for picking maturity in the third season.

h. Yield/plant

Out of the 45 hybrids, 32 had significant relative heterosis in first, four in second and seven in third seasons. The maximum relative heterosis of 127.2% was recorded by Arka Harit x MC-79 followed by Arka Harit x MC-49 (63.83%), MC-78 x MC-79 (50.19%), Priya x MC-79 (30.75%) and MC-79 x MC-69 (29.55%) in the first season. In the second season also Arka Harit x MC-79 recorded the maximum relative heterosis (45.45%) followed by MC-82 x MC-79 (26.17%) and Priya x MC-49 (17.91%). In third season Arka Harit x MC-69 (23.12%) ranked first in relative heterosis followed by MC-82 x MC-79 (21.95%) and Arka Harit x MC-34 (21.2%).

Heterobeltiosis for yield was observed for six crosses in first, four in second and two in third seasons. Maximum values of heterobeltiosis were observed in hybrids Arka Harit x MC-79 (117.17%) and MC-49 x MC-34 (17.34%) (Plate 29) in the first, Arka Harit x MC-79 (43.09%) and MC-84 x MC-49 (6.32%) in second and MC-78 x MC-66 (10.00%) (Plate 30) and MC-49 x MC-34 (6.24%) in the third seasons.

Standard heterosis for yield/plant was significant only for MC-78 x MC-66 (7.46%) and MC-78 x MC-84 (4%) in

Plate-29. MC 49 x MC 34, heterobeltiotic F_1 hybrid for yield

Plate-30. MC 78 x MC 66, heterobeltiotic F_1 hybrid for yield

PLATE-29

Table 32. Mean performance of parents and F_1 ...
yield and fruits/plant during first ...

Parents/Crosses	Days to picking maturity			
	Mean	RH (%)	HB (%)	SH (%)
1	2	3	4	5
Priya	14.25			
MC 78	12.50			
MC 84	13.25			
Arka Harit	12.88			
MC 82	14.00			
MC 79	14.25			
MC 66	13.50			
MC 49	13.00			
MC 69	12.00			
MC 34	12.00			
Priya x MC 78	12.25	-8.40**	-2.00	-14.04
Priya x MC 84	13.50	-1.80	1.89	-5.26
Priya x Arka Harit	13.50	-0.46	5.88	-5.26
Priya x MC 82	13.50	-4.04*	-3.57	-5.26
Priya x MC 79	13.00	-8.77**	-8.77**	-8.77**
Priya x MC 66	12.00	-13.51**	-11.11**	-15.78**
Priya x MC 49	12.50	-8.26**	-3.85**	-12.28**
Priya x MC 69	12.00	-8.57**	0.00	15.78**

hybrids and extent of heterosis for picking maturity,
: season

Yield/plant				Fruits/plant			
Mean (kg)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
6	7	8	9	10	11	12	13
10.19				51.25			
9.55				42.75			
10.45				36.25			
3.19				18.50			
2.50				89.25			
3.50				112.00			
10.18				62.25			
8.65				46.00			
8.85				50.00			
7.45				61.50			
10.40	5.34**	2.06	2.66	51.75	10.10*	0.98	0.98
10.50	1.74	0.48	3.04	47.00	7.42*	-8.29	-8.29
8.40	25.56**	-17.57	-17.57	34.75	-0.35	-32.20	-32.20
6.15	-3.07	-39.65	-39.65	75.25	7.11**	-15.67	46.82**
8.95	30.75**	-12.17	-12.17	101.00	23.74**	-9.82	97.07**
10.40	2.13	2.21	2.06	64.00	9.70**	2.81	24.87**
9.80	4.03*	-3.83	-3.83	61.75	26.83**	20.49**	20.49**
10.10	6.10**	-0.88	-0.88	51.25	2.24	0.00	0.00

Contd.

Table 32. Continued

1	2	3	4	5
Priya x MC 34	12.00	-8.57	0.00	-15.
MC 78 x MC 84	12.25	-4.85*	-2.00	-14.
MC 78 x Arka Harit	13.25	4.43	6.00	-7.
MC 78 x MC 82	13.00	1.89	4.00	-8.
MC 78 x MC 79	14.00	4.67	12.00	-1.
MC 78 x MC 66	13.00	0.00	4.00	-8.
MC 78 x MC 49	12.25	-3.92	-2.00	-14.
MC 78 x MC 69	13.25	8.16	10.42	-7.
MC 78 x MC 34	13.50	10.20	12.80	-5.
MC 84 x Arka Harit	13.50	3.35	5.88	-5.
MC 84 x MC 82	13.00	-4.59*	1.89	-8.
MC 84 x MC 79	13.00	-5.45**	-1.89	-8.
MC 84 x MC 66	13.50	1.00	1.89	-4.
MC 84 x MC 49	12.50	-4.76*	-3.85**	-12.
MC 84 x MC 69	12.00	-4.95*	0.00	-15.
MC 84 x MC 34	12.50	-1.00	4.17	-12.
Arka Harit x MC 82	13.00	-3.26	1.96	-8.
Arka Harit x MC 79	14.00	3.23	9.80	-1.
Arka Harit x MC 66	13.00	-1.42	1.96	-8.

5	6	7	8	9	10	11	12	13
.78**	10.10	14.51**	-0.88	-0.88	55.50	-1.55	-9.75	8.29*
.04**	16.60	6.00**	1.44	4.00**	42.50	7.60**	-0.55	-17.07
.02**	7.40	16.17**	-22.51	-27.38	28.25	-7.80	-33.90	-44.88
.77**	7.40	22.82**	-22.51	-27.38	77.25	17.01**	-13.45	50.73**
.75	9.80	50.19**	2.62	-3.83	90.00	24.35**	-19.64	75.61**
.77**	10.95	11.03**	7.62**	7.46**	71.00	35.23**	14.06**	38.54**
.04**	10.10	11.00**	5.76**	0.88	64.75	45.71**	40.76**	26.34**
.02**	9.75	5.98**	2.09	-4.32	51.00	9.97**	2.00	-0.49
.26	9.55	-4.11	0.00	-6.30	01.50	18.00**	0.00	20.00**
.26	8.15	19.50**	-22.00	-20.00	28.00	2.28	-22.76	-45.37
.77**	7.10	9.65**	-32.01	-30.32	71.00	13.15**	-20.45	38.54**
.77**	8.20	17.56**	-21.53	-19.53	82.25	10.96**	-26.34	60.49**
.26	10.00	-3.03	-4.31	-1.86	62.00	25.88**	-0.40	20.98**
.28**	10.50	10.00**	0.48	3.04	52.00	26.25**	13.04**	1.46
.78**	9.75	1.04	-6.69	-4.32	44.75	3.77	-10.50	-12.68
.28**	9.05	1.12	-13.40	-11.19	51.25	4.86	-16.67	0.00
.77	3.30	16.00**	3.45	-67.60	55.50	3.02	-37.82	8.29**
.75	7.60	127.20**	117.14**	-25.54	124.50	90.80**	11.16	142.93**
.77**	6.05	-9.46	-40.54	-40.66	50.75	25.70**	-18.00	-0.98

Contd.

Table 32. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Arka Harit x MC 49	12.50	-3.38	-1.96	-12.88**	9.70	63.85**	12.12**	-40.66	32.25	0.58	-30.43	-36.58
Arka Harit x MC 69	12.50	0.48	4.16	-12.28**	6.15	2.15	-30.51	-4.81	30.00	0.12	-40.00	-41.46
Arka Harit x MC 34	12.50	0.48	4.16	-12.28**	6.15	15.60**	-17.45	-4.81	40.50	1.25	-34.15	-20.98
MC 82 x MC 79	14.00	0.92	0.00	-1.75	3.05	1.67	-12.86	-70.06	100.00	-0.62	-10.71	95.12**
MC 82 x MC 66	14.00	1.82	3.70	-1.75	6.12	4.38**	-34.98	-35.08	80.50	6.27**	-9.80	57.07**
MC 82 x MC 49	13.25	-1.85	1.92	-8.02	4.75	-14.79	-45.09	-53.38	72.00	6.37*	-19.33	40.49**
MC 82 x MC 69	14.50	11.54	20.83	1.75	7.05	24.22**	-20.34	-30.08	67.50	-3.09	-24.37	31.77**
MC 82 x MC 34	13.25	1.93	10.41	-8.02**	6.55	62.80**	-12.08	-35.72	82.00	8.78**	-8.12	60.00**
MC 79 x MC 66	13.75	-0.90	1.85	-3.51	8.10	18.46**	-20.39	-20.51	94.50	8.46**	-15.63	84.39**
MC 79 x MC 49	13.75	0.91	-5.76**	-3.51	5.60	-7.82	-35.26	-45.04	91.00	15.09**	-18.79	75.56**
MC 79 x MC 69	13.75	4.76	14.58	-3.51	8.00	29.55**	-9.66	-21.44	88.00	8.64**	-21.43	71.71**
MC 79 x MC 34	13.50	2.84	12.50	-5.26	7.00	27.85**	-6.04	-31.31	94.50	8.93**	-21.43	84.39**
MC 66 x MC 49	13.50	1.87	3.85	-5.26	9.75	3.59*	-4.18	-4.32	75.00	38.40**	-33.04	46.34**
MC 66 x MC 69	13.00	1.96	8.33	-8.77**	9.85	3.55*	-3.19	-3.34	57.00	1.56	-8.43	11.22**
MC 66 x MC 34	13.00	1.96	8.33	-8.77**	9.25	4.96**	-9.09	-9.22	60.00	-3.00	-3.61	17.67**
MC 49 x MC 69	13.75	10.00	14.50	-3.51	9.30	6.29**	5.08**	-8.73	58.50	21.71**	-6.02	14.15**
MC 49 x MC 34	12.50	0.00	4.16	-12.28**	10.15	26.09**	17.34**	-0.39	72.00	33.80**	17.07**	40.49**
MC 69 x MC 34	13.50	12.37	13.50	-5.26	8.15	0.00	-7.91	-20.02	56.00	1.35	-8.94	9.27**
CD (p=0.05)	0.83	0.51	0.83	0.83	0.34	0.29	0.34	0.34	4.22	3.65	4.22	4.22
CD (p=0.01)	1.09	0.67	1.09	1.09	0.45	0.39	0.45	0.45	5.54	4.79	4.54	4.54

Table 33. Mean performance of parents and F_1 hybrids and extent of heterosis for picking maturity, yield and fruits/plant during second season

Parents/Crosses	Days to picking maturity				Yield/plant				Fruist/plant			
	Mean	RH (%)	HB (%)	SH (%)	Mean (kg)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	12.25				9.13				40.50			
MC 78	12.88				8.25				35.88			
MC 84	12.75				8.70				36.00			
Arka Harit	13.13				3.08				15.50			
MC 82	14.25				2.38				57.50			
MC 79	13.38				2.98				97.75			
MC 66	12.50				8.63				43.25			
MC 49	12.88				7.63				37.00			
MC 69	13.25				7.25				35.00			
MC 34	12.00				6.75				34.25			
Priya x MC 78	12.63	0.00	2.04	2.04	8.63	-0.72	-5.48	-5.48	38.25	0.33	-5.56	-5.56
Priya x MC 84	13.25	6.00	8.16	8.16	8.75	-1.82	-4.11	-4.11	37.50	1.96	-7.41	-7.41
Priya x Arka Harit	13.50	5.88	10.20	10.20	4.75	-22.13	-47.95	-47.95	28.00	0.00	-30.86	-30.86
Priya x MC 82	13.75	3.77	12.24	12.24	5.50	-4.35	-39.73	-39.73	43.25	-11.73	-24.78	6.79**
Priya x MC 79	13.00	-1.89	6.12	6.12	4.13	-31.82	-54.79	-54.79	53.00	-23.33	-45.78	30.86**
Priya x MC 66	12.50	1.00	2.04	2.04	8.75	-1.40	-4.11	-4.11	42.75	2.08	-1.16	5.56*
Priya x MC 49	12.75	0.99	4.08	4.08	9.88	17.91**	8.22**	8.22**	42.75	10.32**	5.56*	5.56*

Contd.

Table 33. Continued

1	2	3	4	5	6	7
Priya x MC 69	12.75	0.00	4.08	4.08	7.58	-7.
Priya x MC 34	12.75	5.15	6.25	4.08	7.50	-0.
MC 78 x MC 84	13.13	1.96	1.96	6.12	8.45	-0.
MC 78 x Arka Harit	13.00	0.00	1.96	6.12	4.63	-18.
MC 78 x MC 82	13.25	-1.85	3.92	8.16	3.63	-31.
MC 78 x MC 79	13.25	0.95	3.92	8.16	4.50	-37.
MC 78 x MC 66	13.50	6.93	8.00	10.20	8.78	4.
MC 78 x MC 49	13.25	2.91	3.92	8.16	8.38	5.
MC 78 x MC 69	12.75	1.92	0.00	4.08	7.75	0.
MC 78 x MC 34	13.25	7.07	10.42	8.16	7.50	0.
MC 84 x Arka Harit	12.75	-1.92	0.00	4.08	4.43	-24.
MC 84 x MC 82	12.75	-5.50	0.00	4.08	3.83	-30.
MC 84 x MC 79	13.00	-0.95	1.96	6.12	4.70	-19.
MC 84 x MC 66	12.75	0.99	2.00	4.08	8.13	-6.
MC 84 x MC 49	13.00	0.97	1.96	6.12	9.25	13.
MC 84 x MC 69	13.00	0.00	1.96	6.12	8.00	0.
MC 84 x MC 34	12.00	-0.03	0.00	2.05	8.13	5.
Arka Harit x MC 82	13.00	-5.45	-1.89	6.12	2.63	-3.
Arka Harit x MC 79	13.00	-2.80	1.89	6.12	4.40	45.
Arka Harit x MC 66	12.00	-6.80*	-4.00	2.05	4.25	-27.

7	8	9	10	11	12	13
.45	-16.99	-16.99	36.75	-2.65	-9.26	-9.26
.55	-17.81	-17.81	33.75	-9.70	-16.67	-16.67
.29	-2.87	-7.39	34.50	-3.83	-4.17	-14.81
.32	-43.44	-49.30	24.00	-6.34	-32.87	-40.74
.76	-56.06	-60.27	47.50	1.88	-17.39	17.28**
.55	-57.52	-61.59	75.25	12.73**	23.02**	85.80**
.00	1.74	-3.84	39.75	0.63	-8.09	-1.85
.51	1.52	-8.22	39.00	7.22*	5.41	-3.70
.00	-6.06	-15.07	35.50	0.35	-0.70	-12.35
.00	-9.01	-17.80	31.75	-9.29	-11.19	-21.60
.84	-49.13	-51.51	30.75	19.42*	-14.58	-24.07
.92	-56.03	-58.08	51.50	10.16**	-10.43	27.16**
.50	-45.98	-48.49	61.75	-7.66	-36.83	52.47**
.20	-5.80	-10.75	41.75	5.36	-3.47	3.09
.32**	6.32*	1.36	38.00	4.11	2.70	-6.17
.31	-8.05	-12.33	33.25	-6.33	-10.14	-17.90
.18	-6.61	-10.95	33.75	-3.91	-8.78	-16.67
.67	-14.63	-17.23	33.50	-8.22	-41.74	-17.28
.45**	43.09**	-51.78	61.00	7.73**	37.60**	50.62**
.35	-50.72	-53.48	30.25	2.98	-30.06	-25.31

Contd.

Table 33. Continued

1	2	3	4	5
Arka Harit x MC 49	13.00	-0.95	0.00	6.
Arka Harit x MC 69	13.38	1.87	1.87	10.
Arka Harit x MC 34	12.75	0.99	6.25	4.
MC 82 x MC 79	12.75	-8.10**	-5.56	4.
MC 82 x MC 66	12.75	-4.67	2.00	4.
MC 82 x MC 49	13.25	-2.75	1.92	8.
MC 82 x MC 69	12.75	-4.67	-3.77	4.
MC 82 x MC 34	13.25	0.95	10.41	8.
MC 79 x MC 66	12.75	-1.92	2.00	4.
MC 79 x MC 49	13.25	0.00	1.92	8.
MC 79 x MC 69	12.75	-4.67	-3.71	4.
MC 79 x MC 34	12.50	-1.96	4.17	2.
MC 66 x MC 49	12.50	-1.96	0.00	2.
MC 66 x MC 69	12.00	-6.80	-12.00	2.
MC 66 x MC 34	13.00	6.12	8.33	6.
MC 49 x MC 69	12.25	-6.67*	-5.76*	0.
MC 49 x MC 34	13.25	6.00	10.42	8.
MC 69 x MC 34	13.25	4.95	10.42	8.
CD (p=0.05)	0.96	0.82	0.96	0.
CD (p=0.01)	1.26	1.08	1.26	1.

5	6	7	8	9	10	11	12	13
.12	3.88	-27.57	-49.18	-57.50	23.25	-11.43	-37.16	-42.59
.20	4.68	-9.44	-35.52	-48.76	40.00	58.42**	14.29**	-1.23
.08	4.63	-5.85	-31.48	-49.32	21.75	-12.56	-36.50	-46.30
.08	3.38	26.17**	13.45**	-63.01	73.00	-5.96	-25.32	80.24**
.08	4.55	-17.25	-47.25	-50.13	51.50	2.23	-10.43	27.16**
.16	3.80	-24.00	-50.16	-58.36	49.00	3.70	-14.78	20.99**
.08	3.83	-20.52	-47.24	-58.08	53.75	16.21**	-6.52	32.72**
.16	3.88	-15.07	-42.59	-57.53	47.25	3.00	-17.83	16.67**
.08	4.38	-24.57	-49.28	-52.05	61.00	-13.48	-37.60	50.62**
.16	4.80	-9.43	-37.05	-47.39	73.25	8.72**	-25.06	80.86**
.08	4.40	-13.96	-39.32	-51.78	53.25	-19.77	-45.22	31.48**
.04	3.38	-30.59	-50.00	-63.01	42.75	-35.23	-56.27	5.56*
.04	8.38	3.08	-2.89	-8.22	53.25	32.71**	23.12**	31.48**
.05	7.38	-7.09	-14.49	-19.18	44.75	14.31**	3.46	10.49**
.12	7.15	-0.70	-17.01	-21.64	43.50	12.66**	0.58	8.02**
.00	7.25	-2.52	-4.90	-20.55	51.00	41.66**	37.83**	25.93**
.12	7.20	0.17	-5.57	-21.09	52.00	45.96**	40.54**	28.40**
.16	7.38	5.35	1.72	-19.18	41.00	18.41**	17.14**	1.23
.96	0.59	0.51	0.59	0.59	2.68	2.31	2.68	2.68
.26	0.77	0.67	0.77	0.77	3.52	3.04	3.52	3.52

Table 34. Mean performance of parents and F_1 hybrids and extent of heterosis for days to picking maturity, yield and fruits/plant in bitter gourd during third season

parents/Crosses	Days to picking maturity				Yield/plant				Fruits/plant			
	Mean	RH (%)	HB (%)	SH (%)	Mean (kg)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	13.00				9.63				46.50			
MC-78	12.25				9.05				44.75			
MC-84	13.25				9.25				33.00			
Arka Harit	13.75				3.38				16.75			
MC-82	14.25				2.05				85.25			
MC-79	14.00				3.08				99.50			
MC-66	12.75				10.25				59.00			
MC-49	12.50				8.50				41.00			
MC-69	12.75				7.78				45.13			
MC-34	12.25				7.03				55.25			
Priya x MC-78	13.50	6.90	10.20	3.84	9.05	-3.00	-5.97	-5.97	47.00	3.01	1.08	1.08
Priya x MC-84	12.75	-2.85	-1.92	-1.92	7.78	-17.60	-19.22	-19.22	37.00	-2.75	-20.43	-20.43
Priya x Arka Harit	13.25	-0.93	1.92	1.92	5.27	19.00	-45.30	-45.30	27.00	-14.00	-41.94	-41.94
Priya x MC-82	13.50	-0.92	3.85	3.85	4.43	-24.20	-54.03	-54.03	52.50	-20.30	-38.42	-12.90**
Priya x MC-79	13.75	1.85	5.77	5.77	5.20	-18.00	-45.97	-45.97	67.50	-7.53	-32.16	45.16**
Priya x MC-66	12.75	-0.97	0.00	-1.92	10.12	1.78*	-1.38	5.04**	51.00	-3.32	-13.56	9.68**
Priya x MC-49	13.25	3.92	10.41	1.92	8.74	-3.61	12.99	-9.24	42.50	-2.80	-8.60	-8.60
Priya x MC-69	13.00	0.97	1.96	0.00	7.93	-8.80	-17.61	-17.61	41.50	-9.40	-10.75	-10.75

Contd.

Table 34. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Priya x MC-34	12.50	-0.99	2.04	-3.84	5.95	-28.50	-38.23	-38.23	46.00	-9.58	-16.74	-1.08
MC-78 x MC-84	13.50	5.80	10.20	3.84	8.06	-11.96	-12.92	-16.31	37.38	-3.80	-16.48	-19.35
MC-78 x Arka Harit	13.00	0.00	6.12	0.00	5.25	-15.60	-42.04	-45.51	25.25	-17.85	-43.58	-45.70
MC-78 x MC-82	13.00	-1.89	6.12	0.00	4.05	-3.48	-55.25	-57.92	53.00	-18.46	-37.83	13.98**
MC-78 x MC-79	13.50	2.86	10.20	3.84	4.10	-32.37	-54.70	-57.40	61.50	-14.70	-38.19	32.26**
MC-78 x MC-66	12.75	2.00	4.08	-1.92	11.28	16.83**	10.00**	17.14**	55.00	5.02	-6.78	18.28**
MC-78 x MC-49	12.00	-3.00	-2.04	-7.69	8.49	-3.30	-6.24	-11.84	42.50	0.87	-5.03	-8.60
MC-78 x MC-69	13.25	6.00	8.16	1.92	8.15	-3.12	-9.90	-15.32	41.88	-6.80	-6.94	-10.10
MC-78 x MC-34	12.75	4.00	4.00	-1.92	6.08	-24.41	-32.87	-36.88	47.00	-6.00	-14.93	1.08
MC-84 x Arka Harit	13.00	-3.70	-1.89	0.00	4.46	-29.43	-51.84	-53.71	22.50	-9.50	-31.82	-51.61
MC-84 x MC-82	13.25	-3.64	0.00	1.92	2.72	-54.60	-70.64	-71.79	42.00	-28.96	-50.73	-9.68
MC-84 x MC-79	13.50	-0.92	1.84	3.84	3.52	-43.00	-62.00	-63.48	57.50	-13.20	-42.21	23.66**
MC-84 x MC-66	12.75	-1.90	0.00	-1.92	8.19	-16.00	-20.09	-14.41	37.00	-19.57	-37.29	-20.43
MC-84 x MC-49	13.00	0.00	4.00	0.00	7.28	-18.00	-21.35	-24.42	36.50	-1.35	-10.98	-21.51
MC-84 x MC-69	13.25	1.90	3.92	1.92	7.26	-14.70	-21.57	-26.62	37.50	-4.00	-14.67	-19.35
MC-84 x MC-34	13.75	7.84	12.24	5.76	6.93	-14.37	-25.14	-28.04	40.25	-8.78	-27.15	-13.44
Arka Harit x MC-82	13.00	-7.10	-5.45	0.00	2.40	-11.50	-28.89	-75.06	37.50	-26.47	-56.01	-19.35
Arka Harit x MC-79	13.25	4.50	-3.64	1.92	3.20	-7.80	-5.19	-66.75	46.50	-20.00	-53.27	0.00
Arka Harit x MC-66	12.75	-3.70	0.00	-1.92	4.74	-30.50	-53.80	-50.81	24.00	-36.60	-59.32	-48.38

Contd.

Table 34. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Arka Harit x MC-49	13.25	0.95	6.00	1.92	5.27	-11.30	-33.82	-45.30	27.00	-6.50	-34.15	-41.94
Arka Harit x MC-69	12.00	5.64	-1.96	0.56	5.41	23.12**	-30.48	-43.84	28.50	-7.80	-36.67	-38.71
Arka Harit x MC-34	13.25	1.92	8.16	1.92	6.31	21.20**	-10.25	-34.50	43.00	19.44**	-22.17	-7.52
MC-82 x MC-79	13.75	-2.60	-1.78	5.76	3.13	21.95**	1.63	-67.53	100.25	8.53**	0.75	115.60**
MC-82 x MC-66	13.25	-1.85	3.92	1.92	3.13	-49.10	-69.51	-67.53	65.25	-9.53	-23.46	40.32**
MC-82 x MC-49	13.75	5.70	10.00	5.76	3.30	-37.50	-61.18	-65.71	51.50	-18.42	-33.59	10.75**
MC-82 x MC-69	14.00	3.70	9.80	7.69	1.84	-62.50	-76.33	-80.88	55.50	-14.86	-34.90	-19.35
MC-82 x MC-34	13.25	0.00	14.29	1.92	1.92	-58.80	-79.85	-80.10	58.75	-16.37	-31.00	-26.34
MC-79 x MC-66	13.25	0.93	3.92	1.92	4.65	-30.30	-54.68	-51.74	73.00	-7.89	-26.63	56.99**
MC-79 x MC-49	13.75	3.77	10.00	5.76	3.55	-38.60	-58.24	-63.12	54.00	-23.13	-45.72	16.13**
MC-79 x MC-69	13.00	-2.80	1.96	0.00	4.53	-16.50	-41.80	-52.99	58.75	-18.75	-40.95	26.34**
MC-79 x MC-34	12.25	-6.67	0.00	-5.77	4.35	-13.86	-38.08	-54.81	65.25	-15.67	34.42	40.32**
MC-66 x MC-49	13.75	8.90	10.00	5.76	9.77	4.16**	-4.73	1.45	50.00	0.00	-15.25	75.25**
MC-66 x MC-69	13.00	1.96	1.96	0.00	8.78	-2.60	-14.39	-8.83	45.50	-12.61	-22.88	-2.15
MC-66 x MC-34	13.25	6.00	8.16	1.92	6.97	-19.30	-32.05	-27.64	53.00	-7.22	-10.17	13.98**
MC-49 x MC-69	13.50	6.90	8.00	3.84	7.90	-3.00	-7.05	-17.92	41.50	-3.63	-7.78	-10.75
MC-49 x MC-34	13.25	7.07	8.16	1.92	9.03	16.30**	6.24**	-6.18	53.50	11.17**	-3.17	15.05**
MC-69 x MC-34	13.50	8.00	10.20	3.84	5.85	-21.05	-24.82	-39.27	44.25	-11.80	-19.91	-4.84
CD (p=0.05)	1.24	1.08	0.86	0.86	0.20	0.18	0.20	0.20	3.96	3.43	3.96	3.96
CD (p=0.01)	1.63	1.42	1.63	1.63	0.26	0.23	0.26	0.26	5.21	4.50	5.21	5.21

the first season. In the second season only one hybrid (Priya x MC-49) possessed significant standard heterosis. However, in the third season MC-78 x MC-66 (17.14%) and Priya x MC-66 (5.04%) possessed significant standard heterosis.

i. Fruits/plant

Fruits/plant showed significant relative heterosis in 29 crosses in first, 15 in second and 3 in third seasons. In the first season, Arka Harit x MC-79 (90.8%), MC-78 x MC-49 (45.71%) and MC-78 x MC-66 (35.23%); in second season, Arka Harit x MC-34 (58.42%), MC-49 x MC-34 (45.96%) and MC-66 x MC-49 (32.71%); and in third season Arka Harit x MC-34 (19.44%) were superior in relative heterosis.

Significant heterobeltiosis was observed in five hybrids in first and eight in second season. None was significantly superior in the third season. Crosses MC-78 x MC-49 (40.76%) and MC-49 x MC-34 (17.07%) in first and MC-49 x MC-34 (40.54%), MC-49 x MC-69 (37.33%) and Arka Harit x MC-79 (37.6%) in second seasons were superior in heterobeltiosis.

Standard heterosis was shown by 30 crosses in first, 22 in second and 17 in third seasons. The superior hybrids observed were Priya x MC-79 (97.07%), MC-82 x MC-79 (95.12%), MC-79 x MC-34 (84.39%), MC-79 x MC-49 (77.56%) and MC-79 x MC-69 (71.71%) in the first; MC-78 x MC-79 (85.3%), MC-79 x MC-49 (80.86%) and MC-82 x MC-79 (80.29%) in the second; and MC-82 x MC-79 (115.6%), MC-66 x MC-49 (75.2%) and MC-79 x MC-66 (56.99%) in the third seasons.

j. Fruit weight

Relative heterosis for fruit weight was significant for 10 crosses each in first, and second seasons and four in the third season. The crosses between the two small fruited types, MC-82 x MC-79 recorded the highest relative heterosis of 22.94%, 35.57% and 23.5% in first, second and third seasons respectively. Other crosses with higher values were MC-82 x MC-34 (20.75%) in first and MC-84 x MC-34 (13.1%) in second seasons.

Heterobeltiosis was significant only in MC-82 x MC-79 (10.94%) and MC-66 x MC-49 (3.57%) in the first season. In the second season 8 crosses showed significant

Table 35 Mean performance of parents and F_1 ... girth of fruits during first season

Parents/Crosses	Fruit weight			
	Mean (mm)	RH (%)	HB (%)	SH (%)
1	2	3	4	5
Priya	225.00			
MC 78	217.50			
MC 84	300.00			
Arka Harit	205.00			
MC 82	25.75			
MC 79	32.00			
MC 66	206.25			
MC 49	210.00			
MC 69	215.00			
MC 34	120.00			
Priya x MC 78	228.00	3.50	1.33	1.33
Priya x MC 84	282.00	7.43**	6.00	25.33**
Priya x Arka Harit	211.00	-1.86	-6.22	-5.22
Priya x MC 82	96.00	-23.43	-57.33	-57.33
Priya x MC 79	97.00	-27.34	-56.89	-56.89
Priya x MC 66	219.00	1.56	-2.67	-2.67
Priya x MC 49	211.00	-2.98	-6.22	-6.22
Priya x MC 69	216.50	-1.59	-3.78	-3.78

hybrids and extent of heterosis for weight, length and

Fruit length				Fruit girth			
Mean (m)	RH (%)	HB (%)	SH (%)	Mean (cm)	RH (%)	HB (%)	SH (%)
6	7	8	9	10	11	12	13
36.10				16.65			
35.70				14.40			
30.10				23.10			
30.25				23.50			
6.70				8.30			
8.15				6.45			
29.10				6.05			
24.20				18.05			
34.25				16.65			
26.25				15.10			
35.65	-0.69	-1.25	-1.25	14.75	-5.00	-11.41	-11.74
33.10	0.00	-8.31	-8.31	18.10	-8.93	-21.65	8.11**
32.80	-1.13	-9.14	-9.14	15.75	-21.50	-32.98	-5.41
11.65	-45.60	-67.73	-67.73	10.55	-15.43	-36.64	-36.40
12.10	-45.31	-66.48	-66.48	9.30	-19.48	-44.14	-44.14
33.90	3.98**	-6.09	-6.09	16.15	-1.12	-3.00	-3.00
29.75	-1.33	-17.59	-17.59	17.10	-1.44	-5.26	2.70**
35.35	0.49	-2.08	-2.08	16.75	0.60	0.60	0.60

Contd.

Table 35. Continued

1	2	3	4	5	6
Priya x MC 34	185.00	7.25	-17.78	-17.78	29.10
MC 78 x MC 84	262.75	4.05**	-12.42	16.77**	34.10
MC 78 x Arka Harit	217.50	33.54**	0.00	-3.33	33.70
MC 78 x MC 82	101.50	-38.50	-53.33	-54.89	12.65
MC 78 x MC 79	116.00	-7.01	-46.67	-48.44	13.65
MC 78 x MC 66	221.00	4.43*	1.61	-1.78	35.10
MC 78 x MC 49	219.00	2.46	0.69	-2.67	30.10
MC 78 x MC 69	215.00	-0.57	-1.15	-4.40	35.75
MC 78 x MC 34	182.50	8.15**	-16.32	-18.89	29.75
MC 84 x Arka Harit	257.50	1.98	-14.16	14.44**	30.30
MC 84 x MC 82	111.00	-31.85	-63.00	-50.67	14.05
MC 84 x MC 79	124.00	-25.30	-58.67	-44.89	12.65
MC 84 x MC 66	255.00	0.74	-15.00	13.33*	31.10
MC 84 x MC 49	252.00	-0.98	-15.83	12.22**	29.75
MC 84 x MC 69	212.00	-17.48	-29.17	-5.56	32.25
MC 84 x MC 34	205.00	-2.38	-31.67	-8.89	28.65
Arka Harit x MC 82	66.50	-42.36	-67.56	-70.44	10.25
Arka Harit x MC 79	53.00	-55.22	-74.15	-76.44	10.85
Arka Harit x MC 66	201.00	-2.00	-2.30	-10.44	31.25

7	8	9	10	11	12	13
-6.66	-19.39	-19.39	15.60	-1.73	-6.31	-6.31
3.65**	-4.65	-4.48	20.10	7.20**	-13.00	-20.72
2.20*	-5.60	-6.65	21.10	11.34**	-10.21	26.73**
-40.33	-64.56	-64.56	12.35	8.81**	-14.24	-25.83
-37.74	-61.76	-62.19	9.10	-12.71	-36.80	-45.34
9.34**	-1.68	-2.78	16.10	5.75**	0.31	-3.30
0.50	-15.69	-16.62	17.25	6.32**	-4.43	3.60
2.20	0.14	-0.97	15.75	1.45	-5.41	-5.41
-3.95	16.67	-17.59	14.20	6.78**	-5.96	-14.71
0.49	0.17	-16.07	23.30	0.32	-0.85	39.94**
-23.60	-53.35	-61.08	11.55	-26.43	-50.00	-30.63
-33.90	-57.97	-64.96	10.70	-27.58	-53.68	-35.74
5.06**	3.32**	-13.85	20.25	3.44**	-12.34	21.32**
9.58**	-1.16	-17.59	20.55	-0.12	-11.04	23.42**
0.23	-5.84	-10.66	21.30	7.17**	-7.79	27.92**
1.69	-4.82	-20.64	17.25	-9.69	-25.32	3.60**
-44.61	-66.11	-71.61	13.25	-16.67	-43.62	-20.42
-43.44	-64.13	-69.94	11.25	-24.87	-52.13	-32.43
5.31**	3.31	-13.43	16.25	-17.83	-30.85	-2.40

Contd.

Table 35. Continued

1	2	3	4	5	6
Arka Harit x MC 49	215.00	3.61	2.38	-4.48	28.
Arka Harit x MC 69	209.00	-0.48	-2.79	-7.11	31.
Arka Harit x MC 34	185.00	-13.85	-9.75	-17.78	28.
MC 82 x MC 79	35.50	22.94**	10.94*	-84.22	8.
MC 82 x MC 66	86.50	-25.60	-58.06	-61.56	12.
MC 82 x MC 49	101.00	-14.32	-51.90	-55.11	13.
MC 82 x MC 69	104.50	-13.18	-51.40	-53.56	11.
MC 82 x MC 34	88.00	20.75**	-26.66	-60.89	10.
MC 79 x MC 66	89.50	24.87	-56.60	-60.22	10.
MC 79 x MC 49	70.50	-41.73	-66.43	-68.67	12.
MC 79 x MC 69	99.00	-19.83	-53.95	-56.00	12.
MC 79 x MC 34	81.00	6.57*	-32.50	-64.00	11.
MC 66 x MC 49	217.50	4.50*	3.57*	-3.30	28.
MC 66 x MC 69	202.50	-3.85	-5.81	-10.00	33.
MC 66 x MC 34	117.75	-27.80	-43.03	-47.78	28.
MC 49 x MC 69	207.50	-2.35	-3.49	-7.78	30.
MC 49 x MC 34	117.50	-28.79	-44.50	-47.77	21.
MC 69 x MC 34	128.75	-23.13	-40.12	-42.78	30.
CD (p=0.05)	9.98	8.64	9.98	9.98	0.
CD (p=0.01)	13.12	11.36	13.12	13.12	0.

	7	8	9	10	11	12	13
.25	3.77**	-6.61	-21.75	23.95	15.28**	1.91**	43.84**
.60	-2.02	-7.74	-12.47	17.65	-12.08	-24.89	6.01**
.50	0.88	-5.78	-21.05	15.70	-18.67	-33.19	-5.71
.50	14.48**	4.29	-76.45	8.95	21.35**	7.83	-46.25
.25	-31.56	-57.90	-66.07	10.60	-12.90	-13.96	-36.36
25	-14.24	-45.25	-63.30	11.71	-15.75	-38.50	-33.33
.10	-45.78	-67.60	-69.29	11.45	- 8.22	-31.23	-31.23
.25	-37.78	-60.95	-71.61	8.75	-25.37	-42.05	-47.45
65	-42.82	-63.40	-70.50	7.10	-36.88	-55.76	-57.36
90	-20.25	-46.70	-64.27	8.10	-33.88	-55.12	-51.35
65	-40.33	-63.07	-64.96	9.25	-19.91	-44.41	-44.41
75	-31.68	-55.20	-67.45	7.55	-29.90	-50.00	-54.65
50	6.94	2.66	-21.05	18.35	52.28**	1.82**	10.22**
25	4.97**	-2.92	-7.89	18.05	10.40**	8.41**	8.41**
75	3.88**	-1.20	-20.36	16.25	4.33**	1.25	-2.40
60	4.70**	-10.66	-15.24	19.25	10.90**	6.65**	15.62**
70	5.85**	1.75	-26.04	17.30	4.36**	-4.12	3.90**
85	1.98*	-9.93	-14.54	15.85	-0.16	-13.21	-14.80
65	0.57	0.65	0.65	0.34	0.29	0.34	0.34
85	0.75	0.85	0.85	0.45	0.39	0.45	0.45

Table 36. Mean performance of parents and F_1 hybrids and extent of heterosis for weight, length and girth of fruit during second season

Parents/Crosses	Fruit weight				Fruit length				Fruit girth			
	Mean (cm)	RH (%)	RB (%)	SH (%)	Mean (cm)	RH (%)	HB (%)	SH (%)	Mean (cm)	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	230.50				38.85				16.85			
MC 78	230.50				36.85				15.10			
MC 84	228.50				30.20				21.13			
Arka Harit	200.50				27.25				20.85			
MC 82	40.50				6.75				8.10			
MC 79	30.50				7.30				6.60			
MC 66	200.50				29.25				15.50			
MC 49	215.50				23.75				17.35			
MC 69	214.50				33.15				16.50			
MC 34	205.50				25.40				15.25			
Priya x MC 78	227.00	-1.52	-1.52	-1.52	40.10	5.94**	3.22**	3.22**	16.48	3.13	-2.23	-2.23
Priya x MC 84	239.25	4.25**	3.80**	3.80**	31.55	-8.62	-18.79	-18.79	17.75	-6.51	-15.98	5.34
Priya x Arka Harit	160.50	-25.43	-30.37	-30.37	30.50	-7.63	-21.43	-21.43	17.70	-6.10	-15.11	5.04
Priya x MC 82	120.50	-10.91	-47.72	-47.72	9.55	-58.11	-75.55	-75.42	12.60	1.00	-25.22	-25.22
Priya x MC 79	108.50	-16.70	-52.90	-52.90	11.00	-52.22	-71.62	-71.62	12.75	8.74*	-24.33	-24.33
Priya x MC 66	205.50	-5.64	-13.02	-10.85	31.35	-7.93	-19.31	-19.31	17.00	5.10	0.89	0.89
Priya x MC 49	225.50	1.12*	-6.51	-2.17	32.25	3.04**	-16.98	-16.98	17.75	3.80	2.31	5.34
Priya x MC 69	206.50	-7.19	-6.94	-10.41	37.20	3.33**	-4.25	-4.25	16.50	-1.05	-2.08	-2.08

Contd.

Table 36. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Priya x MC 34	222.50	2.04**	-10.80	-3.47	27.60	-14.00	-28.89	-28.89	15.88	-1.09	-5.79	-5.79
MC 78 x MC 84	244.00	6.31**	5.86**	5.86**	31.70	-5.44	-13.98	-18.40	19.25	6.28*	-8.88	14.24**
MC 78 x Arka Harit	191.00	-11.37	-17.14	-17.14	30.25	-5.69	-17.98	-22.20	16.75	-6.82	-19.66	-0.59
MC 78 x MC 82	83.75	-38.07	-63.67	-63.67	10.50	-51.70	-71.44	-72.91	10.45	-9.91	-30.79	-37.98
MC 78 x MC 79	76.50	-41.27	-66.81	-66.81	12.10	-45.30	-67.20	-68.90	8.75	-19.35	-42.05	-48.07
MC 78 x MC 66	217.00	0.69	-5.86	-5.86	30.55	-7.49	-17.03	-21.30	15.50	1.31	0.00	-8.01
MC 78 x MC 49	211.00	-5.38	-8.46	-8.46	28.45	-6.11	-22.80	-26.75	16.75	3.24	-3.46	-0.51
MC 78 x MC 69	221.00	-0.67	-4.12	-4.12	36.45	4.14**	-1.01	-6.18	16.75	6.01*	1.52	-0.59
MC 78 x MC 34	241.00	10.65**	4.56**	4.56**	27.35	-12.13	-25.78	-29.60	16.63	2.97	2.46	-7.27
MC 84 x Arka Harit	143.00	-33.33	-37.96	-37.96	29.80	3.83**	-1.24	-23.23	20.25	-3.51	-4.14	20.18**
MC 84 x MC 82	97.50	-27.37	-57.33	-57.70	12.10	-3.44	-59.85	-68.79	13.15	-5.90	-3.49	-18.40
MC 84 x MC 79	96.75	-25.15	-57.65	-58.03	11.75	-37.33	-61.09	-69.76	11.50	-17.04	-45.56	-31.75
MC 84 x MC 66	196.75	-8.28	-13.89	-14.64	29.45	-0.93	-2.48	-24.20	17.50	-4.44	-17.16	3.86
MC 84 x MC 49	240.50	8.33**	5.25**	4.33**	30.70	13.81**	1.60*	-20.98	19.00	-1.23	-10.06	12.76**
MC 84 x MC 69	233.75	5.53**	2.30**	1.41**	30.55	-3.47	-7.77	-21.30	17.85	-5.12	-15.50	5.93
MC 84 x MC 34	245.50	13.00**	7.44**	6.51**	27.25	-2.01	-9.85	-29.92	14.75	-18.90	-30.18	-12.46
Arka Harit x MC 82	81.25	-32.43	-59.48	-64.75	9.15	-46.18	-66.42	-76.45	11.85	-18.13	-43.16	-29.67
Arka Harit x MC 79	91.50	-20.61	-54.36	-60.30	10.05	-40.00	-63.12	-74.13	11.50	-16.21	-44.84	-31.75
Arka Harit x MC 66	141.00	-29.68	-29.68	-38.82	28.05	-0.71	-4.10	-27.80	18.25	0.41	-12.47	8.30**

Contd.

Table 36. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Arka Harit x MC 49	202.50	-2.64	-6.03	-12.15	27.90	9.41**	2.39**	-28.19	18.25	-4.45	-12.47	8.30**
Arka Harit x MC 69	94.00	-54.70	-56.17	-5.92	29.05	-3.81	-12.37	-25.23	16.63	-10.97	-20.26	-1.33
Arka Harit x MC 34	211.50	4.28**	2.87**	-8.24	26.25	-0.28	-3.67	-32.43	15.63	-13.43	-25.06	-7.27
MC 82 x MC 79	46.75	35.57**	14.88**	-79.71	9.67	37.72**	32.53**	-75.10	9.55	29.93**	17.96**	-43.32
MC 82 x MC 66	88.60	-26.30	-55.80	-61.56	10.57	-41.25	-63.85	-72.78	11.25	-4.66	-27.42	-33.23
MC 82 x MC 49	77.75	-39.14	-63.92	-66.27	10.47	-31.31	-55.89	-73.04	10.88	-14.54	-37.32	-35.46
MC 82 x MC 69	70.75	-44.30	-66.97	-69.28	10.72	-46.24	-67.64	-72.39	11.50	-6.50	-30.30	-31.75
MC 82 x MC 34	82.75	-32.62	-59.75	-64.10	11.32	-29.55	-55.41	-70.85	12.50	7.07*	-27.87	-25.81
MC 79 x MC 66	99.00	-14.10	-50.60	57.05	10.70	-41.45	-63.42	-73.46	11.00	-0.45	-29.03	-34.72
MC 79 x MC 49	92.50	-24.64	-42.92	-59.87	11.32	-27.05	-61.28	-70.85	10.75	-10.23	-38.04	-36.20
MC 79 x MC 69	104.75	-14.31	-51.17	-54.56	11.07	-47.24	-66.60	-71.49	9.65	-16.45	-41.52	-42.73
MC 79 x MC 34	107.75	-8.54	-47.60	-53.25	9.87	-39.60	-61.12	-74.58	10.25	-6.18	-32.77	-39.17
MC 66 x MC 49	157.75	-24.16	-24.90	-31.56	27.85	5.09**	-4.79	-28.31	16.25	-1.07	-6.34	-3.56
MC 66 x MC 69	170.50	-17.83	-20.51	-26.05	31.45	0.80	-5.13	-17.05	16.38	2.34	0.76	-2.82
MC 66 x MC 34	171.50	-15.54	-16.59	-25.60	26.37	-3.48	-9.83	-32.11	14.25	-7.31	-8.06	-15.43
MC 49 x MC 69	143.00	-33.48	-33.64	-37.96	28.67	0.79	-13.50	-26.15	16.37	-3.15	-5.62	-2.82
MC 49 x MC 34	138.50	-34.22	-35.73	-39.91	26.07	6.10**	2.66**	-32.88	15.75	-3.37	-9.22	-6.53
MC 69 x MC 34	184.50	-12.17	-13.98	-19.96	29.07	-0.68	-12.29	-25.16	14.25	-10.24	-13.64	-15.43
CD (p=0.05)	2.35	2.04	2.35	2.35	0.55	0.47	0.55	0.55	1.03	0.90	1.30	1.30
CD (p=0.01)	3.09	2.68	3.09	3.09	0.73	0.62	0.73	0.73	1.36	1.18	1.36	1.36

Table 37. Mean performance of parents and F_1 hybrids and extent of heterosis for fruit weight, fruit length and fruit girth in bitter gourd during third season

Parents/Crosses	Fruit weight				Fruit length				Fruit girth			
	Mean (g)	RH (%)	HB (%)	SH (%)	Mean (cm)	RH (%)	HB (%)	SH (%)	Mean (cm)	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	213.75				35.35				16.00			
MC-78	211.00				34.95				14.20			
MC-84	272.50				29.25				23.30			
Arka Harit	198.25				28.65				23.30			
MC-82	25.50				6.35				8.10			
MC-79	287.50				7.06				6.55			
MC-66	197.50				30.10				16.15			
MC-49	200.00				25.00				18.05			
MC-69	192.50				33.75				16.60			
MC-34	117.50				26.10				15.00			
Priya x MC-78	215.75	1.55	0.94	0.94	35.45	0.85	0.28	0.28	14.55	-3.64	-9.06	-9.06
Priya x MC-84	217.00	-10.70	-20.37	1.52	31.25	-3.20	-11.59	-11.59	17.05	16.38**	-26.82	6.56**
Priya x Arka Harit	202.75	-1.58	-5.16	-5.16	30.00	-6.25	-15.13	-15.13	18.75	27.98**	-19.53	17.19
Priya x MC-82	105.75	-11.59	-50.53	-50.53	14.10	-32.37	-60.11	-60.11	12.60	4.56**	-21.25	-21.25
Priya x MC-79	93.50	-22.89	-56.25	-56.25	17.30	-18.40	-51.06	-51.06	10.50	6.87	-34.38	-34.38
Priya x MC-66	203.50	-1.03	-4.80	-4.78	31.75	-2.98	-10.18	-10.12	16.25	1.08	0.62	1.56
Priya x MC-49	204.75	-1.02	-4.21	-4.21	27.75	-8.20	-21.50	-21.50	17.10	0.44	-5.26	6.88**
Priya x MC-69	196.13	-3.45	-8.25	-8.25	35.50	2.75*	0.42	0.42	16.85	3.37**	1.51*	5.31**

Contd.

Table 37. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Priya x MC-34	131.50	-20.60	-38.48	-38.48	27.50	-10.50	-22.21	-22.21	16.30	5.16**	1.88*	1.88
MC-78 x MC-84	224.75	-7.00	-17.53	5.15**	32.50	1.23	-7.01	-8.06	19.85	34.57**	-14.88	24.06**
MC-78 x Arka Harit	219.00	7.25**	3.79**	2.46**	29.50	2.20	-15.59	-16.55	21.20	54.18**	-9.07	32.50**
MC-78 x MC-82	82.75	-30.02	-60.78	-61.87	12.90	-37.50	-63.09	-63.51	12.40	11.21**	-12.68	-22.50
MC-78 x MC-79	75.25	-37.20	-64.34	-64.80	17.00	-19.05	-51.36	-51.91	13.20	27.20**	-7.04	-17.50
MC-78 x MC-66	211.00	3.30**	0.00	-1.29	31.40	-3.40	-10.15	-11.17	16.30	7.41**	0.93	1.88
MC-78 x MC-49	204.75	-0.37	-2.96	-4.21	26.50	-11.59	-24.18	-25.04	18.05	11.93**	0.00	12.81**
MC-78 x MC-69	197.75	-1.98	-6.28	-7.49	37.50	3.52**	7.30**	6.08**	16.15	4.87**	-2.71	0.93
MC-78 x MC-34	132.75	-19.18	-37.09	-37.89	27.10	-11.22	-22.46	-23.33	15.05	3.08**	0.33	-5.94
MC-84 x Arka Harit	206.25	-12.37	-24.30	-3.51	29.10	0.51	-5.13	-17.68	23.15	-0.64	-0.64	44.69**
MC-84 x MC-82	70.50	-52.68	-74.13	-67.00	18.75	5.34**	-35.90	-46.96	12.50	-20.30	-45.65	-21.88
MC-84 x MC-79	64.50	-57.17	-76.33	-69.82	20.75	14.32**	-29.06	-41.30	10.60	-28.97	-53.91	-33.75
MC-84 x MC-66	222.75	-5.21	-18.26	4.21**	29.70	0.08	-1.33	-15.98	16.30	10.69**	-21.13	1.88
MC-84 x MC-49	200.25	-15.24	-36.51	-6.32	26.70	-1.56	-8.72	-24.47	18.55	-10.28	-19.34	15.94**
MC-84 x MC-69	194.00	-16.56	-28.81	-9.24	34.10	8.25**	1.04	-3.56	16.85	-15.50	-26.74	5.31**
MC-84 x MC-34	202.75	-3.97	-25.59	-5.15	27.05	-2.25	-7.52	-23.48	16.05	-16.19	-30.22	0.31
Arka Harit x MC-82	71.75	-35.86	-63.80	-66.43	13.80	-21.14	-51.83	-60.96	9.55	-39.17	-58.48	-40.31
Arka Harit x MC-79	75.75	-33.48	-61.79	-64.56	16.75	-6.16	-41.15	-52.62	9.10	-39.02	-60.45	-43.13
Arka Harit x MC-66	197.75	-0.06	-0.25	-7.49	29.05	-1.10	-3.48	-17.82	16.05	-18.63	-30.21	-0.31

Contd.

Table 37. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Arka Harit x MC-49	198.50	-0.31	-0.75	-7.13	26.85	-0.09	-6.28	-24.05	18.15	-12.21	-21.87	13.44**
Arka Harit x MC-69	193.00	-1.22	-2.65	-9.77	32.50	4.17**	-3.70	-8.06	16.95	-15.03	-26.30	5.94**
Arka Harit x MC-34	147.75	-6.41	-0.25	-30.88	27.90	1.92	-2.62	-21.07	15.05	6.36**	-36.57	-5.94
MC-82 x MC-79	33.50	23.50**	16.52**	-84.33	7.50	11.90**	-6.38	-78.78	7.95	8.50	-1.85	-50.31
MC-82 x MC-66	47.25	-57.60	-76.08	-77.89	7.40	59.73	-75.41	-79.07	9.55	-21.20	-40.87	-40.31
MC-82 x MC-49	60.75	-45.80	-69.63	-71.58	8.10	-48.33	-67.60	-77.09	9.15	-30.10	-49.31	-42.81
MC-82 x MC-69	34.25	-68.34	-82.40	-83.98	9.10	-41.95	-73.04	-74.26	8.70	-29.69	-47.59	-45.63
MC-82 x MC-34	32.50	-54.55	-72.34	-84.80	8.55	-47.30	-67.24	-75.81	8.85	-23.38	-0.41	-44.67
MC-79 x MC-66	67.75	-40.10	-65.56	-68.30	19.05	2.56	-36.71	-46.11	10.30	-9.25	-36.22	-35.63
MC-79 x MC-49	77.00	-32.67	-62.00	-63.98	20.10	25.43**	-19.60	-43.14	12.30	0.00	-31.86	-23.13
MC-79 x MC-69	80.75	-27.00	-58.05	-62.18	21.75	6.62**	-35.56	-38.47	13.60	17.49**	-18.07	-15.00
MC-79 x MC-34	67.25	-8.40	-42.77	-68.54	18.90	14.07**	-27.59	-46.53	10.25	-4.87	-31.67	-35.94
MC-66 x MC-49	198.75	0.00	-0.63	-7.02	27.90	1.27	-7.31	-2.10	16.25	34.56**	-9.97	1.56
MC-66 x MC-69	195.50	0.25	-1.01	-8.54	32.55	1.96	-3.56	-7.92	16.35	-0.15	-15.06	2.19*
MC-66 x MC-34	139.25	-11.58	-29.49	-34.85	27.10	-3.56	-9.97	-23.33	15.05	-3.30	-6.81	-5.94
MC-49 x MC-69	195.50	-0.38	-2.25	-8.54	34.30	16.78**	1.63	-2.97	17.15	-1.01	-4.99	7.19**
MC-49 x MC-34	172.50	8.66**	-13.75	-19.30	25.25	-1.17	-3.26	-28.57	16.15	-2.26	-10.53	-0.94
MC-69 x MC-34	132.50	-14.52	-31.17	-38.01	30.25	1.08	-10.37	-14.43	15.15	-4.11	-8.73	-5.31
CD (p=0.05)	4.95	4.29	4.95	4.95	0.85	0.74	0.85	0.85	0.34	0.29	0.34	0.34
CD (p=0.01)	6.50	5.64	6.50	6.51	1.12	0.98	1.12	1.12	0.45	0.39	0.45	0.45

heterobeltiosis. MC-82 x MC-79 as in relative heterosis recorded the highest heterobeltiosis (16.88%). In the third season only MC-82 x MC-79 (16.52%) and MC-78 x Arka Harit (3.79%) showed significant heterobeltiosis.

Standard heterosis was significant for 5 crosses in first, 6 in second and three in the third seasons. Priya x MC-84 (25.37%) and MC-78 x MC-84 (16.77%) in first season recorded the highest values of relative heterosis. Heterobeltiosis was relatively lower in the second and third seasons.

k. Fruit length

Out of 45 hybrids, 16 in first, ten in second and eleven in third seasons exhibited significant relative heterosis. The hybrids with significant relative heterosis were MC-82 x MC-79 in first and second seasons with 14.48% and 37.72% relative heterosis respectively. In the third season the hybrid MC-79 x MC-49 (25.43%) showed superiority over others.

Significant heterobeltiosis was exhibited by three crosses in first, five in second and only one in the third seasons. None of the hybrids had significant stand heterosis in the first and second seasons.

MC-78 x MC-69 (6.08) (Plate 31) was the only hybrid with standard heterosis in the third season.

1. Fruit girth

Relative heterosis was significant in 15 crosses in first four in second and 18 in third seasons. Superior crosses were MC-66 x MC-49 (52.28%) and MC-82 x MC-79 (21.35%) in first, MC-82 x MC-79 (29.93%) in second and MC-78 x MC-84 (34.57%), MC-66 x MC-49 (34.5%), Priya x Arka Harit (27.98%) and MC-78 x MC-79 (27.2%) in the third season.

Five hybrids in first, one each in second and third seasons showed significant heterobeltiosis. Crosses MC-66 x MC-49 (8.4%) and MC-82 x MC-79 (7.83%) in first and MC-82 x MC-79 (29.93%) in second possessed comparatively higher relative heterobeltiosis.

The hybrid MC-84 x Arka Harit in general possessed consistant standard heterosis for all the three seasons (39.94%, 20.18% and 44.69%). Other crosses with appreciable standard heterosis were Arka Harit x MC-49 (43.84%) (Plate 32) in the first, and MC-78 x MC-84 in the second and third seasons (14.24% and 32.5%).

Plate-31. MC 78 x MC 69, standard heterotic F_1 hybrid for fruit length

Plate-32. Arka Harit x MC 49, standard heterotic F_1 hybrid for fruit girth

PLATE-31

m. Flesh thickness

Only two hybrids, Priya x Arka Harit (7.34%) and MC-82 x MC-79 (16.92%) showed significant relative heterosis in the first season. In the second season relative heterosis was significant for six hybrids and seven in the third season.

None of the hybrids possessed significant heterobeltiosis in the first and second seasons. However, there were crosses with significant heterobeltiosis in the third season. The cross MC-82 x MC-79 possessed maximum heterobeltiosis (17.86%) followed by Priya x MC-34 (5.77%) and MC-69 x MC-34 (5.76%).

Standard heterosis was significant for four hybrids in the first and 11 each in the second and third seasons. Priya x Arka Harit showed consistent standard heterosis for all the seasons (35.71%, 16.41% and 43.9%).

n. Seeds/plant

Relative heterosis was observed in 11 crosses in first and third and 17 in second season. Maximum heterosis was shown by MC-82 x MC-79 (27.57%) in first MC-82 x MC-69 and MC-82 x MC-34 (40.17% each) in third season.

Table 38. Mean performance of parents and F_1 hybrids and extent of heterosis for flesh thicks, seeds/fruit and 100 seed weight during first season

Parents/Crosses	Flesh thickness				Seeds/fruit				100 seed weight			
	Mean (mm)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)	Mean (g)	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	5.25				25.75				24.25			
MC 78	5.25				23.25				23.25			
MC 84	5.60				24.75				27.00			
Arka Harit	8.03				20.75				20.75			
MC 82	3.38				13.50				18.25			
MC 79	3.13				15.50				7.48			
MC 66	5.00				25.50				28.30			
MC 49	5.28				22.75				20.75			
MC 69	5.25				18.75				22.25			
MC 34	5.00				25.75				22.25			
Priya x MC 78	5.13	-2.38	-2.38	-2.38	24.50	3.78	-4.85	-4.85	25.25	6.32**	4.13	4.13
Priya x MC 84	5.28	-2.76	-5.80	-0.48	23.50	-6.90	-8.74	-8.74	25.50	-0.49	-5.56	5.15*
Priya x Arka Harit	7.13	7.34**	-11.21	35.71**	22.50	-3.20	-12.62	-12.62	21.75	-3.30	-10.31	-10.31
Priya x MC 82	4.23	-2.02	-19.52	-19.52	17.50	[illegible]	-32.03	-32.03	20.25	-4.70	-16.50	-16.50
Priya x MC 79	4.05	-3.29	-22.86	-22.86	22.50	9.09*	-12.62	-12.62	9.25	-41.60	-61.85	-61.85
Priya x MC 66	5.15	0.49	-1.90	-1.90	25.50	-0.49	-0.97	-0.97	27.00	2.76	-4.59	11.34**
Priya x MC 49	5.30	0.71	0.47	0.95	22.00	-0.09	-14.56	-14.56	24.50	8.89**	1.03	1.03
Priya x MC 69	4.25	19.05	-19.04	-19.04	21.00	-5.62	-18.45	-18.45	24.50	5.38*	1.03	1.03

Contd.

Table 38 Continued

1	2	3	4	5	6
Priya x MC 34	5.00	-2.44	-4.76	-4.76	23.50
MC 78 x MC 84	5.18	-4.61	-10.71	-1.43	21.50
MC 78 x Arka Harit	6.05	-8.85	-24.61	15.24**	21.50
MC 78 x MC 82	4.13	-4.65	-21.43	-21.43	19.00
MC 78 x MC 79	4.08	-2.68	-22.38	-22.38	22.00
MC 78 x MC 66	5.23	1.95	-0.48	-0.48	24.50
MC 78 x MC 49	5.15	-2.13	-2.37	-1.90	23.50
MC 78 x MC 69	5.33	1.43	1.43	1.43	21.50
MC 78 x MC 34	5.03	-1.95	-4.29	-4.29	24.50
MC 84 x Arka Harit	6.13	-16.24	-23.68	-16.67**	22.50
MC 84 x MC 82	4.38	-2.51	-21.88	-16.67	15.50
MC 84 x MC 79	3.88	-11.17	-30.80	-76.19	22.50
MC 84 x MC 66	5.20	-1.89	-7.14	-0.75	24.50
MC 84 x MC 49	5.20	-4.37	-7.14	-0.95	25.50
MC 84 x MC 69	5.13	-5.53	-8.48	-2.38	18.50
MC 84 x MC 34	5.33	0.48	-0.28	-1.43	24.50
Arka Harit x MC 82	4.25	-24.43	-47.04	-19.04	18.50
Arka Harit x MC 79	3.75	-32.74	-53.27	-28.57	20.50
Arka Harit x MC 66	5.38	-17.47	-33.02	2.38	23.50

7	8	9	10	11	12	13
-8.74	-8.74	-8.74	23.50	3.30	-3.03	-3.09
-11.57	-13.13	-16.50	28.50	14.43**	5.56**	17.53**
-3.64	-9.47	-16.50	23.50	6.82*	0.00	-3.09
1.67	-20.00	-26.21	20.50	-1.20	-12.77	-15.46
11.75**	-7.35	-14.56	8.25	-46.30	-64.89	-65.98
-0.75	-3.92	-4.85	27.75	7.66**	-1.94	14.43**
0.84	-1.05	-8.74	23.75	7.95**	2.10	-2.06
0.88	-9.47	-16.50	22.50	-1.10	-3.20	-7.22
1.29	-4.85	-4.85	23.25	2.20	0.00	-4.12
1.10	-9.09	-12.85	25.75	7.85**	-04.65	6.19*
-18.95	-37.37	-39.80	24.50	39.00**	-9.26	1.03
11.80**	-9.97	-12.85	8.38	-51.40	-68.98	-65.46
-2.40	-3.92	-4.85	28.75	4.00	1.59	18.56**
7.37*	3.03	-0.97	25.50	6.80**	-5.50	5.50*
-14.94	-25.25	-28.16	21.50	-12.60	-20.37	-11.34
-3.00	-4.85	-4.85	23.00	-6.60	-14.81	-11.34
8.03*	-10.84	-28.16	19.50	0.00	-6.02	-19.59
13.10**	-1.20	-20.39	7.75	-45.10	-62.65	-68.00
1.62	-7.84	-8.74	24.50	-0.10	-13.42	1.03

Contd.

Table 38. Continued

1	2	3	4	5
Arka Harit x MC 49	5.70	-14.29	-28.97	8.57**
Arka Harit x MC 69	5.80	-12.62	-27.73	10.48**
Arka Harit x MC 34	5.23	-19.97	-34.90	-0.48
MC 82 x MC 79	3.80	16.92	12.59	-27.62
MC 82 x MC 66	3.60	-30.60	-28.00	-31.43
MC 82 x MC 49	4.20	-2.33	-20.38	-20.00
MC 82 x MC 69	4.25	-1.45	-19.05	-19.05
MC 82 x MC 34	4.10	-2.09	-18.00	-21.90
MC 79 x MC 66	3.95	0.28	-21.00	-24.76
MC 79 x MC 49	3.78	-10.12	-28.40	-28.00
MC 79 x MC 69	3.68	-12.23	-30.00	-0.30
MC 79 x MC 34	3.90	-4.00	-22.00	-25.71
MC 66 x MC 49	5.40	5.11	2.37	2.86
MC 66 x MC 69	5.25	1.46	0.95	0.95
MC 66 x MC 34	5.00	0.00	0.00	4.76
MC 49 x MC 69	5.05	-4.04	-4.27	3.81
MC 49 x MC 34	5.33	3.65	0.95	1.43
MC 69 x MC 34	5.15	-0.22	-1.90	-1.90
CD (p=0.05)	0.34	0.34	0.29	0.34
CD (p=0.01)	0.45	0.39	0.45	0.45

6	7	8	9	10	11	12	13
22.50	3.37	-1.10	-12.87	22.50	8.43**	8.43**	-7.22
20.50	3.80	-1.20	-20.39	24.50	13.95**	10.11**	1.03
23.50	1.08	-8.74	-8.74	21.50	0.00	-3.37	-11.34
18.50	27.57**	19.35**	-28.16	9.25	-28.08	-49.31	-61.86
19.00	-2.60	-25.50	-26.21	18.75	-19.40	-33.75	-22.68
17.00	-6.20	-25.27	-33.98	19.75	1.28	-4.82	-18.56
19.50	20.93**	4.00	-24.27	19.75	-2.47	-11.24	-18.56
24.50	24.84**	-4.85	-4.85	19.25	-4.90	-13.45	-20.62
19.00	-7.31	-25.49	-26.21	8.25	-56.30	-70.00	-65.95
20.50	7.19	-9.89	-20.39	8.00	-43.30	-61.45	-67.01
20.50	19.70**	9.33*	-20.39	8.25	-44.50	-62.92	-65.98
21.00	1.81	-18.45	-18.45	8.75	-41.10	-60.67	-63.92
21.00	9.80*	-17.65	-18.45	25.50	3.98	-9.87	5.15*
19.00	-14.12	-17.65	-26.21	24.50	-3.16	-13.48	1.03
23.50	-8.30	-8.73	-8.75	22.50	0.89	-20.50	-7.22
20.50	-0.61	-9.89	-20.39	22.50	4.65	1.12	-7.22
23.50	-3.10	-8.74	-8.74	23.50	9.33**	5.60**	-3.09
20.50	-13.68	-20.38	-20.38	21.50	-3.30	-3.30	-11.34
1.80	1.57	1.80	1.80	1.32	1.16	1.32	1.32
2.37	2.06	2.37	2.37	1.74	1.52	1.74	1.74

Table 39. Mean performance of parents and F_1 hybrids and extent of heterosis for flesh thickness, seeds/fruit and 100 seed weight during second season

Parents/Crosses	Flesh thickness				Seeds/fruit				100 seed weight			
	Mean (mm)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)	Mean (g)	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	4.88				20.50				21.75			
MC 78	5.13				17.50				23.75			
MC 84	5.50				20.75				25.50			
Arka Harit	6.38				16.50				20.50			
MC 82	3.25				11.75				17.75			
MC 79	3.20				15.75				7.13			
MC 66	5.10				19.25				23.50			
MC 49	5.25				19.25				19.50			
MC 69	4.88				17.50				20.00			
MC 34	4.63				17.50				19.50			
Priya x MC 78	4.63	-7.50	-9.76	-5.12	22.00	15.79**	7.32	7.32	22.25	-2.15	-6.32	2.30
Priya x MC 84	5.18	-0.24	-5.91	6.15	22.00	1.82	1.20	2.44	21.00	-11.11	-17.65	-3.45
Priya x Arka Harit	5.68	0.89	-10.98	16.41**	17.25	-6.76	-15.25	-15.25	20.50	-2.96	-5.75	-5.75
Priya x MC 82	3.88	-5.10	-20.51	-20.51	15.25	-5.43	-25.61	-25.61	18.75	-5.06	-13.79	-13.79
Priya x MC 79	3.88	-4.02	-20.51	-20.51	18.00	-0.69	-12.20	-12.20	7.75	-46.32	-64.36	-64.36
Priya x MC 66	5.13	2.76	0.49	5.13	22.50	13.21	9.76	9.76	22.50	-0.55	-4.26	3.45
Priya x MC 49	5.13	1.22	-2.38	5.13	22.00	10.69	7.32	7.32	23.50	13.94**	8.05**	8.05**
Priya x MC 69	5.13	5.13	5.13	5.13	17.25	-9.21	-15.25	-15.25	23.50	12.57**	8.05**	8.05**

Contd...

Table 39. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Priya x MC 34	4.85	2.10	4.86	-0.51	22.25	17.11**	8.54	8.54	23.00	11.51**	5.75*	5.75*
MC 78 x MC 84	5.13	-3.53	-6.82	5.13	23.00	20.26**	10.84*	12.20*	23.75	-3.55	-6.80	9.20**
MC 78 x Arka Harit	5.23	9.13*	-18.04	7.18**	17.50	2.94	0.00	-14.65	21.75	-1.72	-8.42	0.00
MC 78 x MC 82	4.23	0.89	-17.56	-13.33	12.50	-14.53	-28.57	-39.02	19.75	-4.82	-16.84	-9.60
MC 78 x MC 79	3.88	-6.91	-24.39	-20.51	20.00	20.30**	14.29*	-2.44	9.25	-40.08	-61.05	-57.47
MC 78 x MC 66	5.13	-0.24	0.00	5.13	23.00	15.17**	19.48**	12.20*	23.50	-0.53	1.05	8.05**
MC 78 x MC 49	5.23	0.72	-0.48	7.18**	21.50	17.00**	11.69*	4.87	23.75	9.83**	0.00	9.20**
MC 78 x MC 69	5.00	0.00	2.43	2.56	19.50	11.43*	11.43*	-4.87	22.50	2.86	-5.26	3.45
MC 78 x MC 34	4.88	0.00	-4.88	0.00	21.50	22.86**	22.86**	4.87	21.25	-1.73	-10.53	-2.30
MC 84 x Arka Harit	5.85	-1.47	-8.24	20.00**	16.50	-11.41	-20.48	-19.50	19.75	-14.13	-22.55	-9.20
MC 84 x MC 82	4.43	1.14	-19.55	-9.23	13.50	-16.92	-34.94	-34.15	17.75	-17.92	-30.39	-18.39
MC 84 x MC 79	3.88	-10.92	-29.55	-20.51	19.50	6.85	-6.02	-4.87	10.25	-37.16	-59.80	-52.87
MC 84 x MC 66	5.13	-3.30	-6.82	5.13	22.00	10.00	6.02	7.32	21.75	-11.22	-14.71	0.00
MC 84 x MC 49	5.48	1.86	-0.46	12.31**	21.50	7.50	3.61	4.87	20.50	-8.88	-19.61	-5.75
MC 84 x MC 69	5.05	-2.65	-8.18	3.59	19.75	2.60	-4.81	-3.66	22.50	-1.10	-11.76	3.45
MC 84 x MC 34	4.88	-3.70	-11.36	0.00	20.50	6.49	-1.20	0.00	21.50	-4.44	-15.67	-1.15
Arka Harit x MC 82	4.15	-13.76	-34.90	-14.87	13.00	-7.96	-21.21	-6.34	19.50	1.96	-4.88	-10.34
Arka Harit x MC 79	3.88	-19.06	-39.22	-20.51	20.50	27.13**	24.24**	0.00	9.25	-33.02	-54.88	-57.47
Arka Harit x MC 66	5.50	-4.14	-13.73	12.82**	22.50	25.87**	16.88**	9.76	22.50	2.27	-4.25	3.45

Contd.

Table 39. Continued

1	2	3	4	5	6
Arka Harit x MC 49	5.75	-1.08	-9.80	17.95**	22.00
Arka Harit x MC 69	5.13	-8.89	-19.61	5.13	19.00
Arka Harit x MC 34	4.88	-11.36	-23.53	0.00	20.50
MC 82 x MC 79	3.25	0.78	0.00	-33.33	15.50
MC 82 x MC 66	3.88	-7.18	-24.02	-20.51	14.00
MC 82 x MC 49	4.38	2.94	-16.67	-10.26	18.00
MC 82 x MC 69	3.88	-4.62	-20.51	-20.51	20.50
MC 82 x MC 34	4.25	7.94	-8.10	-12.82	20.50
MC 79 x MC 66	4.62	11.45**	-9.31	-5.12	15.50
MC 79 x MC 49	4.13	-2.37	-21.43	-15.38	17.00
MC 79 x MC 69	4.63	-14.55**	-4.62	-5.12	21.50
MC 79 x MC 34	4.75	21.41**	2.70	-2.56	21.50
MC 66 x MC 49	5.45	5.31	3.81	11.79**	18.50
MC 66 x MC 69	5.35	7.27*	4.90	9.74*	22.50
MC 66 x MC 34	5.10	4.88	0.00	4.61	20.50
MC 49 x MC 69	5.08	0.25	-3.33	4.10	21.50
MC 49 x MC 34	5.33	7.85**	1.43	9.23**	19.75
MC 69 x MC 34	5.13	7.89**	5.13	5.13	18.50
CD (p=0.05)	0.34	0.29	0.34	0.34	3.12
CD (p=0.01)	0.45	0.39	0.45	0.45	4.11

	8	9	10	11	12	13
8*	14.28**	7.32	20.50	2.50	0.00	-5.75
6*	8.57	-7.32	20.25	1.25	-1.22	-6.90
9*	17.14**	0.00	18.75	-6.25	-8.50	-13.79
3*	-1.58	-24.39	7.75	-37.69	-56.34	-64.36
7	-27.27	-31.71	17.75	0.14	-24.47	-18.39
3*	-6.45	-12.20	17.62	-5.00	-9.62	-18.97
7*	17.14**	0.00	13.50	-28.47	-32.50	-37.93
7*	17.14**	0.00	17.75	-4.43	-8.72	-18.16
3	-19.48	-31.71	8.25	-46.12	-64.89	-62.06
6	-11.69	-17.07	9.25	-30.52	-52.56	-57.47
2*	22.86**	4.87	8.62	-36.41	-56.88	-60.34
2*	22.86**	4.87	8.50	-36.15	-56.41	-60.92
0	-3.90	-9.76	20.00	-6.98	-14.89	-8.05
5*	28.57**	9.76	22.50	3.45	-4.25	3.45
5*	17.14**	0.00	22.50	4.65	-4.25	3.45
5*	11.69*	4.87	21.50	8.86**	7.50*	-1.15
0	2.60	-3.66	22.50	15.38**	12.50**	3.45
3	-6.33	-9.76	21.75	10.13**	8.75*	0.00
0	3.12	3.12	2.23	1.94	2.23	2.23
5	4.11	4.11	2.93	2.53	2.93	2.93

Table 40. Mean performance of parents and F_1 hybrids and extent of heterosis for flesh thickness, seeds/fruit and 100 seed weight in bitter gourd during third season

Parents/Crosses	Flesh thickness				Seeds/fruit				100 seed weight			
	Mean (mm)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)	Mean (g)	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
Priya	5.13				23.50				23.75			
MC-78	5.38				18.50				23.75			
MC-84	5.78				22.38				27.50			
Arka Harit	8.13				16.63				23.00			
MC-82	3.50				13.25				19.00			
MC-79	3.13				15.75				6.75			
MC-66	5.25				20.50				24.50			
MC-49	5.25				29.25				21.50			
MC-69	5.00				18.25				22.00			
MC-34	5.20				21.50				19.00			
Priya x MC-78	5.30	0.95	-1.40	3.41	21.75	3.57	-7.45	-7.45	23.75	0.00	0.00	0.00
Priya x MC-84	5.70	4.58	-1.30	11.22**	22.00	-4.08	-6.38	-6.38	25.50	-0.48	-7.27	7.36**
Priya x Arka Harit	7.38	11.30**	-9.23	43.90**	19.00	-5.30	-29.27	-29.27	26.25	12.30**	10.25**	10.25**
Priya x MC-82	3.88	-10.14	-24.39	-24.40	16.75	-8.80	-43.62	-43.62	20.75	-2.90	-12.63	-12.63
Priya x MC-79	4.38	6.06	-14.63	-14.63	20.75	3.18	-13.83	-13.83	7.63	-50.00	-67.89	-67.89
Priya x MC-66	5.15	-0.72	-1.90	-0.49	20.75	-5.68	-12.66	-12.66	26.50	9.84**	8.14*	11.58**
Priya x MC-49	6.05	16.60**	15.23**	18.05**	20.50	-4.10	-18.08	-18.08	23.50	3.87	-1.05	-1.05
Priya x MC-69	5.15	1.73	0.49	0.49	18.75	-10.17	-20.21	-20.21	19.75	-13.67	-16.84	-16.84

Contd.

Table 40. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Priya x MC-34	5.50	6.54*	5.77*	7.32*	21.00	-6.60	-10.64	-10.64	21.75	1.75	8.42*	-8.42
MC-78 x MC-84	5.30	-4.90	-8.23	3.41	19.00	-7.03	-15.06	-19.14	25.00	-2.43	-9.05	5.26
MC-78 x Arka Harit	6.38	-5.56	-21.54	24.34**	19.00	8.18	2.70	-19.14	22.50	-3.74	-5.26	-5.26
MC-78 x MC-82	4.55	2.53	-15.35	-11.22	17.00	7.09	-8.10	-27.66	18.75	-12.28	-21.05	-21.05
MC-78 x MC-79	3.88	-8.80	-27.90	-24.39	17.75	3.65	-4.05	-24.46	8.25	-45.90	-55.26	-65.26
MC-78 x MC-66	5.13	-3.52	-4.65	0.00	21.50	10.26**	4.88	-8.51	24.00	-0.52	-2.04	1.65
MC-78 x MC-49	5.63	5.88	4.65	9.76**	20.50	8.61**	6.41*	-18.08	25.00	10.49**	5.26	5.26
MC-78 x MC-69	5.13	-3.61	-4.65	0.00	19.00	3.40	2.70	-29.27	21.50	-6.01	-9.47	-9.47
MC-78 x MC-34	5.00	-5.44	-7.00	-2.44	20.75	3.75	-3.49	-12.76	24.50	14.62**	3.16	3.16
MC-84 x Arka Harit	6.13	-11.87	-24.62	19.50**	18.75	-3.85	-16.18	-20.21	22.75	-9.90	-17.27	-4.21
MC-84 x MC-82	4.13	-11.05	-28.57	-19.50	15.75	-11.58	-29.59	-32.98	20.00	-13.98	-27.27	-15.79
MC-84 x MC-79	3.63	-18.54	-37.23	-29.27	18.00	-5.58	-19.54	-23.40	8.75	-48.90	-68.18	-63.16
MC-84 x MC-66	5.50	-0.22	-4.76	7.32*	21.50	0.29	-3.89	-8.51	22.50	-13.46	-18.18	-5.26
MC-84 x MC-49	5.43	-1.60	-6.06	5.85	19.75	-5.11	-11.71	-15.95	20.50	-16.33	-25.45	-13.68
MC-84 x MC-69	5.30	-1.62	-8.23	3.41	21.50	5.85	-3.89	-8.51	21.75	-12.12	-20.91	-8.42
MC-84 x MC-34	5.30	-3.40	-8.23	3.41	20.00	-8.83	-10.59	-14.90	20.50	-11.83	-25.45	-13.68
Arka Harit x MC-82	4.13	-29.03	-49.23	-19.50	18.00	20.50**	8.30*	-23.40	19.25	-8.33	-16.30	-18.95
Arka Harit x MC-79	3.75	-34.76	-53.86	-26.83	17.75	9.65**	6.89	-24.49	8.25	-44.54	-64.13	-65.26
Arka Harit x MC-66	5.13	-23.36	-36.92	0.00	19.25	3.70	-6.10	-18.08	22.75	-4.12	-7.14	-4.21

Contd.

Table 40. Continued

1	2	3	4	5	6	7	8	9	10	11	12	13
Arka Harit x MC-49	6.13	-8.41	-24.62	19.50**	17.75	-1.49	-7.79	-24.47	19.25	-13.48	-10.30	-18.95
Arka Harit x MC-69	6.00	-8.57	-26.50	17.07**	15.75	-9.68	-13.69	-32.98	21.50	-4.44	-6.52	-9.47
Arka Harit x MC-34	6.38	-4.30	-21.38	24.39**	21.75	14.09**	1.16	-7.45	22.25	5.95	-3.26	-6.32
MC-82 x MC-79	4.13	24.50**	17.86**	-19.50	17.00	17.24**	-26.73	-27.66	8.25	-35.92	-56.58	-65.26
MC-82 x MC-66	4.63	5.71*	-11.90	-9.75	16.75	-0.74	-18.29	-43.62	21.50	-1.15	-12.24	-9.47
MC-82 x MC-49	4.50	2.86	-14.29	-12.20	17.00	4.62	-11.68	-27.66	19.75	-2.47	-8.14	-16.84
MC-82 x MC-69	4.13	-2.90	-18.50	-19.50	19.50	23.81**	6.81*	-17.02	20.75	-3.49	-5.68	-12.63
MC-82 x MC-34	4.13	-5.17	-20.67	-19.50	19.75	13.07**	-8.13	-15.95	22.00	15.78**	15.78**	-7.37
MC-79 x MC-66	4.13	-1.49	-21.43	-19.50	16.00	-11.72	-21.95	-31.91	8.25	-47.20	-66.33	-65.26
MC-79 x MC-49	4.50	7.46*	-14.29	-12.20	17.50	10.00*	-9.09	-25.53	8.25	-41.59	-61.60	-65.26
MC-79 x MC-69	4.38	7.69*	-12.50	-14.63	18.50	8.82*	1.37	-21.28	7.50	-47.82	-65.90	-68.42
MC-79 x MC-34	4.63	11.11**	-11.06	-9.76	19.50	4.70	-9.30	-17.02	9.75	-24.75	-48.68	-58.94
MC-66 x MC-49	5.08	-2.87	-2.87	-0.98	20.00	0.63	-2.44	-14.90	23.50	2.17	4.08	-1.05
MC-66 x MC-69	5.30	3.41	0.95	3.41	20.50	5.81	0.00	-18.08	20.50	-11.83	-16.33	-13.68
MC-66 x MC-34	5.33	1.91	1.43	3.90	20.25	-3.57	-5.80	-13.83	22.25	2.29	-9.18	-6.32
MC-49 x MC-69	5.25	2.44	0.00	2.44	20.50	9.33**	6.49*	-18.08	22.75	4.60	3.41	-4.21
MC-49 x MC-34	5.00	-4.31	-4.76	-2.44	21.00	3.07	-2.30	-10.64	22.75	12.35**	5.81	-4.21
MC-69 x MC-34	5.50	7.84*	5.76*	7.32*	18.75	-5.67	-12.80	-20.21	20.75	1.19	-5.68	-12.63
CD (p=0.05)	0.39	0.33	0.39	0.39	1.75	1.51	1.75	1.75	1.62	1.41	1.62	1.62
CD (p=0.01)	0.52	0.44	0.52	0.52	2.30	1.98	2.30	2.30	2.14	1.85	2.14	2.14

Only two crosses in the first, 14 in second and four in third seasons showed significant heterobeltiosis.

None of the hybrids possessed significant standard heterosis.

o. 100 seed weight

Twelve crosses in first, six and in second and third had significant relative heterosis.

Heterobeltiosis was found significant for three crosses in first and third and five in second season. Maximum heterobeltiosis was observed in Arka Harit x MC-69 (10.11%) and Arka Harit x MC-49 (8.43%) in first, MC-49 x MC-34 (12.50%), Priya x MC-49 and Priya x MC-69 (8.05% each) in second MC-82 x MC-34 (15.78%) and Priya x MC-66 (8.16%) in third season.

Standard heterosis was significant for seven crosses in first and two in third seasons. MC-84 x MC-66 (18.56%) in first and Priya x MC-66 (11.58%) in third season had higher standard heterosis.

C. Inheritance of fruit colour, fruit surface and bitterness and study on linkage if any in bitter gourd

1. Fruit colour

Four parental line with contrasting fruit colours (Priya, MC-49, MC-66 and MC-69) were used to study the inheritance of fruit colour in bittergourd. The fruits of Priya and MC-49 were green while those of MC-66 and MC-69 were white. Crosses were made with these four lines to generate F_1, F_2, BC_1 and BC_2. Out of the six crosses, four with contrasting colours were considered for the study (Table 41).

In all the four crosses, the F_1s were all green fruited indicating dominance of green over white. The plants in the segregating F_2s, BC_1s and BC_2s were classified into green and white fruited.

a. Group 1. Priya x MC-66

In the F_2, 200 plants segregated into 154 green and 46 white fitting in the 3:1 ratio (χ^2 = 0.426, P = 0.50 - 0.70). All the 80 plants in BC_1 possessed green fruits. In the BC_2, 120 plants segregated into 63 with green and 57 with white fruits, which fitted well in the 1:1 ratio (χ^2 = 0.30, P = 0.50 - 0.70).

Table 41. Inheritance of fruit colour in bitter gourd

Groups	Generations	Observed number of plants			Expected genetic ratio	χ^2	Probability
		Green	White	Total			
1. Priya	P_1	25	0	25			
x	P_2	0	25	25			
MC-66	F_1	25	0	25			
	F_2	154	46	200	3:1	0.426	0.50-0.70
	BC_1	80	0	80	1:0		
	BC_2	63	57	120	1:1	0.300	0.50-0.70
2. Priya	P_1	17	0	17			
x	P_2	0	17	17			
MC-69	F_1	17	0	17			
	F_2	137	43	180	3:1	0.118	0.70-0.80
	BC_1	70	0	70	1:0		
	BC_2	73	67	140	1:1	0.257	0.50-0.70
3. MC-49	P_1	20	0	20			
x	P_2	0	20	20			
MC-66	F_1	20	0	20			
	F_2	139	51	190	3:1	0.343	0.50-0.70
	BC_1	80	0	80	1:0		
	BC_2	84	81	165	1:1	0.054	0.80-0.90
4. MC-49	P_1	15	0	15			
x	P_2	0	15	15			
MC-69	F_1	15	0	15			
	F_2	155	50	205	3:1	0.040	0.80-0.90
	BC_1	65	0	65	1:0		
	BC_2	58	52	110	1:1	0.327	0.50-0.70

b. Group 2. Priya x MC-69

One hundred and eighty plants in the F_2 segregated into 137 green and 43 white fitting a 3:1 ratio (χ^2 = 0.118, P = 0.70 - 0.80). In the BC_2, 140 plants consisted 73 green and 67 white fruited. This fitted the expected ratio of 1:1 (χ^2 = 0.257, P = 0.50 - 0.70). In BC_1 all plants had green fruits only.

c. Group 3. MC-49 x MC-66

In the F_2, BC_1 and BC_2, the observed frequencies were in agreement with the expected frequencies. Out of 190 plants in F_2 (Plate 33) 139 had green and 51 white fruits (χ^2 = 0.34, P = 0.50 - 0.70). In BC_2 (Plate 34) 165 plants included 84 with green and 81 with white fruits (χ^2 = 0.054, P = 0.80 - 0.90). In BC_1 (Plate 35) all the plants were green fruited.

d. Group 4. MC-49 x MC-69

The observed frequencies in the F_2 fitted well in the expected ratio of 3:1 (χ^2 = 0.04, P = 0.80 - 0.90) where 205 plants segregated into 155 green and 50 white fruited. All the BC_1s were green fruited. In BC_2 also

Plate -33. Inheritance of fruit colour
F_2 segregation, 3 green : 1 white

Plate -34. Inheritance of fruit colour
BC_1 segregation, 1 green : 0 white

Plate -35. Inheritance of fruit colour
BC_2 segregation, 1 green : 1 white

PLATE-33

PLATE-34

PLATE-35

the segregations were in agreement with the expected ratio of 1:1 where 110 plants consisted 58 with green and 52 with white fruits (χ^2 = 0.327, P = 0.50 - 0.70).

2. Fruit surface

Out of the six crosses developed from Priya, MC-49, MC-66 and MC-69, four with contrasting fruit surface were considered for the study of inheritance of fruit shape. The fruits of Priya and MC-66 were spiny, while that of MC-49 and MC-69 were smooth. Crosses were made with these lines to generate the F_1, F_2, BC_1 and BC_2 (Table 42).

Expressivity of smoothness was not complete in MC-49 as evidenced by 2 spiny fruited plants out of 20. So also was the case with MC-69.

The F_1 hybrids in all the crosses were spiny fruited indicating dominance of spininess over smoothness. The plants in the segregating generations were classified into spiny and smooth fruited.

a. Group 1. Priya x MC-49

Out of 225 plants in the F_2, 172 were spiny and 53 smooth fruited. Considering the incomplete expressivity

Table 42. Inheritance of fruit surface in bitter gourd

Group	Generations	Observed number of plants			Expected number considering expressivity		Expected genetic ratio	χ^2	Probability
		Spiny	Ribbed	Total	Spiny	Ribbed			
1	2	3	4	5	6	7	8	9	10
1. Priya	P_1	20	0	20					
x	P_2	2	18	20					
MC-49	F_1	20	0	20					
	F_2	172	53	225	174.38	50.62	3.1:0.9	0.143	0.70-0.80
	BC_1	95	0	95					
	BC_2	61	49	110	60.5	49.5	1.1:0.9	0.009	0.90-0.95
2. Priya	P_1	17	0	17					
x	P_2	0	17	17					
MC-69	F_1	17	0	17					
	F_2	136	44	180			3:1	0.029	0.80-0.90
	BC_1	70	0	70			1:0		
	BC_2	74	66	140			1:1	0.457	0.30-0.50

Contd.

Table 42. Continued

1	2	3	4	5	6	7	8	9	10
3. MC-49	P_1	0	20	20					
x	P_2	20	0	20					
MC-66	F_1	20	0	20					
	F_2	146	44	190			3:1	0.343	0.5-0.7
	BC_1	42	38	80			1:1	0.20	
	BC_2	165	0	165			0:1		0.5-0.7
4. MC-66	P_1	20	0	20					
x	P_2	2	18	20					
	F_1	20	0	20					
	F_2	156	49	205	158.88	46.12	3.1:0.9	0.231	0.5-0.7
	BC_1	65	0	65					
	BC_2	58	52	110	60.5	49.5	1.1:0.9	0.229	0.5-0.7

of smoothness in MC-49, the expected ratio in the F_2 was modified to 3.1:0.9 with expected frequency of 174.38 spiny and 50.62 white. The observed ratio was in agreement with the expected ratio (χ^2 = 0.143, P = 0.70 and 0.80). In BC_1 all the 95 plants had spiny fruits. In BC_2, 110 plants segregated into 61 spiny and 40 smooth fruited fitting in the modified expected ratio of 1.1:0.9 (χ^2 = 0.009, P = 0.90 - 0.95).

b. Group 2. Priya x MC-69

The observed F_2 segregation agreed well with the expected ratio 3:1 (χ^2 = 0.029, P = 0.80 - 0.90). The 180 plants of F_2 possessed 136 with spiny and 44 with smooth fruits. In BC_1 all the plants had spiny fruits. In BC_2, out of 140 plants 74 were spiny and 66 smooth fruited agreeing the expected ratio of 1:1 (χ^2 = 0.459, P = 0.30 - 0.50).

c. Group 3. MC-49 x MC-66

Out of 190 F_2 (Plate 36) plants 146 were spiny and 44 smooth fruited, agreeing the expected ratio of 3:1 (χ^2 = 0.343, P = 0.50 - 0.70). In BC_1 (Plate 37) 80 plants segregated in to 42 spiny and 38 smooth fruited fitting in

Plate-36. Inheritance of fruit surface
F_2 segregation, 3 spiny : 1 smooth

Plate-37. Inheritance of fruit surface
BC_1 segregation, 1 spiny : 1 smooth

Plate-38. Inheritance of fruit surface
BC_2 segregation, 1 spiny : 0 smooth

PLATE-36

PLATE-37

PLATE-38

the expected ratio of 1:1 (χ^2 = 0.02, P = 0.50 - 0.70). In BC_2 (Plate 38) all the plants had spiny fruits.

d. Group 4. MC-66 x MC-69

The 205 plants in the F_2 segregated into 156 spiny and 49 smooth fruited. Considering the incomplete expressivity of smoothness in MC-69, the expected ratio was modified into 3.1:0.9 with the expected 158.88 spiny and 46.12 smooth fruited plants. The observed F_2 ratio was in agreement with this modified expected ratio (χ^2 = 0.231, P = 0.50 - 0.70). The segregation of 110 plants in BC_2 in to 58 spiny and 52 smooth fruited was also in agreement with the modified expected ratio of 1.1:0.9 (χ^2 = 0.229, P = 0.50 - 0.70). In BC_1 all were with spiny fruits.

3. Detection of linkage between fruit colour and surface

Out of the six crosses used for the studied on inheritance of fruit colour and surface seperately, two had parents differing for both colour and surface. The F_2 generations segregating jointly for colour and surface were used to test their independent inheritance.

In both the crosses, the F_1s were all with green, spiny fruited indicating dominance of green spiny fruits over white smooth.

a. Group 1. Priya x MC-69

The joint segregation of F_2 population into green spiny, green smooth, white spiny and white smooth is presented in Table 43. The 180 F_2 plants (Plate 39) segregated into 102 green spiny, 35 green smooth, 34 white spiny and 9 white smooth. This is in agreement with the expected ratio of 9 : 3 : 3 : 1. Inspection of the results showed that the probability of exceeding the calculated value of total χ^2 lies between 0.90 and 0.95, which showed the agreement of the observed frequencies with the expected ratio.

The partitioning of χ^2 (Table 44) into colour, surface and linkage revealed clear independence in the inheritance of fruit colour and surface (χ^2 = 0.3556, P = 0.70 - 0.80).

b. Group 2. MC-49 x MC-66

The joing segregation in F_2 showed that the 190 plants segregated into 106 green spiny, 33 green smooth,

Table 43. Joint segregation of fruit colour and surface in the F_2 segregations in bitter gourd

Groups	Generations	Observed number of plants				Total	Expected genetic ratio				Total χ^2	Probability
		Green		White			Green		White			
		Spiny	Smooth	Spiny	Smooth		Spiny	Smooth	Spiny	Smooth		
1. Priya	P_1	17	0	0	0	17						
x	P_2	0	0	0	17	17						
MC-69	F_1	17	0	0	0	17						
	F_2	102	35	34	9	180	9	3	3	1	0.504	0.09-0.95
	BC_1	70	0	0	0	70						
	BC_2	36	37	38	29	140						
2. MC-49	P_1	0	20	0	0	20						
x	P_2	20	0	20	0	20						
MC-66	F_1	20	0	0	0	20						
	F_2	106	33	40	11	190	9	3	3	1	0.802	0.80-0.90
	BC_1	42	38	0	0	80						
	BC_2	84	0	81	0	165						

Plate-39. Joint inheritance of fruit colour and surface F_2 segregation

9 Green spiny:3 Green smooth:3 White spiny:1 White smooth

PLATE-39

Table 44. Partitioning of χ^2 in the F_2 segregations of two crosses in bitter gourd

Source	df	Crossess	χ^2	Probability
Fruit colour	1	1	0.1185	0.70 - 0.80
		2	0.3438	0.50 - 0.70
Fruit shape	1	1	0.0296	0.80 - 0.90
		2	0.3438	0.50 - 0.70
Linkage	1	1	0.3556	0.50 - 0.70
		2	0.1146	0.70 - 0.80
Total	3	1	0.5037	0.90 - 0.95
		2	0.8022	0.80 - 0.90

40 white spiny and 11 white smooth. This also fitted well in the expected ratio of 9 : 3 : 3 : 1 (χ^2 = 0.8022, P = 0.80 - 0.90).

The partioning of total χ^2 into fruit colour and surface showed that the inheritance of fruit colour is independent to that of fruit surface (χ^2 = 0.1146, P = 0.70 - 0.80).

4. Bitterness

Three parental lines viz. MC-53, MC-79 and MC-34 with varying bitterness in the original set 1 were used for generating three crosses to study inheritance of bitterness. The mean values of bitterness expressed as percentage of ether extract of these three lines, their F_1s, F_2s and back cross generations are presented in (Table 45).

The presence and type of non allelic interactions were determined by A B C and D scaling tests and presented in Table 46.

The generation means were partitioned into different components like mean effect (m), additive effect (d), dominance effect (h), additive x additive effect (i),

Table 45. Generation means for bitterness in bitter gourd

Generations	Crosses		
	$P_1 \times P_2$	$P_1 \times P_3$	$P_2 \times P_3$
P_1	3.01 ± 0.05	3.01 ± 0.05	1.99 ± 0.04
BC_1	2.67 ± 0.05	2.80 ± 0.05	2.17 ± 0.04
F_1	2.49 ± 0.03	2.75 ± 0.03	2.23 ± 0.03
F_2	2.52 ± 0.04	2.75 ± 0.01	2.35 ± 0.02
BC_2	2.23 ± 0.03	2.61 ± 0.04	2.51 ± 0.02
P_2	1.99 ± 0.04	2.54 ± 0.03	2.54 ± 0.03

Table 46. Scaling tests for non-allelic interactions for bitterness

Scales	Crosses		
	$P_1 \times P_2$	$P_1 \times P_3$	$P_2 \times P_3$
A	-0.02	-0.15	0.11
B	-0.02	-0.06	0.26
C	0.82**	-0.03	0.40
D	0.13	0.09	0.02

** p = 0.01

additive x dominance effect (j) and dominance x dominance effect (l) and are presented in Table 47. The components of genetic variances, estimates of heritability and number of effective factors were worked out and presented in Table 48.

The null hypothesis underlying the scaling tests that A = B = C = D was rejected in MC-53 x MC-79 and MC-79 x MC-34 indicating presence of non allelic interactions. However, scaling tests were not significant in MC-53 x MC-34 indicating the absence of non allelic interactions in this cross.

Additive effects (d) were significant in all the three crosses of which MC-79 x MC-34 had negative effect (-0.345). Dominance effect (h) was significant only in MC-53 x MC-79 (-0.266) and it was negative in all the three crosses. The interaction was of additive x dominance (j) type in MC-53 to MC-79 (-0.953).

Additive variance (d) were 0.43 in MC-53 x MC-79, 0.13 in MC-79 x MC-34 and -0.05 in MC-53 x MC-34. Dominance variance (h) was 0.16 in MC-53 x MC-79 and 0.07 in MC-53 x MC-34. It was negative in MC-79 x MC-34 (-0.15).

Table 47. Components of total genetic effect for bitterness

Crosses	Genetic parameters					
	m	d	h	i	j	l
$P_1 \times P_2$	$2.52 \pm 0.04^{**}$	$0.44 \pm 0.05^{**}$	$-0.27 \pm 0.09^{**}$	-0.26 ± 0.20	$-0.95 \pm 0.06^{**}$	-0.43 ± 0.28
$P_1 \times P_3$	$2.95 \pm 0.13^{**}$	$0.24 \pm 0.10^{**}$	-0.60 ± 0.38			
$P_2 \times P_3$	2.35 ± 0.02	$-0.35 \pm 0.04^{**}$	-0.07 ± 0.12	-0.04 ± 0.11	-0.07 ± 0.05	-0.33 ± 0.20

** $p = 0.01$

Table 48. Components of genetic variance, degree of dominance, heritability estimates and number of effective factors for bitterness

Cross	D	H	Degree of dominance $\sqrt{H/D}$	h^2 (n)	h^2 (b)	K_1	K_2
$P_1 \times P_2$	0.43	0.16	0.61	1.20	0.90	0.61	0.001
$P_1 \times P_3$	-0.05	0.07	-1.40	0.51	-0.08	-1.12	0.01
$P_2 \times P_3$	0.13	-0.15	-1.15	1.59	0.67	0.58	-0.01

Components of genetic variance, degree of dominance, heritability estimates and number effective factors for betterness were worked out and are presented in Table 48. The degree of dominance $\sqrt{H/D}$ for bitterness was 0.61 in $P_1 \times P_2$. It was negative in both the other crosses. Estimates of heritability in narrow sense ($h^2(n)$ was high in MC-53 x MC-79 (1.2) and MC-79 x MC-34 (1.58) and moderate in MC-53 x MC-34 (0.51). Estimates of K_1 was 0.61 in MC-53 x MC-79 and 0.58 in MC-79 x MC-34. The estimates of K_2 was very low in all the three crosses.

D. Crossability studies among the three species of Momordica

1. Anthesis

Observations were made on period of anthesis in three species of Momordica (Table 49). All the species differed in their anthesis period.

Table 49. Period of anthesis in three species of Momordica

Sl.No.	Species	Anthesis period
1	Momordica charantia	4.30 - 9.30 AM
2	Momordica dioica	6.00 - 11.30 PM
3	Momordica cymbalaria	8.00 - 11.00 PM

Table 50. Observations on ovary growth in crosses among the three species of *Momordica*

Types of pollination	Duration after pollination							
	12 hours	1 day	2 days	3 days	4 days	5 days	6 days	7 days
Momordica charantia (self)	100% ovary remained green	98% remained green	98% started growing	94% continued growth	92% continued growth	91% continued growth	91% continued growth	91% continued growth
Momordica charantia x *Momordica dioica*	98% ovary remained green	90% remained green	60% remained green 40% started shrinking	29% remained green 71% shrinking and drying	10% remained green 90% shrinking and drying	5% remained 95% drying	2% remained green 98% shrinking and drying	No ovary remained green
Momordica charantia x *Momordica cymbalaria*	97% ovary remained green	91% remained green	65% remained green 35% started shrinking	24.5% remained green 75.5% shrinking and drying	5% remained green 95% shrinking and drying	4% remained green 96% shrinking and drying	1% remained green 99% shrinked and started drying	No ovary remained green
Momordica dioica (Self)	99% ovary remained green	97% remained green	96% started growing	90% continued growth	90% continued growth	90% continued growth	90% continued growth	90% continued growth
Momordica dioica x *Momordica cymbalaria*	96% ovary remained green	91% remained green	65% remained green 35% started shrinking	24% remained green 76% shrinked and started drying	5% remained green 95% shrinking and drying	3% remained green 97% shrinking and drying	No ovary remained green	No ovary remained green
Momordica cymbalaria (Self)	98% ovary remained green	96% remained green	96% started growing	90% continued growth	88% continued growth	85% continued growth	85% continued growth	85.0% continued growth

2. Ovary growth

Observations on ovary growth were taken and expressed as percentage (Table 50). In all the selfed flowers ovary growth was normal. Fruit set was above 85% in all the selfed flowers. However, in crossed flowers more than 70% of the ovaries started shrinking and drying even the 3rd day after pollination. None of the ovaries in any of the crosses remained green after a week. Maximum fruit set was observed in *Momordica charantia* and *Momordica dioica* on selfing (91% and 90% respectively). In *Momordica cymbalaria* the selfed flowers set 85% fruits.

Thus the three species of *Momordica* - *charantia*, *dioica* and *cymbalaria* were found totally cross incompatible. And the crossability index was zero among these three species studied.

Discussion

DISCUSSION

Bitter gourd (Momordica charantia L.) is a very popular Indian vegetable. In terms of nutritive value, it ranks first among the cucurbits, the most important constituents being minerals and vitamins. One hundred g of edible portion of the large fruited variety contains 4.2 g of carbohydrate, 1.6 g of protein, 88 mg of vitamin C, 210 I.U. of vitamin A and 1.6 mg of iron. In small fruited types, the nutrient contents are higher (Choudhury, 1967). Though bitter in taste, tender fruits are used in curries, pickles and fries, besides being used in various indigenous medicines.

Despite the economic, nutritional and medicinal values of bitter gourd, availability of high yielding varieties/hybrids is limited. In bitter gourd, preferences with respect to fruit colour, fruit surface and intensity of bitterness vary with locality and with individual. Fruit colour and fruit surface determine market price considerably. Stability in performance of a variety/hybrid is an important aspect for cultivating bitter gourd through out the year in tropics. There exists other species of Momordica with desirable qualities. Attempts were made to study various aspects of crop improvement in bitter gourd.

The present investigation was carried out mainly with the objectives of studying genetic divergence, identifying stable and heterobeltiotic F_1 hybrids, unravelling genetics of various economic characters and investigating into the crossability among the related species of bitter gourd.

Genetic variability and divergence

Studies on genetic variability and divergence are basic to any crop improvement programme. Effective selection of a genotype depends on estimates of heritability based on phenotypic performance. In the choice of proper selection method(s), estimates of heritability coupled with genetic advance are more useful than any one of the two alone (Johnson et al., 1955).

Many workers have earlier reported existence of very high heritability in respect of several vegetative, productive and qualitative characters in bitter gourd. The components of variation due to phenotype and genotype were studied in the present investigation.

Significant differences were observed among 50 genotypes for all the 18 characters - branches/plant, main vine length, node at which first female flower formed, days to first female flower opening, female flowers/plant, percentage of female flowers, days to picking maturity, fruits/plant, fruit weight, fruit length, fruit girth, flesh thickness, seeds/fruit, 100 seed weight, protein content, T.S.S and vitamin C content. Bitter gourd being cross pollinated due to monoecy exhibits much variation, and therefore, the present observed variation is quite rational as reported earlier by Srivastava and Srivastava (1976), Ramachandran and Gopalakrishnan (1979), Mangal (1981) and Chaudhari (1987).

Fruit yield/plant was maximum in Priya (12.76 kg) which was on par with MC-84 (12.48 kg), MC-78 (12.25 kg) and MC-66 (12.17 kg). Fruits/plant were maximum in MC-79 (113.25) and minimum in Arka Harit (17.25). MC-34 took the least (33.50) days to first female flower opening.

Maximum phenotypic coefficient of variation was observed for fruit weight (48.77) followed by yield/plant (39.91) and fruits/plant (31.82). Similar findings were earlier made by Ramachandran and Gopalakrishnan (1979), Mangal (1981) and Chaudhari (1987).

Phenotypic coefficient of variation (pcv) was moderate for fruit length (29.56), per cent of female flowers (28.56), female flower/plant (27.37) and main vine length (22.32). These values were higher in the earlier report of Mangal (1981). However, the observed average pcv for fruit length was in agreement with that of Chaudhari (1987).

In the present study, earliness had only a low value of pcv. The lowest values of pcv were observed for node to first female flower formation (8.18) days to opening of first female flower (8.38) and days to picking maturity (8.47). Least values of pcv for days to flower opening was also reported by Mangal (1981). The low estimates of pcv for early female flower formation and early harvest obtained by Chaudari (1987) also confirms the present findings. It is therefore suggested that variation for earliness and maturity is comparatively low in bitter gourd lines used for the present study.

The genotypic coefficient of variation (gcv) resulting in high heritability was of higher magnitude for fruit weight, yield/plant and fruits/plant. This indicates low impact of environments on the expression of these characters. High gcv with high heritability was also reported by Singh et al. (1977), Ramachandran (1978) and Chaudari (1987). Node to first female flower formation and days to picking maturity had the lowest values of gcv and heritability indicating greater impact of environment on earliness and maturity aspects in bitter gourd.

High heritability does not mean a high genetic advance for a particular quantitative character. For effective selection, heritability along with genetic advance should be considered. In the present study high heritability along with genetic gain was observed for fruit weight, yield/plant and fruits/plant. The estimates of gcv were also of high magnitude for these characters. This revealed that variation for the above characters were mainly due to action of additive genes. This confirms to the earlier findings of Srivastava and Srivastava (1976), Singh et al. (1977), Ramachandran (1978) and Mangal et al. (1981).

Though heritability was high for primary branches/ plant and days to opening of first female flower, the genetic gain was of low magnitude, indicating the action of non additive genes for expression of these characters. Similar findings were earlier made by Srivastava and Srivastava (1976). Non additive gene action for days to first female flower opening was also reported by Ramachandran and Gopalakrishnan (1979).

Genetic divergence

The D^2 statistics is a tool in estimating the genetic divergence in plant breeding experiments. It permits precise comparison among all possible pairs of population in any group.

Following Tocher's Method, 50 bitter gourd genotypes were grouped into five clusters. The study revealed that lines of different origin/sources fell in the same group and different groups consisted of lines of the same source/origin.

Cluster I contained lines with less economic value. Cluster II had lines with average yield. The high yielding lines like Priya, MC-84, MC-78, MC-66 etc. were in Cluster III. The bush types Arka Harit and MC-82 fell in Cluster IV. Cluster V had only one line MC-79, the perennial type. In the present study maximum distance (D = 30.16) existed between clusters IV and V. Theoretically, therefore, maximum heterosis would be expected in crosses involving parents belonging to these clusters. From the study, it is observed that choices of parents for hybridisation or for other crop improvement programmes need not necessarily be based on source or origin or geographical distance.

Stability analysis

Bitter gourd is grown through out the year in the tropics. Varieties differ in their response to varying environmental conditions. Stability analyses of yield and its components reveal the genetic bases of stability of parents and hybrids. A phenotypically stable and hetero-beltiotic F_1 hybrid is more important considering the possibility of growing bitter gourd through out the year in tropics. An attempt was made in the present study to evaluate performance of bitter gourd parents and hybrids under different environments and to know the genotype-environment interaction aimed at identifying stable hybrids suited to high, medium and low envirohments.

Ten parents and 45 F_1 hybrids were grown in a randomised block design consecutively for three seasons. Observations were made on earliness and various vegetative and productive characters.

Pooled analysis of variance was done for all the characters. Stability parameters for yield and its components were estimated as proposed by Eberhart and Russell (1966).

Significant genotype x environment (G x E) interaction was observed for all the characters. The genotypes were significantly different in all the three seasons. Environments were also significantly different among one another. The pooled deviation was highly significant for all the characters except for node to first female flower formation. This suggested that the genotypes interacted significantly with the environments. The linear components of genotypes x environment interaction was highly significant for nodes to first female flower, female flowers/plant, fruits and yield/plant and significant for branches/plant and fruit girth. It was not significant for vine length, days to first female flower opening, fruit weight and fruit length. Significance of the linear components of genotype x environmental interaction suggested that the genotype environment interactions were linear and the genotypes differ considerably with respect to the above characters. This was reported earlier in other crops like cowpea (Sanghi and Kandalkar, 1983), bhindi (Suresh Babu, 1981) and brinjal (Ushamoni, 1987).

Eberhart and Russell (1966) considered both linear b(i) and non linear $Sd^2(i)$ components while judging the phenotypic stability. The highest overall mean yield/

plant was recorded by MC-78 x MC-66 (10.33 kg) followed by Priya x MC-66 (9.75 kg). Considering the regression coefficients approximately equal to unity (bi ⟶ 1) and deviations from regression not significantly different from zero ($S^2d(i) \longrightarrow 0$), Priya x MC-84, MC-78 x MC-69, MC-84 x MC-66, MC-84 x MC-49, MC-84 x MC-69, MC-66 x MC-34 and MC-49 x MC-34 were found stable (Table 51). Priya x MC-69, Priya x MC-34, MC-78 x MC-84, MC-78 x MC-34 were the F_1 hybrids with above average stability. Lines like Priya, MC-78, MC-84, MC-66, MC-49, MC-69 and MC-34 and hybrids like Priya x MC-78, Priya x MC-66, Priya x MC-49, MC-78 x MC-49, MC-84 x MC-34, MC-66 x MC-49, MC-49 x MC-69 and MC-69 x MC-34 are below average stable genotypes. The highest yielding hybrid MC-78 x MC-66 was unstable.

It revealed that hybrids responded more to varying environments than their parents. It also identified hybrids suited to low, medium and high environments so as to make bitter gourd cultivation profitable through out the year.

Combining ability analysis

The common approach of selecting parents on the basis of <u>per se</u> performance does not necessarily lead to

Table 51. Mean, regression coefficient and deviation from regression for various bitter gourd genotypes suited for high, medium and low environments

Genotypes	Environments								
	High			Medium			Low		
	Mean	b(i)	$S^2d(i)$	Mean	b(i)	$S^2d(i)$	Mean	b(i)	$S^2d(i)$
Priya x MC-69	8.53	1.13	0.00						
Priya x MC-34	7.84	1.62	0.26						
MC-78 x MC-84	9.03	1.13	0.05						
MC-78 x MC-34	7.70	1.32	0.04						
Priya x MC-84				9.00	1.07	0.47			
MC-78 x MC-69				8.55	0.87	0.02			
MC-84 x MC-66				8.77	0.89	-0.04			
MC-84 x MC-49				9.00	1.06	0.99			
MC-84 x MC-69				8.33	1.02	0.26			
MC-66 x MC-34				7.78	1.05	-0.01			
MC-49 x MC-34				8.79	0.99	1.55			
Priya							9.64	0.34	0.07
MC-78							8.95	0.44	0.26
MC-84							9.46	0.71	0.09
MC-66							9.68	0.36	1.25
MC-49							8.25	0.28	0.32
MC-69							7.95	0.64	0.08
MC-34							7.07	0.27	-0.01
Priya x MC-78							9.64	0.55	0.74
Priya x MC-66							9.75	0.47	0.86
Priya x MC-49							9.47	0.23	0.61
MC-78 x MC-49							8.98	0.80	-0.04
MC-84 x MC-34							8.03	0.72	0.71
MC-66 x MC-49							9.29	0.33	0.90
MC-49 x MC-69							8.15	0.83	0.14
MC-69 x MC-34							7.12	0.73	1.17

the best result in hybridisation programme (Allard, 1960). Selection of best parents based on complete genetic information and knowledge of combining ability leads to fruitful results in the identification of promising F_1 hybrids. The diallel crosses help in the estimation of general combining ability (gca) and specific combining ability (sca) of parents and hybrids respectively. The gca and sca are attributed to additive and non additive gene action respectively (Spragye and Tatum, 1942).

In the present investigation, ten diverse bitter gourd lines were selected based on colour, shape, size and yield of fruits and earliness. They were crossed in all possible combinations without reciprocals to develop 45 F_1 hybrids. These crosses along with the parents were grown for three seasons to study the combining ability.

The study revealed that the variances due to gca were significant for all the characters in all the three seasons. The sca variances were also significant for all the characters excepting node to first female flower formation and days to picking maturity in the third season and fruit girth and 100 seed weight in the second season. The significance of gca and sca variances indicated the role of additive as well as non additive gene action in the control of most of the characters. Significant gca and sca values were noted for vine length, fruits/plant, yield/plant, length, diameter and weight of fruits, flesh thickness and seeds/fruit by many workers (Sirohi and Choudhury, 1977; Singh and Joshi, 1979; Pal *et al.*, 1983; Srivastava and Nath, 1983 and Chaudhari, 1987). For the improvement of such characters, recurrent selection could be resorted to.

It was also noted that parents showing high gca for yield and other characters also gave good *per se* performance. The parents like Priya, MC-84, MC-78 and MC-66 which gave high yields also possessed significant gca effects for yield.

On analysing the parental lines used in developing crosses, the parent Priya showed high gca effects for total yield, fruit length, seeds/fruit and per cent of female flowers/plant. Other parents with high gca effects for yield were MC-78, MC-84, MC-66 and MC-49. The parent MC-84 had the highest gca effects for branches/plant, fruit girth and fruit weight. MC-34 possessed the highest negative gca effects for node to first female flower formation. It was observed that when parents possessing high gca effects were crossed, the F_1 hybrids gave best performance.

Pooled analysis of variance for combining ability revealed that the gca variances were highly significant for all the characters. The sca variances were highly significant for 13 characters. Higher magnitude of gca indicated the predominance of additive gene action. The interaction of gca with environments were significant for all the characters excepting for earliness indicating that the impact of environments on gca were considerably high. Interaction of sca with environments were also significant for all the characters, revealing inconsistent sca effects of the crosses. It may, therefore, be suggested that for unbiased estimates of combining ability, the studies must be carried out over a range of environments.

The present study revealed the importance of both additive and non additive gene effects in the inheritance of majority of the characters. Since additive gene effects were more predominant, pedigreee method would be the most efficient method for obtaining the desirable plant types. Simultaneously, as the sca effects were also significant, diallel selective mating among the parents on the basis of gca would result in greater variability for recurrent selection.

Heterosis

Heterosis was studied in 10 x 10 diallel set of bitter gourd for 15 characters in three seasons (Table 52 to 59). Significant differences were observed among the genotypes in all the three seasons for all the characters except days to picking maturity in the third season.

Significant heterobeltiosis was observed for branches/plant by three hybrids in the first, seven in second and four in the third season. Arka Harit x MC-82 in the first and third (15.15% and 14.63%) and MC-84 x MC-49 (19.82%) in the second seasons recorded highest values of heterobeltiosis for this trait. Even though the hybrid Arka Harit x MC-82 exceeded their better parent in first and third seasons, their per se performance was not promising. This may be attributed to the poor general combining ability effects of the parents. However, in MC-84 x MC-49, the per se performance also was good, which is attributed to the high gca effects of the parents and high sca effects. The parents in Arka Harit x MC-82 belonged to different clusters. The observed heterobeltiosis in this cross may be due to high genetic distance. In MC-84 x MC-49, the observed heterobeltiosis is due to the involvement of the parents

Table 52. Number of hybrids showing heterosis for important characters in bitter gourd

Characters	Environments	RH(%)	HB(%)	SH(%)
Node of first female flower	E_1	7	4	37
	E_2	5	0	23
	E_3	6	3	16
Days to opening of first female flower	E_1	16	5	17
	E_2	10	9	1
	E_3	28	10	27
Female flowers/plant	E_1	9	4	17
	E_2	13	4	16
	E_3	9	0	17
Percentage of female flowers	E_1	23	0	4
	E_2	12	5	1
	E_3	8	9	2
Fruits/plant	E_1	29	5	30
	E_2	15	7	22
	E_3	3	0	17
Fruit weight	E_1	10	2	5
	E_2	10	8	6
	E_3	4	2	3
Yield/plant	E_1	32	6	2
	E_2	4	4	1
	E_3	7	2	2

with high gca effects. Heterosis for branches/plant was earlier reported by Lal _et_ _al_. (1976) and Singh and Joshi (1979).

Fifteen hybrids in the first, one in second and ten in third season recorded significant relative heterosis for vine length. Arka Harit x MC-79 had the hight and consistent _per_ _se_ performance (7.35 m, 6.675 m and 6.625 m) with high relative heterosis (44.42%, 57.5% and 42.9%). The sca effect of the above cross was high in all the three seasons. MC-79 had the highest gca effect in all the three seasons. The _per_ _se_ performance of the above cross also was high (7.35 m).

Several hybrids exhibited relative and standard heterosis as well as heterobeltiosis for node to first female flower. Considering all the three seasons, standard heterosis was the highest in crosses MC-84 x Arka Harit (-18.68%, -17.2% and -16.27%) and Arka Harit x MC-82 (-18.68%, -11.83% and -15.12%). The gca effects were higher and negative for Arka Harit and MC-82. The _per_ _se_ performance was good in first and third and moderate in the second season for Arka Harit x MC-82. MC-84 x Arka Harit had negative values of sca effect while it was positive for Arka Harit x MC-82. Heterosis for lower nodes of first female flower formation was reported earlier by Lal *et al*. (1976) in bitter gourd.

Significant and negative relative heterosis heterobeltiosis and standard heterosis for days to first female flower production were exhibited by several hybrids. Standard heterosis was significant for MC-66 x MC-49 (-14.97%), MC-49 x MC-34 (-13.23%) and MC-79 x MC-34 (-13.17%) in the first and MC-49 x MC-34 (-17.65%), MC-82 x MC-49 (-13.53%), MC-66 x MC-49 (-12.44%), MC-82 x MC-34 (-11.76%) and MC-79 x MC-34 (-11.18%) in the third season. The significant heterosis in majority of the above crosses is due to involvement of the good general combiner MC-49. In other cases the genetic divergence between parents might have contributed to earliness. Similar observations were made by Agrawal *et al*. (1957) and Chaudhari (1987).

Nine hybrids in first, thirteen in second and seven in third season exceeded the midparental values for female flowers/plant. It was observed in the present study that in crosses where MC-79 which possessed the highest gca effect (29.46, 25.29 and 23.17) is involved, the hybrids had high heterosis. Standard heterosis was high in crosses where either of the parents possessed high gca effects. Highest heterosis over the standard variety Priya was shown by Arka Harit x MC-79 (88.92%) followed by MC-82 x MC-79 (54.98%) and Priya x MC-79 (53.5%) in the first season. These possessed high sca effects and high per se performance. More over, the parents belonged to different clusters.

Standard heterosis for percentage of female flowers was significant mainly in first season. It was the highest in MC-49 x MC-34 (7.91%) followed by MC-49 x MC-69 (7.1%) and MC-78 x MC-49 (4.72%). In these crosses, the observed high heterosis is attributed to the involvement of MC-49 with the highest gca effect in all the three seasons (1.07, 0.68 and 0.78). The per se performance was also high. However they were all in the same cluster. This suggested that high genetic distance is not always essential for heterosis in the crosses.

Heterobeltiosis for picking maturity was observed in five F_1 hybrids in the first and one in the second season. Priya x MC-66 had the highest negative heterobeltiosis and sca effect for earliness (-11.11%) in the first season. The per se performance was also good (12 days) for this hybrid. However, the performance of the cross Priya x MC-79 with higher negative heterobeltiosis

Table 53. Node to first female flower in salient F_1 hybrids

Environ-ments	Hybrids	Perse performance	sca effect	RH(%)	HB(%)	SH(%)
E_1	MC 78 x MC 82	20.25	-0.37	-2.76	-3.85	-10.99^{**}
	MC 84 x Arka Harit	18.50	-1.61	-10.30^{**}	-1.33	-18.68^{**}
	MC 84 x MC 66	20.25	-0.91	-8.40^{**}	-6.90^{**}	-10.99^{**}
	Arka Harit x MC 82	18.50	-0.57	-3.01	-1.33	-18.68^{**}
	MC 49 x MC 34	20.25	-1.73	-10.00^{**}	-8.99^{**}	-10.09^{**}
E_2	Priya x Arka Harit	19.25	-1.90	-9.94^{**}	-1.28	-17.20^{**}
	Arka Harit x MC 79	18.25	-1.53	3.94	-1.35	-21.50^{**}
	MC 84 x Arka Harit	19.25	-1.55	-6.10^{*}	-1.28	-17.20^{**}
E_3	MC 78 x MC 69	18.50	-1.79	-11.90^{**}	-9.76^{**}	-13.95^{**}
	MC 84 x Arka Harit	18.00	-1.68	-11.60^{**}	-1.37	-16.27^{**}
	Arka Harit x MC 82	18.25	-0.31	-0.58	0.00	-15.12^{**}

Table 54. Days to first female flower in salient F_1 hybrids

Environ-ments	Hybrids	Perse performance	sca effect	RH(%)	HB(%)	SH(%)
E_1	MC 84 x Arka Harit	42.50	-1.70	-5.82**	-5.56**	1.80
	Arka Harit x MC 66	39.50	-2.89	-9.97**	-7.61**	-5.39**
	MC 79 x MC 49	37.50	-1.79	-9.37**	4.90	-10.18**
	MC 79 x MC 69	40.50	-2.60	-9.75**	-5.26**	-3.00
	MC 79 x MC 34	36.25	-3.61	-13.17**	-2.74	-13.17**
	MC 66 x MC 49	35.50	-1.42	-9.55**	-0.92	-14.97**
	MC 49 x MC 34	35.50	1.64	-1.73	0.69	-13.28**
E_2	Priya x MC 49	39.00	-2.24	-8.77**	-4.29*	-4.29*
	MC 84 x Arka Harit	40.00	-1.71	-5.88**	-5.88**	-1.84
	Arka Harit x MC 49	39.25	-2.32	-10.03**	-7.65**	-3.68
E_3	MC 84 x MC 49	37.88	-2.04	-9.96	0.67	-11.18**
	Arka Harit x MC 66	40.25	-2.76	-10.22**	-7.47**	-5.29**
	Arka Harit x MC 34	39.50	-0.52	5.95**	4.64	-7.06**
	MC 82 x MC 49	36.88	-0.98	-5.90**	-2.00	-13.53**
	MC 82 x MC 34	37.50	-0.55	-4.70**	-0.60	-11.76**
	MC 79 x MC 34	37.75	-2.90	-11.44**	0.00	-11.18**
	MC 66 x MC 49	37.00	-1.13	-8.50**	-1.33	-12.94**
	MC 49 x MC 34	35.13	0.11	-14.10**	-7.25**	-17.65**

Table 55. Female flowers/plant in salient F_1 hybrids

Environments	Hybrids	perse performance	sca effect	RH(%)	HB(%)	SH(%)
E_1	Priya x MC 79	104.00	9.74	19.20**	-2.76	53.50**
	MC 78 x MC 49	68.63	7.35	18.87**	12.76**	1.11
	Arka Harit x MC 79	128.00	4.86	84.50**	19.91**	88.92**
	MC 82 x MC 79	105.00	-7.22	0.60	-1.63	54.98**
	MC 82 x MC 34	85.50	2.79	-1.58	16.18**	26.20**
	MC 49 x MC 34	79.00	11.70	19.25**	10.10**	16.60**
E_2	Arka Harit x MC 49	43.88	1.93	23.51**	-11.11	-23.80
	MC 82 x MC 79	99.25	9.75	10.50**	-10.79	71.86**
	MC 79 x MC 66	96.25	10.22	13.24**	-13.18	66.67**
	MC 79 x MC 49	103.38	17.84	28.77**	-6.97	79.22**
	MC 49 x MC 34	61.75	8.14	27.65**	-48.08	6.93*
E_3	Priya x MC 79	91.00	5.99	7.85**	-13.3	43.30**
	Arka Harit x MC 79	85.00	20.69	27.67**	-19.24	33.84**
	MC 82 x MC 79	95.00	-1.62	14.97**	-9.70	49.60**
	MC 79 x MC 69	89.00	5.94	6.90*	-15.40	40.10**

Table 56. Percentage of female flowers in salient F_1 hybrids

Environ-ments	Hybrids	Perse performance	sca effect	RH(%)	HB(%)	SH(%)
E_1	Priya x MC 79	5.85	1.13	28.36**	-6.47	-6.47
	Priya x MC 49	6.75	-0.13	4.81**	1.89	7.91**
	MC 78 x MC 49	6.55	0.25	9.12**	-1.13	4.72**
	Arka Harit x MC 69	5.95	0.82	17.82**	-10.53	-4.88
	MC 82 x MC 49	5.85	0.67	22.13**	-11.70	-6.47
	MC 49 x MC 69	6.70	-0.34	0.94	0.75	7.10**
	MC 49 x MC 34	6.75	0.67	20.81*	1.81	7.91**
E_2	Priya x MC 79	5.35	0.78	17.91**	-10.08	-10.08
	Priya x MC 49	6.30	0.56	13.77**	5.88**	5.88**
	MC 84 x MC 49	5.57	0.56	17.37**	8.75**	-6.36
	MC 82 x MC 79	3.27	0.50	16.96**	4.80**	-44.96
E_3	Priya x MC 79	5.40	1.16	24.10**	-9.24	-9.24
	Arka Harit x MC 66	5.65	0.82	22.80**	-6.61	-5.04
	Arka Harit x MC 49	5.75	0.96	26.37**	-3.36	-3.36
	MC 49 x MC 34	6.15	0.81	20.58**	3.36*	3.36*

Table 57. Yield/plant in salient F_1 hybrids

Environments	Hybrids	Perse performance	sca effect	RH(%)	HB(%)	SH(%)
E_1	Priya x MC 79	8.95	0.89	30.75**	-12.17	-12.17
	MC 78 x MC 84	10.60	-0.07	6.00**	1.44	4.00**
	MC 78 x MC 79	9.80	1.75	50.19**	2.62	-3.83
	MC 78 x MC 66	10.95	0.57	11.03**	7.62**	7.46**
	Arka Harit x MC 79	7.60	2.53	127.20**	117.14**	-25.54
	Arka Harit x MC 49	9.70	2.66	63.85**	12.12**	-40.66
	MC 49 x MC 34	10.15	1.31	26.09*	17.34**	-0.39
E_2	Priya x MC 49	9.88	1.50	17.91**	8.22**	8.22**
	MC 84 x MC 49	9.25	1.04	13.32**	6.32**	1.36
	Arka Harit x MC 79	4.40	2.19	45.45**	43.09**	-51.78
	MC 82 x MC 79	3.38	1.55	26.17**	13.45**	-63.01
E_3	MC 78 x MC 66	11.28	2.09	16.83**	10.00**	17.14**
	Arka Harit x MC 69	5.41	0.33	23.12**	-30.48	-30.48
	Arka Harit x MC 34	6.31	1.71	21.20**	-10.25	-34.50
	MC 82 x MC 79	3.13	0.38	21.95**	-10.25	-34.50
	MC 49 x MC 34	9.03	0.81	16.30**	6.24**	-6.18

Table 58. Fruits/plant in salient F_1 hybrids

Environments	Hybrids	Perse performance	sca effect	RH(%)	HB(%)	SH(%)
E_1	Priya x MC 79	101.00	9.06	23.74**	-9.82	97.07**
	MC 78 x MC 66	71.00	10.02	35.23**	14.06**	38.54**
	MC 78 x MC 49	64.75	9.42	45.77**	40.76**	26.34**
	Arka Harit x MC 79	124.50	47.81	90.80**	11.16**	142.93**
	MC 82 x MC 79	100.00	-9.84	-0.62	-10.71	95.12**
	MC 79 x MC 69	88.00	-0.54	8.64**	-21.43	71.71**
	MC 79 x MC 34	94.50	-1.73	8.93**	-21.43	84.39**
	MC 49 x MC 34	72.00	10.60	33.80**	17.07**	40.49**
E_2	MC 78 x MC 79	75.25	12.79	12.73**	23.02**	85.80**
	Arka Harit x MC 79	61.00	8.03	7.73**	37.60**	50.52**
	MC 82 x MC 79	73.00	-0.12	-5.96	-25.32	80.29**
	MC 79 x MC 49	73.25	5.95	8.72*	-25.06	80.66**
	MC 66 x MC 49	53.25	7.17	32.71**	23.12**	31.48**
	MC 49 x MC 69	51.00	7.90	41.66**	37.83**	25.93**
	MC 49 x MC 34	52.00	12.51	45.96**	40.54**	28.40**
E_3	Arka Harit x MC 34	43.00	10.15	19.44**	-22.17	-7.52
	MC 82 x MC 79	100.25	17.92	8.53**	0.75	115.60**
	MC 79 x MC 66	73.00	0.26	-7.89	-26.63	56.99**
	MC 66 x MC49	50.00	2.44	0.00	-15.25	75.25**

Table 59. Fruit weight in salient F_1 hybrids

Environments	Hybrids	Perse performance	sca effect	RH(%)	HB(%)	SH(%)
E_1	Priya x MC 84	282.00	23.88	7.43**	-6.00	25.33**
	MC 78 x MC 84	262.75	4.40	4.05**	-12.42	16.77**
	MC 82 x MC 79	35.50	34.56	22.94**	10.94**	-84.22
	MC 82 x MC 34	88.00	28.67	20.75**	-26.67	-60.89
	MC 66 x MC 49	217.50	18.00	4.50*	3.57*	-3.30
E_2	MC 82 x MC 79	46.75	37.13	35.57**	14.88**	-79.71
	MC 84 x MC 34	245.50	28.17	13.10**	7.44**	6.51**
E_3	MC 78 x Arka Harit	219.00	18.06	7.25**	3.77**	2.46**
	MC 82 x MC 79	33.50	50.18	23.50**	16.52**	-84.33

and high sca effects was poor. This may be ascribed to the involvement of the poor general combiner, MC-79 for maturity. This suggested that the combining ability of the parents were more related to per se performance.

Several hybrids exhibited relative heterosis for yield/plant in all the three seasons. The hybrids MC-78 x MC-66 in the first and second (10.95 kg and 11.275 kg) and Priya x MC-49 in the second season (9.875 kg) had the highest per se yield with significant relative heterosis. The sca effects of the above crosses where the parents possessed high combining ability effects were also higher. This suggested that in heterosis breeding programme, gca effects of parents, per se performance of hybrids and their sca effects should be considered.

Six hybrids in first and two each in the second and third seasons had significant heterobeltiosis for yield/plant. It was maximum in Arka Harit x MC-79 in the first and second seasons (117.17% and 43.09%) with high sca effects (2.53 and 2.19). However their per se performance was poor in both the seasons (7.6 kg and 4.4 kg). This is attributed to the involvement of two poor general combiners in this hybrid. This suggested that the combining ability of the parents were more related to per se performance of yield than sca effects. The hybrid MC-78 x MC-66 and MC-84 x MC-49 in the first, Priya x MC-49 in the second and Priya x MC-66, MC-78 x MC-66 and MC-66 x MC-49 in the third season appeared higher yielding than the standard variety, Priya. It was in general observed that when parents possessing high gca effects were crossed the F_1 hybrids gave best performance. Varying extent of heterosis was also reported earlier by Srivastava and Srivastava (1970), Lal et al. (1976), Sirohi and Choudhuri (1977), Pal et al. (1983) and Chaudhari (1987).

Out of 45 hybrids, 27 in the first, 15 in second and two in the third season exhibited significant relative heterosis for fruits/plant. F_1 hybrids MC-78 x MC-49 (40.76%) and MC-49 x MC-34 (40.54%) had maximum heterobeltiosis with corresponding high sca effects (9.42 and 12.51) in the first and second seasons respectively. Their per se performances were not however high. The parents were poor combiners and belonged to same cluster which in turn might have contributed to the poor per se performance.

Eight hybrids in first, ten in second and four in third exceeded the mid-parental value for fruits weight. The crosses with two small fruited lines, MC-82 x MC-79 recorded the highest relative heterosis in all the three seasons. Their performance was not promising due to poor gca effects of the parents. Similar finding of higher heterosis in hybrids between small fruited varieties than hybrids between large fruited varieties were reported earlier by Pal and Singh (1946).

Other parameters of fruit size such as fruit length, fruit girth and flesh thickness as well as seeds/plant had a similar trend in the present study. Hybrids between the two small fruited types, MC-82 x MC-79 recorded the highest heterosis for fruit length, fruit girth and flesh thickness in all the three seasons.

Heterobeltiosis for 100 seed weight was observed in three hybrids each in first and third seasons and in five in second season. Hybrids involving parents like MC-69 and MC-49 with good gca effects exhibited higher values of heterobeltiosis. Their sca effects as well as _per se_ performance were high. In crosses of small x large seeded lines, all the hybrids had small seeds. Similar findings were made by Esquines-Alcazar and Gulick (1983).

Inheritance of fruit colour, fruit surface and bitterness

In bitter gourd there exists lines with white, green, spiny, nonspiny, highly bitter and less bitter fruits. Preferences of bitter gourd with respect to fruit colour, surface and intensity of bitterness vary with locality and with individual. Colour, surface appearance and size determine the market price considerably. Information on inheritance of such characters is useful in transferring them to a desired variety.

In the present study, an attempt was made to study the inheritance of fruit colour, fruit surface appearance and bitterness and also to detect linkage between colour and surface appearance. Four lines (Priya, MC-49, MC-66 and MC-69) differing in fruit colour (green/white) and surface (Spiny/smooth) were used to develop 6 generations of P_1, P_2, F_1, F_2, BC_1 and BC_2. In all the crosses, the F_1s were green fruited indicating dominance of green over white. In F_2 the population segregated into a ratio of 3 green : 1 white indicating monogenic inheritance of the character. This was further confirmed in BC_2 generation where the segregating population fitted in a ratio of 1 green : 1 white. This was in agreement with the earlier reports of Esquinas-Alcazar and Gulick (1983) who suggested that the white pericarp is controlled by a single gene 'w', white being recessive to green.

In crosses involving spiny fruited and smooth fruited lines, all the hybrids were spiny fruited indicating the dominance of spininess over smootheness. The F_2 generations segregated into a ratio of 3 spiny : 1 smooth fruited, suggesting monogenic inheritance of the character. This was again confirmed by a 1 : 1 ratio of spiny : smooth fruited plants in the BC_2. The present finding of monogenic mode of inheritance of fruit surface appears to be the first report.

Out of six crosses used for the studies on inheritance of fruit colour and surface seperately, two had parents differing for both colour and surface. The F_2 generations from these two crosses which segregated jointly for fruit colour and surface were used to test the presence of linkage.

The F_1s from both the crosses were all green spiny fruited indicating dominance of green spiny fruits over white smooth. The joint segregation of F_2 population ... green smooth, white spiny and white the study revealed that the fruit colour and surface are independent in inheritance.

Intensity of bitterness is another factor affecting consumer preference in bitter gourd. There exists bitter gourd lines with varying levels of bitterness. Though the exact methodology for the quantitative estimation of bitterness and consequent studies on its inheritance is lacking an attempt was made using the ether extract of fruits as suggested by Visratha and Ungsurungsie (1978).

Three parental lines viz. MC-53, MC-79 and MC-34 with varying levels of bitterness as revealed by organoleptic tests were used for generating three crosses to study inheritance of bitterness. The mean values of bitterness expressed as percentage of ether extract were used for the study. The normal distribution of the values (ether extract) in the F_2 and back crosses indicated quantitative inheritance of the character. Using the mean values and variances of P_1, P_2, F_1, F_2, BC_1 and BC_2 generations of the above crosses, components of gene action were estimated (Mather, 1949). The genetic effects were partitioned into additive, dominance epistasis in the materials studied. The magnitude and type of epistasis were also estimated along with the main effects. Fixable heritability ($h^2(n)$) and number of units of polygenes (k) governing the character were also worked out.

Additive effects were significant in all the crosses, of which MC-79 x MC-34 had negative effect. In one cross dominance effect was significant and it was negative in all the other crosses. Interaction was of additive x dominance type in MC-53 x MC-79. The degree of dominance was positive in one cross and negative in other two crosses. Estimates of narrow sense heritability was high in two crosses and moderate in the other. Additive, dominance and additive x dominance effects were involved in the inheritance of bitterness in bitter gourd. Selection and heterosis breeding method could be resorted to for the improvement of the character.

Crossibility studies among the related species of Momordica

The genus Momordica contains about 60 species of which seven are Indian (Chakravarthy, 1959). Some are cultivated for edible fruits while others are grown wild. Fruits of majority of the species are bitter and a few are non-bitter. The species differ in content of nutrients also (Sheshadri, 1986). Information on the crossability association among the various species would help transfer of desirable attributes to the cultivated species *Momordica charantia*.

In the present study, three related species of *Momordica* - *charantia*, *dioica* and *cymbalaria* (Syn. *Momordica tuberosa*, *Luffa tuberosa*) were used for crossing with diverse types of *Momordica charantia*. Two hundred crosses were made in all possible combinations including reciprocally. Selfings were also done in all the three species.

In all the selfed flowers, ovary growth and fruit set were normal. However in crossed flowers, more than 70% of the ovaries started shrinking and drying even on the third day of pollination. None of the ovaries in the cross remained green after a week. Thus the three species of *Momordica* - *charantia*, *dioica* and *cymbalaria* were found cross incompatible. Trivedi and Roy (1972) also reported total incompatibility among three species of *Momordica* - *charantia*, *dioica* and *balsamina*. Tracing the cause of failure of embryo formation in these ovaries through fluorescence microspic studies, Dutt and Pandey (1982) observed heavy callose deposition at the tip of pollen tube and birfurcation of the growing tips. Consequently the pollen tube could not reach the embryo-sac to effect fertilization.

The present investigations on genetic variability, divergence, combining ability, heterosis, stability analysis, inheritance of economic characters and cross-ability studies were carried out with the objective of overall improvement in bitter gourd. Corresponding to the earlier reports, this study revealed high genetic variability in the germplasm evaluated. The stability of heterobeltiotic F_1 hybrids were encouraging. Inheritance of fruit colour surface and bitterness using suitable cross combinations was also studied. An attempt was also made on the crossability of three species of Momordica in the present work.

Summary

SUMMARY

The present investigation "Homeostatic analysis of components of genetic variance and inheritance of fruit colour, fruit shape and bitterness in bitter gourd (*Momordica charantia* L.)" was conducted at the College of Horticulture during 1981-85. The objectives were estimation of genetic divergence, gene action, inheritance of economic characters, identification of heterobeltiotic and stable F_1 hybrids and understanding crossability among related species of bitter gourd (*Momordica charantia* L.).

2. The extent of genetic variability in 50 bitter gourd lines were assessed. Ten diverse parents were selected, and 45 F_1s developed and evaluated alongwith the parents for three seasons. The combining ability and heterosis were estimated. The stability ofthese hybrids were worked out for commercial exploitation of the promising heterobeltiotic F_1 hybrids. Inheritance of fruit colour, fruit surface and bitterness using crosses of parents differing for these characters was studied. An attempt was also made to understand crossability among the three species of *Momordica* - *charantia*, *dioica* and *cymbalaria*.

3. Significant differences were observed among the 50 genotypes for all 18 characters studied, viz. branches/ plant, vine length, node to first female flower, days to opening of first female flower, female flowers/plant, percentage of female flowers, days to picking maturity, yield/plant, fruits/plant, fruit weight, fruit length, fruit girth, flesh thickness, seeds/fruit, 100 seed weight, T.S.S., Vitamin C content, and protein content. The genotype MC-34 was the earliest for first female flower formation (33.5 days). MC-79 had maximum fruits/plant (113.25) fruit size being small. Priya had the highest yield/plant (12.76 kg) which was on par with MC-84 (12.48 kg), MC-78 (12.25 kg) and MC-66 (12.17 kg). The highest phenotypic coefficient variation was observed for fruit weight (48.77) followed by yield/plant (39.91) and fruits/ plant (31.82). It was moderate for fruit length (29.56), percentage of female flowers (28.56) and female flowers/ plant (27.33). The pcv was low for node to first female flower formation (8.18) and days to first female flower opening (8.38). The genotypic coefficient of variation resulting in high heritability was of high magnitude for majority of the characters. High heritability coupled with high genetic gain was observed for fruit weight and

yield/plant. Branches/plant and days to first female flower formation despite with high heritability had only low genetic gain.

4. Ten diverse bitter gourd lines selected from the original germplasm were crossed in all possible combinations to develop 45 F_1 hybrids. Stability of these parents and hybrids was analysed by growing them continuously for three seasons. Pooled analysis of variance showed significant genotype x environment interaction for all the characters. The genotypes were significantly different in all the three seasons and the environments were also significantly different among one another. The pooled deviation was highly significant for all the characters except for node to first female flower, which indicated presence of interaction of the genotypes with the environment.

5. The linear components of genotype x environmental interaction was highly significant for yield and related characters indicating linear nature of interaction of genotypes with environments and presence of considerable differences among the genotypes themselves. The highest over all mean yield/plant was recorded by MC-78 x MC-66 (10.33 kg) followed by Priya x MC-66 (9.75 kg). Considering

the regression coefficient approximately equal to unity ($bi \longrightarrow 1$) and deviation from regression not significantly different from zero ($S^2d(i) \longrightarrow 0$), Priya x MC-84, MC-78 x MC-69, MC-84 x MC-66 and MC-84 x MC-49 were stable hybrids. Priya x MC-69, MC-78 x MC-84 and MC-78 x MC-34 were above average stable and Priya x MC-78, Priya x MC-66 and MC-84 x MC-34 were below average stable hybrids.

6. The 45 F_1 hybrids alongwith their 10 parents were evaluated for three seasons to study combining ability and heterosis. Analysis of variance for combining ability for separate environments showed significant gca variances for all the 15 characters in all the three seasons. The sca variances were also significant for all the characters excepting days to picking maturity, fruit girth and 100 seed weight in the second and node to first female flower in the third season.

7. Analysis over environments for combining ability variances showed significance of gca and sca variances indicating role of both additive and non-additive gene action for control of majority of characters. The interaction of gca and with environments were high for all the characters, excepting earliness indicating additive role of

environments on combining ability of the parents. Significant sca x environment interaction for all the characters revealed inconsistent sca effects of the crosses. The parents Priya, MC-78, MC-84 and MC-66 which gave highest yields found possessed significant gca effects. When parents with high gca effects were crossed, the F_1 hybrids gave best performance. The present study revealed importance of both additive and non-additive gene effects in the inheritance of majority of characters. Pedigreee system and diallel selective mating among the parents on the basis of gca would result in greater variability for recurrent selection to be resorted to for improvement in bitter gourd.

8. Several hybrids recorded significant relative heterosis, heterobeltiosis and standard heterosis for majority of the characters in all the three seasons. Significant and negative relative heterosis, heterobeltiosis and standard heterosis were exhibited by several hybrids for days to first female flower. MC-66 x MC-49 (-14.97%) and MC-49 x MC-34 (-13.28%) in the first and Arka Harit x MC-82 (-11.76%) in the third season were significantly earlier for the first female production than the standard variety Priya.

Priya x MC-49 (7.91%) and MC-49 x MC-34 (7.91%) and MC-49 x MC-69 (7.1%) were the important hybrids with high standard heterosis for percentage of female flowers.

Six hybrids in the first and two each in the second and third seasons exceeded their better parents for yield/plant. Arka Harit x MC-79 had high heterobeltiosis in the first and second seasons (117.17% and 43.09%). MC-78 x MC-66 (7.46%) and MC-78 x MC-84 (4%) in first and MC-78 x MC-66 (17.14%) and Priya x MC-66 (5.04%) in the third season had higher yield than the standard variety Priya.

MC-78 x MC-49 (40.76%), MC-49 x MC-34 (17.07%) in the first and MC-49 x MC-34 (40.54%), MC-49 x MC-69 (37.83%) and Arka Harit x MC-79 (37.6%) in second season were superior heterobeltiotic F_1 hybrids for fruits/plant.

9. Studies on inheritance of fruit colour and fruit surface using six crosses of four parents with contrasting fruit colour and surface revealed that both the characters are monogenic in inheritance, green and spiny fruits being dominant over white and smooth fruits respectively. Both colour and surface are independent in inheritance. Inheritance studies on bitterness using three crosses of highly bitter, and less bitter types of bitter

gourd showed quantitative inheritance of the character. Non-allelic interaction was present in two crosses. Additive, dominance and additive x dominance types of gene action were involved in the inheritance of bitterness. Estimates of narrow sense heritability was high in two crosses and moderate in one.

10. Crossability studies using three species of *Momordica* - *charantia*, *dioica* and *cymbalaria* showed complete incampatibility among the three species tried.

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* Original not seen

Appendices

Appendix-I

Mean performance of 50 bitter gourd genotypes for yield and component characters

Sl. No.	Genotypes	Branches per plant	Main vine length (m)	Node to first female flower	Days to first female flower opening	Female flowers/ plant	Percentage of female flowers	Days to picking maturity	Yield/ plant (kg)	Fruits/ plant
1	2	3	4	5	6	7	8	9	10	11
1	MC-4	29.28	4.35	18.50	38.75	75.50	5.47	12.00	6.02	35.50
2	MC-10	28.75	4.53	23.50	39.13	47.00	3.70	13.25	7.54	41.13
3	MC-15	36.25	5.02	20.25	43.50	61.00	3.84	15.38	7.06	56.13
4	Priya	36.13	6.25	24.13	40.75	68.13	6.55	12.75	12.76	56.25
5	Arka Harit	24.00	2.66	20.25	43.75	31.88	3.55	15.38	4.07	17.25
6	MC-34	32.25	5.63	20.50	33.50	71.75	4.65	10.63	8.28	68.38
7	MC-42	29.25	5.40	21.25	40.38	61.50	5.45	13.25	7.23	49.87
8	MC-48	31.13	4.46	19.88	39.50	65.63	5.71	13.50	8.14	50.38
9	MC-49	33.00	5.45	22.75	37.63	61.50	6.57	13.38	9.67	47.50
10	MC-50	34.00	5.80	22.63	38.50	71.63	3.67	15.63	8.44	54.50
11	MC-51	31.25	5.00	23.63	44.38	71.00	4.79	15.13	7.52	44.75
12	MC-52	29.75	5.34	24.13	45.12	66.50	6.39	16.50	4.93	42.88
13	MC-53	32.75	5.45	23.00	46.00	54.63	5.58	13.75	5.02	53.75
14	MC-54	34.13	5.72	22.13	43.50	53.88	5.33	13.75	7.49	32.88
15	MC-57	29.00	2.80	18.13	39.63	66.88	5.57	12.38	4.90	40.13

Contd.

Appendix-I. Continued

1	2	3	4	5	6	7	8	9	10	11
16	MC-60	29.75	4.53	20.63	41.38	43.25	4.36	14.00	4.65	61.50
17	MC-61	33.38	5.43	23.88	40.50	52.38	3.11	13.25	9.05	49.38
18	MC-62	33.00	5.58	23.88	37.13	73.63	5.30	13.50	8.94	63.00
19	MC-63	30.00	5.02	23.25	36.75	74.00	5.87	14.00	6.03	49.38
20	MC-64	36.00	4.79	20.75	37.38	60.13	4.25	13.63	6.10	51.63
21	MC-65	36.50	4.92	21.80	37.50	58.00	2.94	14.50	5.14	46.63
22	MC-66	37.13	6.01	22.00	41.38	81.88	6.25	12.38	12.18	60.75
23	MC-67	33.50	3.57	21.75	41.88	59.38	5.40	12.88	5.06	60.50
24	MC-68	27.75	4.53	19.38	45.13	60.00	4.96	13.25	5.42	47.25
25	MC-69	34.25	5.56	20.50	43.63	70.00	6.48	14.25	9.62	50.88
26	MC-70	33.00	4.91	22.88	43.50	55.88	3.23	13.13	4.04	51.50
27	MC-71	32.00	5.03	23.88	45.13	51.50	2.66	12.63	5.05	43.63
28	MC-72	29.00	3.73	21.88	46.50	43.38	2.13	14.25	5.23	31.00
29	MC-73	26.25	5.50	20.63	43.25	48.38	3.21	14.25	3.70	35.88
30	MC-74	33.50	5.85	21.38	43.13	64.38	3.73	13.00	8.20	50.25
31	MC-75	34.25	5.50	21.75	41.88	63.75	3.35	14.38	9.15	52.25
32	MC-76	34.00	5.40	22.38	39.88	65.00	3.80	13.75	10.08	55.25
33	MC-77	34.25	4.99	23.88	39.75	59.00	3.38	13.25	10.29	47.37
34	MC-78	35.50	6.49	22.75	46.38	53.88	5.08	12.50	12.25	44.63

Contd.

Appendix-I. Continued

1	2	3	4	5	6	7	8	9	10	11
35	MC-79	43.63	7.79	21.50	46.38	120.00	2.76	16.12	4.06	113.25
36	MC-80	20.50	3.13	21.13	47.25	115.25	2.85	13.50	4.82	41.38
37	MC-82	20.00	1.98	22.50	40.38	103.00	2.89	15.75	2.41	89.50
38	MC-83	34.75	4.55	25.13	40.38	119.88	4.79	14.38	7.80	100.00
39	MC-84	36.13	6.86	24.13	47.25	59.75	4.40	15.00	12.49	40.50
40	MC-85	33.50	4.03	21.75	40.38	104.00	6.72	12.38	6.51	90.13
41	MC-86	35.75	4.67	24.25	39.50	91.00	5.28	13.00	3.53	74.75
42	MC-87	36.13	3.50	24.25	37.88	65.25	2.66	13.37	4.83	51.25
43	MC-88	30.75	3.98	23.75	35.88	68.13	3.07	13.50	5.53	55.63
44	MC-89	31.38	3.79	23.13	37.38	71.13	3.97	15.00	4.43	59.50
45	MC-90	30.38	4.78	24.63	37.25	81.63	4.56	14.00	2.47	70.38
46	MC-91	31.38	5.00	23.50	38.75	94.38	5.07	13.00	2.32	79.88
47	MC-92	31.63	5.43	20.13	37.75	65.25	3.47	13.75	7.43	50.00
48	MC-93	32.63	5.75	21.63	39.50	67.88	4.32	13.88	9.13	60.13
49	MC-94	31.13	4.55	25.00	38.00	72.00	3.17	13.50	8.36	54.50
50	MC-95	29.13	3.49	24.25	37.25	71.88	3.13	13.75	3.53	57.50
	CD (p=0.05)	2.61	0.51	1.80	1.50	4.43	0.32	0.84	0.44	3.20

Appendix-II

Mean performance of 50 bitter gourd genotypes for fruit character

Sl. No.	Genotypes	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Flesh thickness (mm)	Seeds/ fruit	100 seed weight (g)	T.S.S. (%) °Brix	Vit.C. mg/100g	Protein (%)
1	2	3	4	5	6	7	8	9	10	11
1	MC-4	198.75	37.75	13.90	5.60	20.13	22.00	2.31	51.75	13.25
2	MC-10	209.75	36.40	16.20	5.55	22.75	20.90	2.31	45.50	11.37
3	MC-15	190.63	34.47	14.28	5.65	23.13	22.50	3.47	53.50	13.37
4	Priya	240.50	38.25	17.07	5.90	24.50	24.37	3.13	64.50	18.12
5	Arka Harit	238.13	21.95	24.32	9.40	20.63	23.10	3.56	80.25	16.25
6	MC-34	119.88	28.37	15.35	5.25	23.88	23.30	3.30	71.87	15.50
7	MC-42	150.50	35.45	15.15	4.81	20.25	20.90	2.47	52.37	13.20
8	MC-48	161.00	35.17	14.33	5.02	24.13	21.50	2.95	63.87	14.70
9	MC-49	231.00	26.30	17.87	6.45	27.75	20.10	2.63	75.50	13.17
10	MC-50	148.25	32.15	16.23	5.61	21.75	19.60	3.53	61.59	18.17
11	MC-51	140.75	33.00	14.97	4.52	20.50	20.60	2.50	64.75	18.45
12	MC-52	109.87	32.00	13.92	5.40	19.88	21.60	3.06	50.02	14.35
13	MC-53	120.63	33.10	15.10	5.30	20.88	20.70	2.40	55.00	14.62
14	MC-54	138.63	28.50	16.20	4.16	17.75	21.70	2.50	71.30	17.10
15	MC 57	149.25	24.65	16.30	5.17	19.13	19.80	3.31	85.50	17.65

Contd.

Appendix-II. Continued

1	2	3	4	5	6	7	8	9	10	11
16	MC-60	119.75	31.95	15.22	5.77	20.50	20.00	3.44	55.25	15.60
17	MC-61	150.87	35.65	15.00	5.90	21.00	22.60	3.15	66.87	14.17
18	MC-62	139.87	36.25	13.90	5.77	22.00	22.00	2.50	72.50	14.27
19	MC-63	130.75	38.15	13.15	5.57	21.50	22.35	2.22	60.75	14.25
20	MC-64	119.37	36.50	14.12	5.47	17.63	23.10	2.25	94.87	14.00
21	MC-65	129.37	36.20	15.07	5.56	18.00	24.30	2.66	66.12	13.50
22	MC-66	211.00	32.42	16.00	5.80	23.88	27.10	3.16	68.62	16.40
23	MC-67	110.37	34.05	13.15	5.50	24.38	20.80	2.22	73.00	17.12
24	MC-68	98.37	32.15	14.13	5.00	24.38	21.80	2.15	77.12	17.87
25	MC-69	231.00	36.47	16.76	5.47	17.25	23.40	3.75	93.00	13.47
26	MC-70	109.62	31.95	14.15	5.30	20.75	23.40	3.25	65.95	16.12
27	MC-71	150.75	37.00	13.94	5.77	23.00	23.00	2.50	55.87	16.27
28	MC-72	140.00	32.92	13.27	5.60	21.26	22.20	3.15	60.50	14.37
29	MC-73	119.87	34.22	12.13	5.82	21.00	21.70	2.66	69.50	13.12
30	MC-74	191.12	36.15	15.15	5.75	21.38	23.00	2.47	61.37	12.27
31	MC-75	200.50	34.95	15.00	5.60	24.00	22.90	3.06	73.62	15.10
32	MC-76	199.25	34.52	15.15	5.60	23.50	21.75	3.16	65.50	13.12
33	MC-77	250.75	34.90	15.20	5.70	20.63	22.00	3.16	60.87	14.07
34	MC-78	289.50	40.52	15.25	5.70	22.50	23.00	3.06	71.20	15.90

Contd.

Appendix-II. Continued

1	2	3	4	5	6	7	8	9	10	11
35	MC-79	31.50	7.92	6.43	3.30	17.25	6.60	2.10	76.12	16.20
36	MC-80	119.35	33.05	8.22	4.92	24.25	21.70	2.34	80.50	16.12
37	MC-82	25.25	6.55	10.04	3.55	12.00	17.40	3.16	122.38	20.15
38	MC-83	79.62	22.17	10.03	5.77	24.13	19.70	2.56	92.12	12.67
39	MC-84	311.00	30.02	24.35	6.70	23.38	26.40	3.16	81.75	16.17
40	MC-85	77.50	16.17	12.15	4.75	14.25	19.25	3.00	96.25	12.35
41	MC-86	50.12	11.25	10.07	4.82	15.50	19.60	2.66	97.25	12.25
42	MC-87	99.87	28.00	13.06	4.20	16.25	21.70	2.56	97.07	13.07
43	MC-88	98.00	27.15	14.07	4.25	17.00	22.30	2.84	86.63	12.30
44	MC-89	90.63	22.20	12.09	4.02	16.00	21.40	2.56	54.50	13.50
45	MC-90	38.25	17.22	13.17	4.00	15.75	21.00	2.05	80.19	13.75
46	MC-91	30.37	9.07	13.27	4.25	14.00	18.90	2.31	73.75	12.87
47	MC-92	79.50	24.30	15.29	4.20	17.50	22.40	3.16	65.75	14.05
48	MC-93	79.00	23.55	14.80	4.20	17.75	22.20	2.16	70.63	12.12
49	MC-94	51.00	20.37	14.05	4.35	17.00	21.60	2.25	66.00	12.27
50	MC-95	53.50	50.40	12.24	3.60	14.25	18.00	2.50	67.00	13.15
	CD (p=0.05)	5.90	1.20	0.43	0.73	2.10	1.25	0.26	3.53	1.33

Appendix III

Source of 50 bitter gourd genotypes

Sl. No.	Geno-type	Source	Sl. No.	Geno-Type	Source
1	MC-4	Vellanikkara	26	MC-70	Pilicode
2	MC-10	Vellanikkara	27	MC-71	Pilicode
3	MC-15	Vellanikkara	28	MC-72	Trichur
4	Priya	Vellanikkara	29	MC-73	Trichur
5	Arka Harit	I.I.H.R.	30	MC-74	Vellanikkara
6	MC-34	Malappuram	31	MC-75	Vellanikkara
7	MC-42	Malappuram	32	MC-76	Trichur
8	MC-48	I.A.R.I.	33	MC-77	Vellanikkara
9	MC-49	I.A.R.I.	34	MC-78	Vellanikkara
10	MC-50	I.A.R.I.	35	MC-79	Mannuthy
11	MC-51	I.A.R.I.	36	MC-80	Madavoor
12	MC-52	Trichur	37	MC-82	Madavoor
13	MC-53	Almora	38	MC-83	Trivandrum
14	MC-54	Trichur	39	MC-84	Mudicode
15	MC-57	Trichur	40	MC-85	N.B.P.G.R.
16	MC-60	Coimbatore	41	MC-86	N.B.P.G.R.
17	MC-61	Vellanikkara	42	MC-87	N.B.P.G.R.
18	MC-62	Vellanikkara	43	MC-88	N.B.P.G.R.
19	MC-63	Vellanikkara	44	MC-89	N.B.P.G.R.
20	MC-64	Mudicode	45	MC-90	N.B.P.G.R.
21	MC-65	N.B.P.G.R.	46	MC-91	N.B.P.G.R.
22	MC-66	N.B.P.G.R.	47	MC-92	N.B.P.G.R.
23	MC-67	Solan	48	MC-93	N.B.P.G.R.
24	MC-68	Canannore	49	MC-94	N.B.P.G.R.
25	MC-69	Canannore	50	MC-95	N.B.P.G.R.

HOMEOSTATIC ANALYSIS OF COMPONENTS OF GENETIC VARIANCE AND INHERITANCE OF FRUIT COLOUR, FRUIT SHAPE AND BITTERNESS IN BITTER GOURD (*Momordica charantia* L.)

By

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ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree

Doctor of Philosophy in Horticulture

Faculty of Agriculture
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ABSTRACT

The present investigations "Homeostatic analysis of components of genetic variance and inheritance of fruit colour, fruit shape and bitterness in bitter gourd (*Momordica charantia* L.)" were conducted at the College of Horticulture during 1981-85. Assessment of genetic variability showed significant differences for 18 characters in the 50 bitter gourd genotypes. The highest phenotypic coefficient of variation was observed for fruit weight, yield and fruits/plant. Earliness had only low value of pcv. The gcv resulting in high heritability was of high magnitude for majority of the characters. High heritability coupled with high genetic gain was observed for fruit weight, yield and fruits/plant.

The stability analysis of 45 F_1 hybrids along with 10 parents for three seasons showed significant genotype x environment interaction for all the characters. The genotypes differed in interaction which was linear for yield and related characters. The study identified hybrids suitable for high, medium and low environments. Combining ability analysis of the above set of F_1 hybrids and parents for three seasons indicated significant gca variances for all the characters. The sca variances were also significant

for majority of the characters. Analysis over environments showed significance of gca and sca variances for most of the characters. The interaction of gca as well as sca variances with environments was also high for all the characters, except earliness. Parents of high gca gave F_1s of best performance. Several hybrids possessed significant relative heterosis, standard heterosis and heterobeltiosis for majority of the characters. Hybrids like MC-66 x MC-49, MC-49 x MC-34 and Arka Harit x MC-82 were earlier. Priya x MC-34 and MC-49 x MC-69 possessed standard heterosis for percentage of female flowers. Arka Harit x MC-79, MC-78 x MC-66, MC-78 x MC-84 and Priya x MC-66 had higher yield than the standard variety, Priya. MC-78 x MC-48, MC-49 x MC-34, MC-49 x MC-69 and Arka Harit x MC-79 were heterobeltiotic for yield/plant.

Studies on inheritance of fruit colour and surface revealed that both are monogenic; green and spiny fruits being dominant over white and smooth fruits respectively. Inheritance of bitterness suggested involvement of additive, dominant and additive x dominance type of gene action.

Crossability studies using three species of _Momordica_ - _charantia_, _dioica_ and _cymbalaria_ revealed complete incompatibility among the three species.

The studies recommended heterotic hybrids with green, white, smooth and ribbed types of bitter gourd for year round cultivation.