COMBINING ABILITY AND STABILITY STUDIES IN BITTER GOURD

(*Momordica charantia* Linn.)

करेला (मोमोरडिका केरेशिंया लिन) में संयोजिता व स्थायत्व पर अध्ययन

GUGAN RAM MATORIA

THESIS

Doctor of Philosophy in Agriculture

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(GUGAN RAM MATORIA)

- : CONTENTS : -

-: LIST OF TABLES :-

-: LIST OF APENDICES :-

-: LIST OF FIGURES/GRAPHS :-

ABSTRACT

The investigation was carried out to gather the information pertaining to extent of heterobeltiosis, economic heterosis, combining ability and stability of Bitter gourd (*Momordica charantia* Linn.) genotypes for 13 yield contributing attributes viz. Days taken to the appearance of first female flower, node number at which first female flower appear, length of main shoot (cm), number of lateral branches per plant, number of male flower per plant, number of female flower per plant, percentage fruit set, number of fruits per vine, length of fruit (cm), girth of fruit (cm), weight of fruit (g), fruit yield per vine (g) and number of seeds per fruits. The experimental material comprising 56 genotypes (10 parents, 45 F_1's and 1 standard check for economic heterosis) was raised in a randomized block design with three replications at Horticulture Farm, RCA, Udaipur under 4 environments (created by various fertilizer application).

The analysis of variance indicated existence of adequate genetic variability in the experimental material and genotypes highly interacted to the environmental fluctuations.

The hybrids P_1xP_6, P_5xP_9 and P_5xP_{10} were superior for fruit yield and its componential traits, since they exhibited higher estimates of heterobeltiosis, economic heterosis and sca effects in desired direction. Hybrid (P_5xP_7) was best for days taken to the appearance of first female flower and (P_2xP_5) for node number of which first female flower appear.

The parents P_2, P_6, P_8 and P_{10} were good general combiner for most of the traits, these parents may be used in further breeding programme.

The hybrids (P_1xP_6) and (P_5xP_9) were stable for most of the attributes. Hybrid (P_5xP_{10}) was suitable for poor environments, while (P_7xP_8) was good under favourable environmental conditions.

The existence of both additive and non-additive gene action with a prominent role of non-additive one, was indicated by significant of gca and sca variance (combining ability analysis), alongwith linear (regression coefficient) and non-linear (pooled deviation) components of G x E interaction (pooled analysis of variance for stability) under such situation selection should be adopted for population improvement followed by isolation of superior inbred lines for future hybridization programme.

अनुक्षेपण

करेला (*मोमोरडिका करेशिंया लिन.*) के समपैत्रिको की कटिबंधीत व आर्थिक संकरोजा, संयोजिता, तथा स्थायत्व के सम्बन्ध में सूचना प्राप्त करने हेतु 13 उपज के अंशदायी गुणों यथा- प्रथम मादा फूल निकलने में लगे दिन, पर्व की संख्या जिस पर प्रथम मादा फूल निकला, मुख्य तने भी लम्बाई (सेमी.), प्रति पौधा पार्श्व शाखाओं की संख्या, प्रति पौधा नर फूलों की संख्या, प्रति पौधा मादा फूलों की संख्या, फल लगने का प्रतिशत, प्रति पौधा फलों की संख्या, फल की लम्बाई (सेमी.), फल की गोलाई (सेमी.), फल का भार (ग्राम), प्रति पौधा फलों की उपज (ग्राम), प्रतिफल बीजों की संख्या, पर एक अन्वेषण किया गया। संपरीक्षात्मक सामग्री जिसमें 56 समपैत्रिकों [10 पैत्रिक संतति, 45 संकर तथा 1 मनक तुलनक आर्थिक ओज के लिए] सम्मिलित थे, को यादृच्छिक खण्डक अभिकल्पना मे तीन अभ्यापृत्तियों में उद्यान क्षेत्र, राजस्थान कृषि महाविद्यालय, उदयपुर पर 4 अवस्थाओं (विभिन्न खाद की मात्रा देकर तैयार की गई) में उगाया गया।

विचरण विश्लेषण से यह प्रदर्शित होता है कि संपरीक्षात्मक सामग्री में पर्याप्त जननिक विभिन्नता उपस्थित थी तथा समपैत्रिक वातावरणीय परिवर्तनों के साथ अधिक मिथः क्रिया करते थे।

संकर P1xP6, P5xP9 तथा P5xP10 फलों की उपज तथा इसके संघटक गुणों के लिए उत्कृष्ट थे, क्योंकि ये इच्छित दिशा में अधिकतम कटिबंधीत संकट ओज, आर्थिक संकर ओज तथा विशिष्ट संयोजन क्षमता प्रभाव प्रदर्शित करते थे। संकर P5xP7 प्रथम मादा फूल निकलने में लगे दिन हेतु, जबकि P2xP5 पर्व की संख्या जिस पर प्रथम मादा फूल निकला हेतु सबसे अच्छा पाया गया।

पितृक P2, P6, P8 तथा P10 अधिकतर गुणो के लिए अच्छे सामान्य संयोजक थे। ये पितृक आगामी प्रजजन कार्यक्रम में उपयोग किए जा सकते हैं।

संकट P1xP6 तथा P5xP9 अधिकांश गुणों हेतु स्थाई थे। संकर P5xP10 प्रतिकूल वातावरणों हेतु, जबकि P7xP8 अनुकूल वातावरणीय दशाओं हेतु उत्तम पाए गये।

सार्थक सामान्य तथा विशिष्ट संयोजन क्षमता विचरण [संयोजन क्षमता विश्लेषण] के साथ-साथ रेखीय (समाश्रयण-गुणांक) तथा अरेखीय [यानि समुह विचरण] [संयुक्त स्थायत्व विश्लेषण], यह प्रदर्शित करते थे कि अंसयोजी जीन अभिक्रिया के अधिक प्रभावी होने के साथ-साथ दोनो संयोजी तथा अंसयोजी जीन अभिक्रियाएं उपस्थित थी। ऐसी परिस्थिति में करेला पादप समूह की उन्नति हेतु पारस्परिक प्रत्यवर्ती चयन के पश्चात उत्कृष्ण्ट अन्तः प्रजातों का चयन किया जाना चाहिए, जो कि भविष्य के संकरण कार्य क्रम में उपयोग किये जा सके।

Introduction

India is world's second largest producer of vegetables next only to China with an annual production estimated around 71.66 million tonnes from 6.2 million hectares (Chadha, 1996), per capita consumption is 135 gms per day, while for balanced diet 285 gms of vegetables required per day for a human. Thus our availability of vegetables is less than half of the requirement. Our vegetable requirement in the country is estimated 225 million tonnes by 2020. To achieve this target and provide balanced diet it is necessary to boost up the productivity of vegetables by increasing area, use of improved technology and by developing high yielding varieties or hybrids by systematic breeding work.

Genus momordica is the second largest genera of cucurbitaceae family having 60 species. Bitter-gourd (*Momordica charantia* Linn.) is one of the most nutritive and commercially important cucurbit vegetable. Fruit of bitter gourd is a good source of vitamin C and contains 88 mg vitamin C, 210 I.U. Vitamin A, 1.8 mg Iron, 70 mg phosphorus, Potassium 120 mg, 20 mg calcium and 25 calories energy per 100 gms edible portion.

They are tonic, stomachic, carminative and produce a cooling effect. The fruits, leaves and roots have long been used in our country as a ayurvedic medicine for diabetic patients. Fruits of this vegetable are cooked in many ways-fried, boiled, stuffed, dried and pickled. In India, it is grown both as a summer and rainy season crop.

Bitter gourd is a monoecious, climbing and cross pollinated annual crop. Hardly any care has been taken to maintain the genetic purity of the crop. As a result a mixture of varieties are in use by most of the growers. In lack of suitable varieties and F_1 hybrids of the crop the growers are deprived of superior cultivars, which may provide higher yields alongwith other desirable characters i.e. Fruit shape, size, better colour, early maturity, narrow sex ratio etc. Though a wide variability in plants and fruit characters is available in this crop, very little work appears to has been done in improving the existing cultivars.

Distinct variability in fruit characters like-size, shape, fruit surface, fruit colour. Number of seeds per fruit, maturity, fruit weight, yield per plant and monoecious nature which provides easy pollination imparts a great opportunity for developing desirable variety/hybrids in bitter gourd through careful selection and hybridization.

The yield is a complex, polygenic character and hence is not amenable to straight application of mendelian principles. In breeding of high yielding varieties of vegetables, the breeder often deals with problem of selecting the desirable parents. Combining ability is one of the important aspect for selecting the desirable parents and crosses. Hence, by estimating GCA and SCA effects the suitable combiner lines can be selected which may be used in developing hybrids.

There is no environment which is static with regard to climatic conditions, irrigation facilities and fertility levels of soil etc. Hence all organisms attempt to cope up with environmental variability through individual and population adaptability (Cook and Johnson, 1968). The stability of productivity is very necessary and hence it is desirable to isolate genotypes manifesting low genotype-environment interaction in respect of important characters. The information regarding magnitude of genotype x environment interaction involved in the expression of given characters also helps plant breeders in planning a proper breeding programme.

Although, bitter gourd is grown extensively through out country and in other part of the world also, but has not been exploited sufficiently by plant breeders for its improvement. In view of wide variability and economic and medicinal importance, it is worth while to initiate steps towards investigation considering these aspects. The present investigation was under taken with the following objectives:

(i) To calculate heterosis over the best parent (Heterobeltiosis) and over the check (economic heterosis).

(ii) To study the combining ability (GCA and SCA both) in different environments as well as over the environments.

(iii) To determine the genotypic stability of parents and hybrids.

Review of Literature

The present investigation was conducted to study the "combining ability and stability studies in Bitter gourd (*Momordica charantia* Linn.)". The available relevant literature on these aspects in vegetable crops is reviewed here under.

2.1 HETEROSIS

In the history of development of scientific concepts and their application in agriculture, heterosis deserves a prominent position. The term heterosis; as is now widely used, refers to the phenomenon in which the F_1s obtained by crossing two genetically dissimilar individuals manifest increased or decreased vigour over the mid parental values. Shull (1908, 1914) coined the term heterosis and described this phenomenon as the stimulus of heterozygosis. Fonseca and Patternson (1968) and Mather and Jinks (1971) suggested a new term 'heterobeltiosis' to describe improvement of heterozygote in the comparison with better parent.

Genetical, biochemical and physiological basis of heterosis have been reviewed by Sinha and Khanna (1975). Several genetical phenomena, like dominance of genes (Davenport, 1908; Keeble and Pellow, 1910; Bruce, 1910 and Jones 1917); over dominance of genes (Shull, 1908; East, 1908 and 1936; Stadler, 1939; Hull, 1945 and Gustafson, 1946); genes dispersion in parental lines, epistatic interaction, linkages of genes, maternal effect and genotype x environmental interaction (Mather and Jinks, 1971) and mitochondrial complementation (Hanson *et al.*, 1960; Sarkissian and Srivastava, 1969), have been put forward to explain the causes of observed heterosis. There is no evidence however, to attribute only a single cause responsible for heterosis (Strickburger, 1976). The observed heterosis might result be the combined action of several underlying causes.

Hayes and Jones (1911) were the first investigators to report heterosis in cucurbits. They reported 24-39% increase in yield in cucumber.

The manifestation of heterosis for early ripening in 59 F_1 hybrids among 83 melon hybrid combinations was reported by Manukjan (1966). He also concluded that selection of parent pairs for obtaining heterosis for early ripening is possible. Foster

(1967) reported that four commercial cultivars and 4 crown blight resistant breeding strains were paired in various combinations to give different F_1 hybrids. These hybrids and their parents were compared for yield, quality characteristics and crown blight reaction. In a 2 years trial, $1F_1$ musk melon stock produced twice as much marketable fruits as its high yielding (commercial) parent.

Lozanov (1969) obtained that the F_1 hybrids Caserto x Gribovo -37, Jantra x Gribovo - 37, Jantra x Caserto, Sete x Jantra and Jantra x Odesso - 52 all expressed heterosis for earliness and yield. The first three hybrids were the best, out yielding the standard variety Jantra by 68.3, 20.0 and 71.3% respectively.

Bhattacharya *et al.* (1970) reported that the American male sterile lines MS_1 and MS_2 were crossed the Japanese commercial varieties Earl's favourite and Pearl various degree of heterosis were observed among F_1 hybrids for number of nodes, plant height, number of days to male and female flower formation, fruit maturity, fruit weight and sugar content.

Nath and Dutta (1970) concluded that among 80 hybrid water melons studied, the hybrid IHR-6 x Charleston Gray, IHR-20 x Crimson Sweet and Sugar Baby x Crimson Sweet produced more than 50% heterosis with regards to yield. In fruit quality, these hybrids exceed all other hybrids and the parents. They again (1970) studied the fruit characters in hybrids derived from three inbred lines of *Cucumis melo* var. utilissimus and two inbred lines of *Cucumis melo* var. *Momordica*. The hybrids resembled *Cucumis melo* var. momordica in the number of fruiting cycles/season and in a number of qualitative fruit characters. Heterosis for fruit yield seemed to be primarily due to more fruit cycles per season, improved fruit set, more fruit/plant and higher fruit weight.

The value of heterosis for increasing yield and improving quality in forage pumpkin was reported by Shelpov and Kulchitskaya (1970).

Singh *et al.* (1970) were used the pistillate lines of cucumber as female parents for the production of F_1 hybrid seed. Seven cucumber cultivars both slicing and pickling types were used as male parent. They reported that all the hybrids gave significantly higher early and total yield compared to the standard cultivar. The range of increase in early and total yield varied from 70.31 to 153.68 and 45.74 to 78.86%

over the well adopted cultivar Japanese Long Green. The significant increase in number of fruits produced in hybrid has been mainly responsible for the increase in yield.

Srivastava (1970) found out striking hybrid vigour in bitter gourd, with regard to increase in growth, yield, earliness and the best hybrid showed 64 per cent increase over the better parent. The increase in number of fruits was also observed. Considerable heterosis for early and total yield, number of fruits/plant and fruit length in summer squash were reported by Gill *et al.* (1971).

Petkova (1971) reported that several heterotic small-fruited varieties for salting or pickling have been bred at the experiment station of vegetable crops, Gorna oryakhorista, from partially dioecious parent varieties. The female parent varieties are maintained by the use of intermediate hermaphrodite lines. Compared with the initial parents, the heterotic combinations have up to 40% higher early and 22% higher total fruit yield.

Kolhe (1972) studied hybrid vigour over mid parent, better parent and best variety in cucurbits. The hybrid performance in respect of yield in 91 crosses obtained from 25 parents in bitter gourd was studied. Similar studies were made in 57, 16 and 6 combinations from 16, 12 and 13 parents in ridge gourd, smooth gourd and bitter gourd respectively. It was found that only one cross combination in bottle gourd (Kalyanpur -9 x Malkapur - 26) and one in ridge gourd (Baroda - 24 x Mulshi -33) and one in smooth gourd (In done - 6 x M.P.7) showed heterosis of considerable magnitude worth of practical exploitation.

In muskmelon significant and fabourable heterosis for time to first fruit harvested, average weight of first three fruits and weight of all fruits per plant was obtained by Lippert and Legg (1972). Tyagi (1973) demonstrated heterosis for the number of pistillate flowers, number of fruits per plant, weight per fruit and number of seeds per fruit.

Brar and Nandpuri (1974) studied the F_1, F_2 and two back-cross generations of the crosses Special 1 x Charleston Grey, Shipper x Charleston Grey and Sweet Princess x special 1 in 1970 to 1972 and found that the average fruit weight showed considerable heterosis due to over dominance in the cross Shipper x Charleston Grey and partial dominance for weight in the other two crosses. Both additive x additive and additive x dominance effects were significant.

Hussain *et al.*, (1974) reported that twelve promising varieties were crossed in 21 combinations. The crosses Isahi Sugar x Cream Swika and Charleston Grey x Kakow Swika gave the best improvements in fruit size over mid parental values and the superior parent. The corresponding crosses for fruit weight were Isahi Sugar x Cream Swika and Blondike Striped x Sugar Baby.

Nandpuri *et al.* (1974) studied sixteen F_1s from crosses between four male parents and four female parents, including two male sterile lines, exhibited heterotic effect for yield per vine, ratio of yield per vine to vine length, ratio of number of fruits per vine to vine length, weight per fruit, distance of the first ripe fruit from the vine base and vine length. The overall quality of the progeny of Edisto x Hara Madhu was highest.

Pashin (1974) evaluated the F_1 from a number of cross combinations and found that the following hybrids showed heterosis for yield: 12 (Posrednik 97 [Intermediary 97] x Raketa [Roket], 41 (Plodovityl 147 [Fertile 147] x Berlizovskii], 138 [Prolog 128] uspekh 221 [success 221] and 59 [Nezhin 12 x Krymsk 7]. They out yielded the recommended varieties by 20-25%.

When the varieties of wide genetic diversity were crossed in all possible combinations and compared with the resulting 90 hybrids, the number of fruit/plant increased to 9 maximum of 41.8%, fruit wt. increased to a maximum of 16% and sugar content (TSS) increased to a maximum of 21% over that of the better parent. In promising hybrids, yield increase of 87% over the yield of the better parent resulted from increases in fruit length, breadth and number, Sachan and Nath (1976). Heterosis for sugar content in various hybrid combinations have also been reported (Brar and Sidhu, 1977).

Zavadskaya (1976) presented data on the yield and earliness of F_1 hybrids compared with their parental forms. The high yielding heterotic hybrids studied were suitable for pickling and out yielded the recommended variety Dolzhik by 50-70% and the hybrid VIR 507 by 12-20%.

Pandey and Kalloo (1977) obtained a significant difference for mean value among parents and hybrids for all characters. Hybrids Mono-2 x Sharbati and Mono-2 x Arka Jeet were found to have the sweetest taste. A high degree of heterosis for yield was recorded in hybrid Mono-2 x Hara Madhu over that of the best parent.

Chadha and Nandpuri (1980) reported hybrid vigour on 10 important characters from 45 one way crosses made among ten varieties. The magnitude of heterosis was found to be high for most of the characters studied for the crosses-Hara Madhu x Lucknow, Hara Madhu x Early gold, Hara Madhu x Arka Jeet, Sarda x Arka Rajhans. Earligold x Home garden and Arka Rajhans x Halesbest.

Dixit and Kalloo (1983) observed the highest amount of heterosis over the better parent for number of fruits per plant (54.3%) in the cross combination Punjab Sunehri x Sel. 1. In respect of fruit yield, heterosis to an extent of 46-70% and 38.10% was noticed in the F_1 hybrids Pusa Sharbati x Sarda Melon and Pusa Sharbati x Punjab Sunehri, respectively. Heterotic hybrids (Arka Jeet x Durgapura Madhu and Arka Jeet x Sarda melon) for fruit quality (TSS content) were also identified. Data are tabulated on heterosis for 6 fruit character in pumpkin crosses among 9 inbred lines. The cross I.H.R.-6 x CM -12 showed heterosis for several characters, Doijode and Sulladmath (1984).

Prudek (1984) analysed data on the yields of the parental lines and F_1 populations from a 5 line diallel cross in cucumber and showed heterosis for both number and weight of fruits per plant was high in some F_1 populations and depended on over dominance.

Mishra and Seshadri (1985) reported that two genetically male sterile lines were crossed with 32 cultivars and studied for the 8 characters. The great heterosis over the better parent was observed for early yield (4337.2%). Hybrid heterotic for earliness of first harvest were also generally heterotic for early yield (up to 80 DAS). Heterosis for total yield was generally due to heterosis for number of fruits or for fruits wt. or both, although there were some hybrids which were heterotic for total yield alone.

Sidhu and Brar (1985) reported heterosis in a seven parent diallel set with 21 F_1 hybrids of watermelon the average weight of fruit and number of fruits/plant.

Swamy (1985) studied 20 yield and quality characters in 45 genotypes and a 10 parent diallel cross showed that Arka Jeet x UFG-515 showed the highest heterosis (111.4%) over the better parent. Heterosis over the mid parental value was significant (39.6%) for main stream x Arka Rajhans.

Jankiram and Sirohi (1989) reported that heterosis for 9 yield components was studied in $45F_1$ crosses of 10 parents of Lagenaria sicraria. The 3 best F_1 hybrids (S 46 x S 54, S 10 x S 52-7 and S 54 x S 52-7) showed 84.5, 80 and 80% heterosis, respectively for yield over best parental line, S 41. The high yields in these crosses were attributed to increase in fruits/plant, fruit weight and fruit size S 46 x S 54 gave a 148.77% higher yield than the commercial cultivar Pusa summer prolific round.

Lawande and Patil (1990) examined heterosis for fruit yield and other component characteristics of $55F_1$, hybrids in bitter gourd. Maximum and significant heterosis was observed for yield/vine (86.07%), fruit number (62.92%) and weight (20.79%). Five hybrids viz. Green long x Co-2 White long, Co. 1. Green x Green long and Co-1 Green x Delhi local were found promising for yield as they exhibited a high percentage of heterosis coupled with high *per se* performance.

Heterosis was observed for most of the characters studied in an evaluation of 6 parents and their 15 F_1 hybrids for 8 yield - related traits in muskmelon (Randhawa and Singh 1990).

Jankiram and Sirohi (1991) suggested heterosis breeding for improvement of fruit characters in bottle gourd.

Cui *et al.* (1992) reported that 14 traits, data are tabulated on heterosis over the mid parental value (MP) and over the better parent (HP) and performance relative to a standard (CP) in a partial diallel cross of cucumber (*Cucumis sativus*). F_1 progeny were earlier when there was parental traits, especially when MP and HP depended on the parental mean.

Kitroongriang *et al.* (1992) reported that seven local musk melon lines and five American cultivars were evaluated in a 7 x 5 design II cross during dry and rainy season in chiang mai, Thailand for vine length at the age of 8 weeks, days to first harvest, number of fruits per plant, fruit weight, fruit weight per plant, percent flesh, percent soluble solids content, rind firmness, shape index, net appearance and presence of vein tract. Variance among crosses and their parents were found to be highly significant for all traits. Correlations between the performance of parents and the average of their hybrids were found to be highly significant for all traits. Favourable heterosis over female parents was shown for all traits except days to first harvest.

2.2 COMBINING ABILITY

One of the most important practical problems encountered by plant breeders has been the appropriate choice of parents which nick well in hybridization and produce superior off-springs in the progeny. Studies conducted earlier led to the concept of general and specific combining ability of parental lines.

Use of diallel cross design in plant breeding to evaluate general combining ability (GCA) and specific combining ability (SCA) has been commonly used. Sprague and Tatum (1942) were the first to estimate components of variance for both GCA and SCA. They found that lines tested and selected for yield potential had marked variance due to SCA than GCA for grain yield, showing presence of dominance and epistatic effects. Rojas and Sprague (1952) analysed diallel crosses which were tested over number of locations and years. They reported that in superior crosses variance due to specific combining ability was consistently more than general combining ability.

Stephens and Quinby (1952) suggested that hybrids among two unrelated inbreds (or varieties) were likely to exhibit more vigour than their parents. However, very few lines producing such hybrids were economically valuable. Lines yielding superior hybrids were eventually more valuable in breeding. Hence line selection should be based on combining abilities than their *per se* performance for producing superior hybrids.

Griffing (1956a,b) elaborated the hypothesis of Sprague and Tatum (1942) and developed techniques for working out GCA and SCA effects along with their variances.

These were :

(i) Parents, one set of F_1's and their reciprocals

(ii) Parents and one set of F_1's without reciprocals

(iii) One set of F_1's and their reciprocals only.

(iv) One set of F_1's only.

He further pointed out that for the materials showing high degree of inbreeding depression, method I and II be used to determine combining ability to produce synthetic varieties. Hayman (1957) reported that in the abscence of epistasis, general combining ability consisted of both additive and dominance portions, while specific combining ability involved only dominance. However, in the presence of epistasis, both general and specific combining abilities contained epistatic portion. In general combining ability, a portion of the epistasis formed part of the average epistatic effects in the corresponding array of that parent, while in specific combining ability it was related more directly to its presence in a particular cross.

Bhattacharya *et al.* (1970) reported that the American male sterile lines MS_1 and MS_2 were crossed with the Japanese commercial varieties Earl's favourite and pearl. The various components of general combining ability were larger than those of specific combining ability for number of nodes, plant height, number of days to male flower initiation and fruit maturing. Earl's favourite showed the best combining ability with high additive effects for most characters. Pearl showed high specific combining ability effects for plant height, fruit weight, sugar content and fruit maturity in muskmelon.

Shelpov and Kul'chitskaya (1970) studied the combining ability of different varieties and lines. Variety x line crossed proved best, they gave higher yields of fruits and of dry matter than the parents and standard varieties.

Mikhov and Petkova (1971) reported that wisconsin 5MR 18, Picxie and model had the best general combining abilities among ten varieties of cucumber studied.

Gill *et al.* (1971) reported that in summer squash the varieties Australian Green, EC 27050, vegetable marrow, sel.1-PI08, Sel -9 PL-2 and Early yellow prolific were compared with their parents for early and total yield, number of fruits per plant and fruit length. General and specific combining abilities of parents and F_1's were estimated. Non-additive gene action was important for all treats. EC 27050 had the best GCA with respect to total yield, while sel - 1 PL-8 and vegetable marrow had the best GCA for number of fruits and fruit length, respectively.

Lippert and Hall (1972) reported that hybrids from a diallel cross and the ten parental varieties involved in the diallel were grown at three localities in southern

California. On the basis of their combining ability values, the varieties Campo, Hale's Best, PMR 45 and Schoon's Hard shell were selected for further breeding work.

Leppert and Legg (1972) found that ten muskmelon cultivars were evaluated for six characters. The general combining ability effect was significant for all trials when evaluated from single locality data, and was more important than the specific combining ability effect.

Nandpuri *et al.* (1974) studied several economic characters in 16 F_1 hybrid from crosses between four male parent and four female parents including two male - sterile lines muskmelon. General combining ability effects were more important for the male than for the female parents. The male parents Arka Rajhans and Hara Madhu and the male sterile lines were good combiners for the greatest number of economic characters. The F_1s of the crosses MS_2 x Arka Rajhans, Edisto x Hara Madhu and Edisto x Arka Rajhans gave high yielding progeny in subsequent generations.

Olivieri and Parrini (1974) reported that differences between the female parents and in the interaction progeny x female parent with in groups composed of progeny with the same female parent were significant for seven of the eight characters studied in chichory, the exception being number of leaves formed during branching. The effect of environment was apparent in the interaction progeny within groups x blocks for six characters, the exceptions being the two previously mentioned. Material effects were present for all characters with the exception of leaf pigmentation. General combining ability was usually high and specific combining ability was present for most characters. The additive dominance model was only satisfactory for leaf pigmentation, which had an average degree of domi.

Fursa and Sheneglov (1975) presented the results of a study of a number of F_1 hybrids in water melon. High combining ability for yield was shown by Sugar Baby and Mramornyi (Marble). Good results were obtained from Tsera 21 and Gribovsvkii tsel'notistryi (Gribovo entire leaved) as female parents.

Chekalina (1976) reported that in summer squash the combining ability (CA) of eight forms was tested in crosses with Gibrid 72 (Hybrid 72). All the forms showed low CA for fruit yield. The CA of individual plants within each form varied markedly. Thus Gibrid

72 x Volzhskaya seraya 92 (Volga Grey 12) had a fruit yield varying between 43% and 103% of that of Gibrid 72, depending on the biotype used.

Pandey and Kalloo (1977) reported that the two monoecious lines Mono-1 and Mono-2 were obtained from andromonoecious Hara Madhu using y rays and diethyl sulphate. Line x tester analysis of combining ability for yield and its components was performed with the two monoecious lines as female and six andromonoecious testers. A significant difference for mean value among parents and hybrids was recorded for all characters and analysis of variance for combining ability shoed a significant difference for all characters. Mono-2 and Arka Jeet were found to be the best female and male general combiners, respectively crosses involving both or atleast one of the good general combiners showed good specific combining ability as well as high heterosis. Mono-2 x Arka Jeet and Mono-1 x Arka Jeet are considered to be the best crosses for commercial use.

Data recorded on 18 characters in six parental varieties and their hybrids were analysed. In general, additive effects predominated over non additive. Within each year considered separately, variances in general combining ability (GCA) were constant and highly significant, while no significance was found for specific combining ability effects. Presijski 5, lednice and solartur showed the best GCA values (Prudek, 1977).Sirohi and Choudhary (1977) studied the combining ability in bitter gourd in a 8 x 8 diallel cross excluding reciprocals. Out of eight parents, P_1 (Pusa Do Mousami), P_7 (S-63) and P_5 (S-144) were observed to be the best combiners as they have made significant contribution in as many as eight out of ten characters studied. It was observed that when either one or two of the parental lines having high g.c.a. effect for yield and its component characters were involved in the crosses, the F_1 hybrids gave the best performance. In all the characters studied, the variance due to general combining ability was greater than that due to specific combining ability. It may be concluded that the characters showed appreciable additive gene action (i.e. high g.c.a. effects) can be fixed easily by careful selection. The additive genetic variance can also be utilized by producing synthetic varieties in bitter gourd.

Combining ability studies were made in 5 x 5 diallel cross (excluding reciprocals) in summer squash for length of vine, number of branches, number of fruits and yield per plant. Additive gene effect was responsible for length of vine, whereas non additive effects were prevalent for number of branches as well as number of fruits per plant. On the basis of gene action, heterosis breeding would be more useful than the pedigree method of selection. Vegetable Marrow x Early Yellow Prolific was found to be the best combiner followed by vegetable marrow x 51-1 P-8. Number of fruits per plant was found to be the major component of yield (Bhagchandani *et al.* 1980).

Chadha and Nandpuri (1980) reported that combining ability analysis of 10 quantitative characters was estimated from parents and F_1 data of a diallel set of 10 muskmelon cultivars. Variance due to both general and specific combining ability were highly significant for all the characters. Both GCA and SCA variance seemed to be important, however, GCA variance contributed major part of genetic variation for most of the traits. Additive genetic variance had a predominent role in expression of all the characters as g.c.a. variance was found much higher than s.c.a. variance. Varieties Earli Gold and Lucknow were excellent general combiner for earliness. Kabul was best combiner for average fruit weight, flesh thickness and Skin thickness while Arka Rajhans was superior for total yield. The variety Hara Madhu was the best general combiner for total soluble solids. The crosses involving either Arka Rajhans, Earli Gold or Hara Madhu were good specific combiners. The cross Hara Madhu x Arka Rajhans was found the best specific combiner for yield. The cross can be utilized both for developing high yielding lines by selection and for exploiting hybrid vigour.

Singh and Joshi (1980) studied the combining ability in a diallel set of 5 lines in bitter gourd and found "BWL1" to be a good general combiner for yield and its components.

Solanki and Seth (1983) in cucumber estimated combining ability in a 10 x 10 diallel set from parents, F_1, F_2 and reciprocals. Variances due to GCA and SCA were significant in all the traits except for plant height. The higher magnitude of GCA than SCA variance indicated that inheritance of these characters were predominantly governed by additive, additive x additive, and epistatic components of genetic variance. The strain Chaubattia Local, Solan Local, Balam-Khira, Hinreka and Bundelkhand local were found to be good general combiners.

Prudek (1984) reported that analysis of data on the parental lines and F_1 populations from a 5 line diallel cross showed that both GCA and SCA were of significance in determining both the number and the wt. of fruits/plant, but the GCA was the more important. SCA was of no importance with regards to earliness and mean single fruit weight. The line Ps-66, which displays male sterility determined by a single recessive gene, had high GCA value for all the above mentioned characters in melons.

Li and Shu (1985) analysed the data on Brix value, fruit weight, fruit number per plant, pericarp thickness and hardness in 15 hybrid from a diallel cross of 6 inbred lines, GCA effects were significant for all 5 characters. While SCA effects were significant only for centre brix and fruit weight.

Swamy (1985) studied 20 yield and quality characters in 45 genotypes and a 10 parent diallel cross showed that yield per plant was positively correlated with number of fruits, average fruit weight, number of nodes of the main stem, stem length, inter node length, number of primary branches and fruit shape index. The parent Arka Rajhans, Hara Madhu, and Arka Jeet were good general combiners for most characters.

Anek-Bangka (1986) reported that the top cross progenies from line 14-1-9 showed best combining ability for number of fruit, fruit weight per plot, first pistillate flower on the lowest node and fewest branches. The top cross progenies from the line 2-2-11 showed combining ability for fruit width and fruit firmness. The top cross progenies from line 4-4-3 showed best combining ability for early male and female flowering. The top cross progenies from line 1-11-3 showed best combining ability for fruit thickness. The top cross progenies from line 18-6-3 showed best combining ability for fruit length, fruit width and femaleness. The 6 top crosses and 11 lines from top cross S_1 progenies were evaluated in, the result showed that there was no significant difference between lines of the same cross and average mean of any cross for yield per plant, fruit weight and femaleness. The correlation coefficient between number of fruit and yield per plant and between fruit weight and yield per plant were highly significant.

Sirohi *et al.* (1986) studied combining ability in pumpkin in a 10 x 10 diallel cross excluding reciprocals. Nine important characters including total yield per plant were studied. The square for g.c.a. were larger than these for SCA in all characters except days to open first male flower. The estimated component of variance for s.c.a. were larger than those GCA in all the characters except in vine length. This indicated that the suppier performance of F_1 hybrids showing high SCA was largely due to epistatic interaction. The F_1 hybrid S-93 x CM -12 was the best combiner for total yield per plant and second best combiner for number of fruits per plant and fruit weight.

Sivakami *et al.* (1987) studied the combining ability for yield and its components in long fruited bottle gourd in a set of 10 x10 diallel cross excluding reciprocals. The mean squares of GCA as well as SCA were highly significant for all the nine characters, namely vine length, days to open first male flower, days to open first female flower, days to first harvest, fruit length. Fruit girth, number of fruits per plant, fruit weight and total yield/plant. This indicated the importance of both additive and non-additive variance for the expression of these traits. There is therefore scope for improvement both by selection and hybridization in this crop. The ratio of components of genetic variance indicated preponderance of additive gene action over non additiveness for these traits. Thus recurrent selection appears to be effective for the improvement of these characters.

Kalloo *et al.* (1990) studied combining ability in muskmelon and observed highly significant difference for GCA and SCA for all the traits except weight of fruit, width of cavity and length of vine for GCA and thickness of flesh and node of first hermaphrodite flower for SCA. Varieties Punjab Sunahari and Pusa Sharbati for thickness of flesh Durgapura Madhu for earliness exhibited high GCA. Crosses Pusa Sharbti x Sarda Melon, Arka Jeet x Pusa Sharbati and Pusa Sharbati x Punjab Sunahari for yield, Pusa Sharbati x Sharda Melon and Hara Madhu x Sarda Melon for thickness of flesh, Arka Jeet x Sarda Melon and S-445 x sel. 1 for TSS and Durgapura Madhu x Sarda Melon and Hara Madhu x Sarda Melon for earliness showed high GCA.

Lawande and Patil (1990) derived information on combining ability from data on 5 yield components in 55 F_1 hybrids form 11 (*Momordica charentia)* lines grown during 1985-86. C.O.-1 Green, Green Long, Hissar Selection, Delhi Local and C.O.2 White long were the best general combiners.

An evaluation of 6 parents and their 15 hybrids for 8 yield-related traits in 1984-85 indicated that the best general combiners were Durgapura Madhu for fruit yield, Punjab Sunehari for traits associated with earliness and WMR-29 for vine length (Randawa and Singh, 1990).

Chaudhari and Kale (1991) evaluated growth and yield attributes in parents and F_1 generation of an 11 diallel cross of pure inbred genetically diverse lines of bitter gourd. GCA and SCA effects were significant for 11 of the 13 characters studied. The best combiners were Coimbator Long and Hissar selection, their were indication of epistatic additive gene action.

Kitroongriang *et al.* (1992) reported that seven local muskmelon lines and five American cultivars were evaluated in a 7 x 5 design II cross during dry and rainy seasons in Chiang Mai, Thailand for vine length at the age of 8 weeks, days to first harvest, number of fruits per plant, fruits weight, fruit wt./plant, percent flesh, percent soluble solids content, rind firmness, shape index, net appearance and presence of vein tract. General combining ability of male parents (GCAM) and specific combining ability (SCA) accounted for a greater portion of the variability among crosses than general combining ability of female parents (GCAF) for all traits except shape index.

2.3. STABILITY PARAMETERS

The environmental conditions play an important role in the expression of characters of a genotype. However, all the genotypes don't get influenced equally by these conditions. Thus, the relative performance of the genotypes under various environments is known as genotype x environment interaction and "the ability of a genotype to produce narrow range of phenotype in different environments is termed as phenotypic stability". The magnitude of G x E interactions and stability parameters can be estimated by growing experimental material in a number of natural or artificially created environments.

The importance of genotype x environment interaction has now been well recognised by plant breeders obviously, the presence of G x E interaction creates difficulty, particularly when new and promising material is tested.

It is, therefore, necessary to look for phenotypically stable varieties. Two analytical approaches. viz. statistical (Yates and Cochran, 1938; Finlay and Wilkinson, 1963; Eberhart and Russell, 1966) and genetical (Bucio-Alanis, *et al.* 1966) are available by which results from experiment conducted in different environments can be interpreted in order to judge the stability of performance of a genotype.

The efforts to provide suitable measures of G x E interactions or stability of genotypes started after 1950's, when Levis (1955) suggested a simple measure of phenotypic stability or least stability factor (SF) calculated as.

$$S.F. = \frac{Mean\ performance\ in\ high\ yielding\ environment}{Mean\ performance\ in\ low\ yielding\ environment}$$

The maximum phenotypic stability or least interaction with environment was when sf = 1, greater deviation of SF from unity represents stability in the genotypes.

Finaly and Wilkinson (1963) considered linear regression slope as a measure of stability. The regression analysis of Finaly and Wilkinson was improved by Eberhart and Russell (1966) by adding another parameter of stability namely the deviation from regression (S^2di). According to them, the stable variety is one which posses a unit regression coefficient (bi = 1), least deviation from regression (S^2di = 0) along with high mean value (ui). The genotype with least standard error or deviation around the regression being the most stable and *vice-versa*.

Finlay and Wilkinson (1963) considered linear regression slopes as a measure of stability. The regression technique of Finlay and Wilkinson was improved by Eberhart and Russell (1966) by using another parameter of stability namely the deviation from regression. According to them the ideal variety is one which has a high mean value (u) unit regression coefficient (b = 1.0) and least deviation from regression (S^2d = 0).

The estimates of genotype x environment interactions amongst yield and other characters studied in twenty five varieties of tomatoes were worked out at the vegetable research form of the P.A.U. Ludhiana by Nandpuri *et al.* (1974). They obtained variety E.C. 55055 gave the maximum yield and was followed by early pear type with the performance consistent in both the season. The fruit size was maximum in E.C. 16462 and Punjab Tropic in autumn and spring, respectively. In general the yield was lower in autumn than in spring, irrespective of the varieties. EC 55055, early Par Type and S-12 were found to be promising for use in the future breeding programmes.

Peter and Rai (1976) reported that in a study of the elite germplasm of tomato, the yield components, days to fruit maturity, primary branches/pt. and infloresceence/pt. were observed to be phenotypically stable attributes. Their phenotypic expression, therefore would not fluctuate over a range of environment. The study indicated that HS-101, S-5 first, Momor and Marglobe varieties could be utilised for cultivation under high yielding environment, Pusa Early Dwarf, Roma and B-2247 could be good varieties for commercial cultivation under stress environments.

Stability parameters for sixteen varieties of peas for pod yield were worked out by Korla *et al.* (1978) raising them at three locations in H.P., Lincoln and G.C. 141 were the high yielders with below average stability (b>1.0), Kinnauri and G.C.-31 were comparatively low yielders with above average stability (b<1.0). The remaining varieties which neither showed any consistency over environments not gave good yield were considered poor in stability, hence GC-31 and Kinnauri proved good varieties for cultivation under different climatic conditions in H.P.

Sooch *et al.*, (1981) reported that the investigations on stability analysis of some characters in twenty chilli genotypes were carried out at four locations. The second order interactions were important for all the characters, while first order interactions in few cases. The linear component of G.E.I. was significant for almost all the characters. The high mean yields were given by S-118, S-114 and S-138, S-138 had relatively better adaptability. S-118, S-114 and Long Red 70-4-4 were specifically adopted to high yielding environments. While N.P.- 46A was consistently poor performer. The genotype S-14 for plant height and S-147 for plant spread showed wider adaptability and high stability. The genotypes S-114 and Shankot chillies were highly stable for fruit length while 70-2-1 for fruit diameter.

Singh *et al.* (1985) studied genotype x environment interaction for yield of twelve varieties of brinjal for three seasons. Highly significant differences among genotypes, environments and genotype x environment interaction were found. Year 80-81 was considered to be favourable for high yielding environment. Variety PBr 91-2 exhibited high mean value (510 q/ha) with high 'b' value (1.318) and S^2d value (2330.65). Azad Kranti was considered as next stable variety.

Bacusmo (1987) evaluated fourteen clones of sweet potato at 4 sites in north Carolina and south Carolina, with and without fertilizer application. Stability parameters were estimated using 4 methods. W-151 Resisto and W-192 were the most stable for number -1' root yields, and W-151 and W-192 were also stable for total root yields. There were significant G x E interactions for yield components when fertilized and unfertilized plots were compared. Rank correlation coefficient for yield in fertilized and unfertilized test were high, but rank correlation for stabilities were low. Broad sense heritabilities for yield were higher for fertilized than for unfertilized tests. It is suggested that selection for yield can be done with or without fertilizer application, but when stability is added as a selection criterion material should be screened in environmental resembling those where the released cultivars will be grown.

Sidhu *et al.* (1988) reported that when 15 genotypes of onion were grown in a randomized block design at Ludhiana during the autumn seasons of 1981-82 to 1984-85 and bulb yield calculated, the mean square due to G x E interaction and environments were significant. P1RG selection and selection 102-1 gave above average yields in all 4 years. Selection 102-1, Pusa Red and P-648 were considered to be stable genotype. Selection 102-1 was recommended for further improvement.

EL-Beheidi (1989) derived information on stability from data on 7 characters in 14 tomato varieties grown at zagazig, Egypt, in 1984-87 with 4N- fertilizer regimes. The most stable varieties are listed for each character.

Gill and Kumar (1989) reported that genotype x environment interaction plays a great role in the expression of various polygenic characteristics in water melon i.e. Days to first female flower, days to maturity, yield per plant, fruit weight and fruits per plant exhibited significant interactions. The linear type of interaction was obtained for yield per plant, fruit weight and fruits per plant, while non-linear type interaction was noticed for days to maturity and days to first female flowering. Genotypes 'Sugar Baby', Arka Jyoti, 'RSHC' and 'Special No. 1' had been identified with an average stability. It was further concluded that late maturing genotypes though high yielding, had low stability.

Vadivel and Bapu (1989) evaluated 10 promising accessions of brinjal during 1987-88 after bimonthly staggered sowing G x E interaction was significant and the accession Ep 65 and Annamalai were the most stable, giving high fruit yield over all environments. CO. 2 performed well in favourable environments and C.O. 1 and Ep 44 in less favourable ones.

Prasad and Singh (1990) derived information on stability from data on yield and 4 fruit characters in 23 genotypes of cucumber grown during 1987-88. Significant genotype x environment interactions were noted and stability differed significantly between genotypes. CH.20 was most adaptable and highest yielding.

Krishna Parsad and Singh (1991) evaluated the performance environment interaction of twelve genotype of pointed gourd from 1985-86 through 1987-88 for yield and its components. The genotypes exhibited significant difference in all the traits. The predictable and non-predictable components contributed for the stability of different genotypes. The genotypes CHES-12 and CHES-7 indicated their adaptability to the good environment and CHES-19 and CHES-2 may be specially good under less favourable environments.

Ghanti *et al.*, (1991) reported that in field experiments at Kalyani, India, 9 varieties of bhindi were sown on different dates (14 February, 14 April and 14 June) in RBD experiment with 3 replications. Total fruit yield was recorded after harvesting at 3 day interval from 45-52 days after sowing. Sowing date significantly influenced the yield (number of fruits, length and weight of fruits) per plant and per hectare. The highest yield was obtained when the crop was sown on 14 April (this growing period had the highest temp. and light intensity). Sel-2 was the highest yielder averaging 21.5 tonnes fruits per hectare but was unsuitable for February sowing. Variety Habro-1 produced the highest yield under the February sowing (11.9 tonnes/ha).

Ngeve (1991) conducted two experiments, each involving set of 6 *Ipomoea batatas* clones, the first set developed in sites differing in altitude, and the second in sites differing in soil type, at 3 locations over 4 years in Cameroon. Data obtained were subjected to analysis of variance to determine the presence of genotype x environment (G x E) interaction, and to joint regression analysis to measure the performance of clones across environments. The first experiment (E_1) produced higher yields and contained more stable clones than the second (E_2). In both experiments, mean yields were almost twice as high in 1984 (21.1 t/ha) as in each of the other years (11.0 t/ha), and highest at Nyombe (18.0 t/ha). In E_1 the G x E interaction mainly concerned interaction with location, where as in E_2 it concerned interaction with years. Clones 1611 (E_1) and 048 (E_2) yielded above average and gave linear regressions. Significantly above unity for most traits, indicating specific adaptation to high yielding environments and hence below average stability clones 1112, 1639 and TIb-1 (E_1) yielded above average and had regression slopes equal to unit, indicating average stability and thus general adaptability. Clones TIb-2 (E_1) and 1487 (e_2) produced below average yields, indicating specific adaptation to low yielding environments. As preferred clones should have stable marketable yields, only clones 1112, TIb-1 and 1639 were considered suitable for release to growers.

Materials and Methods

The present investigation entitled "combining ability and stability studies in bitter gourd (*Momordica charantia* Linn.)" was conducted during kharif season, 1993 at Horticultural Farm, Rajasthan College of Agriculture, Udaipur. Situated at an elevation of 579.50 metres above mean sea level on latitude of 24°-35′N and longitude of 72°-19′E. The meteorological observations comprising week wise data on maximum and minimum temperatures, relative humidity and rainfall during the crop duration (July 1993 to October 1993) are presented in Appendix I and also represented graphically in figure I. The physico-chemical characteristics of the soil is presented in Table 1.

MATERIALS

Experimental material consisted of ten promising genotypes of bitter gourd selected on the basis of their diverse geographical origin and wide variation in morphological characters. Name, origin and characters are given in table-2. These ten varieties/strains were crossed in all possible combinations (excluding reciprocals) during summer, 1993 to produce F_1 seeds by hand pollination. Hence the experimental material consisted of ten parents, their forty five F_1's and one standard check for economic heterosis.

EXPERIMENTAL DESIGN AND CROP HUSBANDRY

The experimental material comprising of ten parents, fortyfive F_1's and one standard check for economic heterosis was sown under four environments created by various fertilizer application as per given below, in randomized block design with three replications. All the treatments were grown in 6 M long single row plots, maintaining row to row and plant to plant distance of 150 cm and 60 cm, respectively. The uniform recommended agronomic practices were adopted during course of investigation. Full dose of FYM, P_2O_5 and half dose of N applied as basel dose before sowing, rest N applied as top dressing after one month of sowing according to environment. The details of four environments are given below:

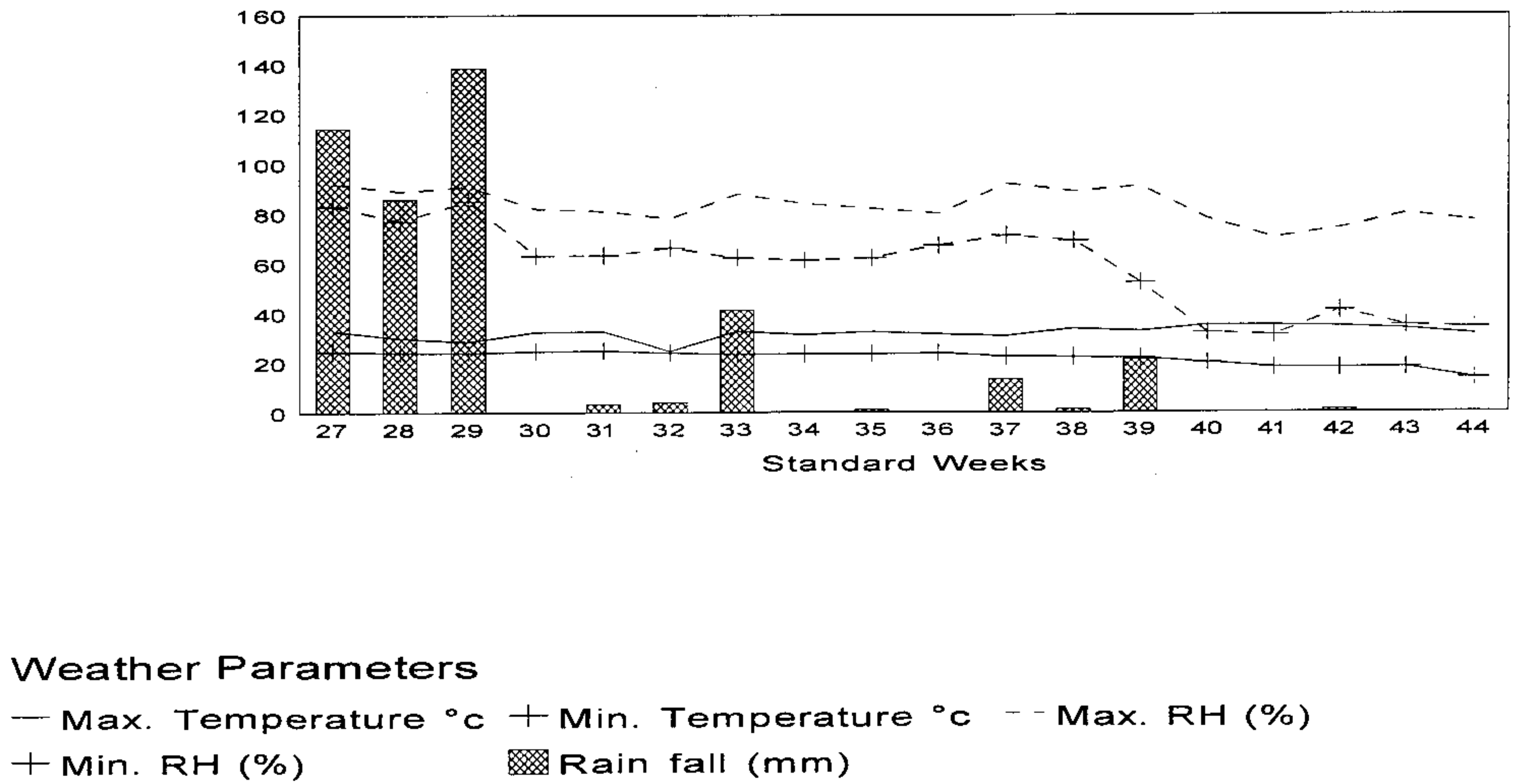
Table 1. Physico-chemical characteristics of the soil of experimental sites at Horticulture Farm, RCA, Udaipur

	Soil characteristics	Content
A.	**Mechanical**	
1.	Course sand (%)	10.45
2.	Fine sand (%)	27.16
3.	Silt (%)	26.68
4.	Clay (%)	27.13
5.	Textural class	Clay loam
B	**Physical**	
1.	Bulk density (g/cc)	1.45
2.	Particle density (g/cc)	2.68
3.	Porosity (%)	21.18
4.	Field capacity (%)	26.36
5.	Permanent wilting point (%)	11.45
C.	**Chemical**	
1.	Organic carbon (%)	1.08
2.	Total nitrogen (%)	0.13
3.	Available P (kg/ha)	101
4.	Available K (kg/ha)	562
5.	pH	8.6
6.	EC m mhos/cm	0.37

ble 2. Names, origin and characteristics of the ten parental lines

No.	Code no.	Name	Origin/source	Characteristics							
				Days to the appearance of first flower	Node number at which first female flower appear	Length of main shoot (cm)	No. of female flower per plant	No. of fruits per vine	Length of fruit (cm)	Weight of fruit (gm)	Colour of fruit
.	P_1	Udaipur local	Dept. of Horti. R.C.A. Udaipur	35.62	11.85	344.74	19.22	15.83	11.37	38.04	Dark Green
.	P_2	NBPGR/TCR-72	NBPGR Regional Station TRICHUR	43.93	25.86	412.05	18.62	15.34	10.74	49.93	Whitish Green
.	P_3	Pusa vishesh	I.A.R.I. New Delhi	34.73	7.13	296.05	24.28	21.03	11.25	42.92	Glossy Green
.	P_4	Coimbatore-long	N.S.C. (selection) Coimbatore	41.32	12.19	480.81	30.56	26.48	16.56	74.83	White
.	P_5	NBPGR/TCR-36	NBPGR/Regional Station Trichar	40.38	21.32	357.05	19.37	16.26	11.35	28.05	Green
.	P_6	B.G.-14	M.P.A.U. Rahuri	40.71	13.70	436.94	33.71	29.44	8.14	21.00	Green
.	P_7	C.0-1	T.N.A.U. Coimbatore	31.79	11.34	327.83	23.69	19.80	10.04	35.25	Green
.	P_8	M.C.-84	Dept. of Horti. R.C.A. Udaipur	39.26	15.17	419.52	22.12	18.97	8.71	29.27	White
.	P_9	Jounpuri long	Jounpur (U.P.)	42.65	14.59	289.66	16.99	14.38	9.39	50.58	Dark Green
10.	P_{10}	Pusa Do Mausami	I.A.R.I. New Delhi	42.19	10.93	308.99	26.46	23.09	9.70	37.63	Dark Green

Fig. 1: MEAN WEEKLY WEATHER PARAMETERS DURING *Kharif*, 1993



Environments	Fertilizer application
E_1	No fertilizer application
E_2	30 tonnes FYM/ha
E_3	30 tonnes FYM, 30 kg nitrogen and 25 kg phosphorus/ha
E_4	30 tonnes FYM, 60 kg nitrogen and 50 kg phosphorus/ha.

TRAITS UNDER INVESTIGATION

The observations were recorded on five randomly selected plants per treatment per replication in each environment, after avoiding end plants to avoid border effects. Detailed procedure adopted to record observation in each character is given below:

(1) Days Taken to the Appearance of First Female Flower

Days taken from sowing to the opening of first female flower in 50 per cent of the plants were recorded for each treatment.

(2) Node Number at Which First Female Flower Appear

Total number of nodes from the base of the plant to node at which first female flower appear were recorded as node number .

(3) Length of Main Shoot (cm)

Length of main shoot was measured in centimeters from the base of the vine to tip of main shoot at the time of maturity.

(4) Number of Lateral Branches Per Plant

Total lateral branches of selected plants were counted and recorded.

(5) Number of Male Flower Per Plant

Total number of male flower recorded alternate day.

(6) Number of Female Flower Per Plant

Total number of female flower recorded alternate day.

(7) Percentage Fruit Set

Percentage fruit set was calculated by using number of female flower per plant and number of fruit per plant.

(8) Number of Fruits Per Vine

Total number of fruits per vine were counted during picking and recorded.

(9) Length of Fruit (cm)

Five fruits were randomly picked up from the marketable harvest of each selected plant in each entry and fruit length was measured in centimeters from the base of calyx to the tip of the fruit and average was completed.

(10) Girth of Fruit (cm)

Same fruits as taken for measuring the fruit length were taken for fruit girth. The girth of the fruit was measured in centimeters at its central point.

(11) Weight of Fruit (g)

Fruit weight was recorded by dividing weight of marketable fruit in grams with total number of fruits of each picking for each selected plant and average was computed.

(12) Fruit Yield Per Vine (g)

Yield per vine was derived by adding the weight (g) of all the marketable fruits harvested at each picking of every selected plant and averaging it.

(13) Number of Seeds Per Fruit

Five fruits were randomly picked up from each selected plant in each entry and the seeds from each fruits were counted and averaged.

STATISTICAL ANALYSIS

Data on different characters studied for four environments were separately computed for following statistical parameters:

(1) Analysis of variance for experimental design.

(2) Estimation of heterobeltiosis and economic heterosis.

(3) Estimation of combining ability (GCA and SCA both)

(4) Estimation of stability parameters.

(1) Analysis of Variance for Experimental Design

The data obtained for each character in F_1 generation and parents were analysed separately for each environment as well as pooled over environments (Panse - and Sukhatme, 1985). The skeleton ANOVA is presented in Table 3 and 4.

(2) Estimation of Heterobeltiosis and Economic Heterosis

Heterobeltiosis expressed as percent deviation over better parent towards desirable side, whereas economic heterosis is expressed as per cent deviation from standard check.

The formulae used for their estimation are as under :

(i) Heterobeltiosis (%) (Fonseca and Patterson, 1968) $[\bar{F}_1 - \overline{BP}] \times 100/\overline{BP}$ its significance was tested by students 't' test :

"t" $[(b-1)(t-1)] = [\bar{F}_1 - \overline{BP}] / [SE(\bar{F}_1 - \overline{BP})]$

$$SE(\bar{F}_1 - \bar{BP}) = \sqrt{(2\ MSE/b)}$$

Where,

$\overline{BP}$ = Mean of better parent

(ii) Economic heterosis (%) = $[\bar{F}_1 - \overline{CV}] \times 100/\overline{CV}$ the formulae used for calculation of 't^*' was as under

$t^* [(b-1)(t-1)] = [\bar{F}_1 - \overline{CV}] / [SE(\bar{F}_1 - \overline{CV}]$

Where,

$\overline{CV}$ = Mean of the standard check variety used in the experiment towards desirable direction.

$$SE(\bar{F}_1 - \bar{CV}) = \sqrt{[2\ MSE/b]}$$

Negative direction was considered desirable for characters like days taken to the appearance of first female flower, node number at which first female flower appear, number of male flower per plant and number of seeds per fruit. Whereas for all other characters positive direction was considered desirable.

Table 3. Analysis of variance for individual environments

Source	d.f.	S.S.	MSS	Expectation of mean square
Replication	(r-1)	S_b	Mb	Ve + gvb
Treatments	(g-1)	S_g	Mg	Ve + bvg
Error	(r-1) (g-1)	S_e	Me	Ve

Table 4. Analysis of variance over the environments

Source	d.f.	SS	MS	Expected MS
Environments	l-1	$\frac{1}{gr}\sum_{k=1}^{l}\left\{\sum_{i=1}^{g}\sum_{m=1}^{r}(X_{imk})\right\}^2 - C.F.$	M_1	$\sigma^2e + r\sigma gl^2 + rg\sigma^2l$
Replication with in environments	P(r-1)	$\sum_{k=1}^{l}\left[\frac{1}{g}\sum_{m=1}^{r}\left(\sum_{i=1}^{g} X_{imk}\right)^2 - \left\{\left(\sum_{i=1}^{g}\sum_{m=1}^{r} X_{imk}\right)^2 / gr\right\}\right]$		
Genotypes	g-1	$\frac{1}{lr}\sum_{i=1}^{g}\left\{\sum_{k=1}^{l}\sum_{m=1}^{r} X_{imk}\right\}^2 - C.F.$	M_2	$\sigma^2e + r\sigma^2gl + rl\sigma^2g$
Genotypes x Environments	(g-1) (l-1)	$\left[\sum_{i=1}^{g}\sum_{k=1}^{l}\left\{\sum_{m=1}^{r} X_{imk}\right\}^2 / r\right] - CF - SS\ Environments - SS\ Genotypes$	M_3	$\sigma^2e + r\sigma^2gl$
Error	l(g-1) (r-1)	Pooled over environments	M_4	σ^2e

Where, r, l and g were number of replication, environments and genotypes respectively.

(3) Diallel Analysis

(i) Combining ability analysis

The combining ability analysis was computed for four environments according to method-2 (Parents and one set of F_1's with out reciprocals) model I (fixed effect) of Griffing (1956, a). In this model, experimental material was regarded as population about which inference was to be drown and combining ability effects of parents could be compared. When parents themselves are used as tester to identify good combiner. In model-I, it was assumed that variety and block effects were constant but error (environment and other uncontrollable components) was variable and normally and independently distributed with mean zero and variance $\sigma^2 e$. The following was the statistical model for combining ability.

$$X_{ij} = \mu + g_i + g_j + S_{ij} + \frac{1}{b} \sum_k e_{ijk}$$

Where,

μ	=	Population means
g_i	=	General combining ability (gca) effect of i^{th} parents.
g_j	=	General combining ability effect of j^{th} parent,
S_{ij}	=	Specific combining ability (sca) of ij^{th} cross.
e_{ijk}	=	Environmental component pertaining to ijk^{th} observation, and
b	=	Number of replications.

The restrictions imposed to this model are :

$$\sum_i g_i = 0 \textit{ and } \sum_j S_{ij} + S_{ii} = 0 \textit{ (for each i)}$$

$$\sum_j g_j = 0 \textit{ ,are imposed}$$

Sum of squares for gca and sca were calculated as shown below:

$$S_g = \frac{1}{P+2} \left[\sum_i (x_i + x_{ii})^2 - \frac{4}{P} x^2 .. \right]$$

Sum of squares for specific combining (S_s) ability was calculated as :

$$S_s = \sum_i \sum_j x_{ij}^2 - \frac{1}{P+1} \sum_i (x_i + x_{ii}) + \frac{2}{(P+1)\ (P+2)}$$

Where,

P	=	Number of parents,
S_g	=	Sum of squares due to gca,
S_s	=	Sum of squares due to sca,
x_{ij}	=	Value of the cross between i^{th} and j^{th} parent,
x_i	=	Total of i^{ij} (row) array in diallel table (summed over j)
x..	=	Grand total of 'P' parents/lines and P(P-1)/2 progenies of diallel table, and
x_{ii}	=	Parental value of the i^{th} parent.

Table 5. The analysis of variance for combining ability for individual environment

Source of variation	d.f.	S.S.	M.S.	Expected M.S.
GCA	P-1	S_g	M_g	$\sigma_e^2 + \sigma_s^2 + (P+2)\frac{1}{(P-1)} \Sigma g_i^2$
SCA	$\frac{P(P-1)}{2}$	S_s	M_s	$\sigma_e^2 + \frac{2}{P(P-1)} \sum_{i \le} \sum_j S_{ij}^2$
Error	(r-1) (P-1)	S_e	M_e	σ_e^2

The mean squares of gca and sca were calculated by dividing respective sum of squares with the corresponding degree of freedom. Error mean square for combining ability analysis was obtained as under:

Where,

M_e	=	Error mean square in the analysis of the experimental design (R.B.D.), and
b	=	Number of replications.

We was used for calculation of variance ratio (F) as a test of gca and sca mean squares. In F_2 also M_e was used to calculate variance ratio (F).

Combining Ability Effects :

General and specific combining ability effects were calculated as follows:

General combining ability (GCA) effects of i^{th} parent,

$$g_i = \frac{1}{P+2} (x_i + x_{ii} - \frac{2}{P} x..)$$

Specific combining ability (SCA) effects of ij^{th} cross,

$$S_{ij} = x_{ij} - \frac{1}{P+2} (x_i + x_{ii} + x_j + x_{jj}) + \frac{2}{(P+1)(P+2)} x..$$

Where,

g_i	=	Estimation of GCA effect of i^{th} parent, and
S_{ij}	=	Estimation of SCA effect of ij^{th} cross.

Other notations were the same as explained earlier.

Estimation of variance of these effects and differences as under :

(i) g_i = (P-1) M′e/P(P+2) to test individual gca effect.

(ii) Variance S_{ij} = P + 2 x M′e/(P+1) (P+2) to test individual SCA effect.

(iii) Variance g_i-g_j = 2M′e/(P+2) to test the difference between two GCA effects.

(iv) Variance S_{ij}-S_{ik} = 2(P+1) M′e/ (P+2) to test the difference between SCA of the same array or column.

(v) Variance S_{ij}-S_{ki} = 2P x M′e/(P+2) to test the difference between SCA estimates of any two cross.

Standard error was calculated by taking the square root of the variance. Each GCA and SCA estimate was subjected to 't' test to determine the difference.

't' test for GCA and 't' test for SCA

$$t = \frac{g_i - 0}{SE\ (g_i)}$$

$$t = \frac{S_{ij} - 0}{SE\ (S_{ij})}$$

The 't' value thus obtained was tested against the table 't' value at 5% and 1% probability levels at error degree of freedom.

For testing significance of difference between two effects, the critical difference was calculated by multiplying the respective standard error of difference 't' value at error degree of freedom.

II. Combining Ability Analysis Over Environment :

Pooled analysis over two locations was done according to the method suggested by Singh (1973a, b and 1979). Mathematical model for the said analysis is given below:

$$X_{ijk} = \mu + g_i + S_{ij} + I_k + (gl)_{ik} + (gl)_{jk}\ (sl)_{ijk} + \frac{1}{be} \sum_{m} \sum_{r} e_{ijkmr}$$

Where,

X_{ijk}	=	An observation on the phenotype of a cross of i^{th} and j^{th} parent in k^{th} environment.
μ	=	Population mean
g_i	=	General combining ability effect of i^{th} parent.
g_j	=	General combining effect of j^{th} parent.
S_{ij}	=	Specific combining ability effect for the cross between i^{th} and j^{th} parents such that $S_{ij} = S_{ji}$
I_k	=	The effect of k^{th} environment.
$(gl)_{ik}$	=	The interaction corresponding to g_i and l_k
$(sl)_{ijk}$	=	The interaction corresponding to S_{ij} and l_k
e_{ijkmr}	=	Environmental effect peculiar to the individual.

The analysis of variance used for combining ability with expectations of mean squares for Model I and Method II was as follows (Table -6):

Table 6. Analysis of variance for combining ability over the environments

Source of variation	d.f.	S.S.	M.S.	Expected M.S.
GCA	P-1	$SS_{(g)}$	A_g	$\sigma^2 + \frac{(P+2)\ lr^2}{(P-1)} \sum_i g_i^2$
SCA	$\frac{P\ (P-1)}{2}$	$SS_{(s)}$	A_s	$\sigma^2 + \frac{2lr^2}{P\ (P-1)} \sum_{i \le} \sum_j S_{ij}^2$
Locations	l-1	$SS_{(l)}$	A_l	$\sigma^2 + \frac{P\ (P+1)\ r^2}{2\ (l-1)} \sum_k l_k^2$
GCA x Location	(P-1) (l-1)	$SS_{(gl)}$	A_{gl}	$\sigma^2 + \frac{(P+2)\ r^2}{(P-1)\ (l-1)} \sum_k \sum_i (gl)^2_{ik}$
SCA x Location	$\frac{P\ (P-1)\ (l-1)}{2}$	$SS_{(sl)}$	A_{sl}	$\sigma^2 + \frac{2r^2}{P(P-1)\ (l-1)} \sum_k \sum_{i \le} \sum_j (Sl)^2_{ijk}$
Error	P(r-1) (g-1)	m	A_e	σ^2

Where,

σ^2 = MS pooled error

P = Number of parents

l = Number of locations

g = Number of genotypes

r = Number of replications.

The sum of squares :

$$SS_{(\mu)} = 2 \left[\sum_{i=1}^{p} \sum_{j>i}^{p} \sum_{k=1}^{l} \sum_{m=1}^{r} X_{ijkm} \right]^2 / P\ (P+1)\ lr$$

$$SS_{(g)} = \frac{\sum_{i=1}^{p} \left(\sum_{j>1}^{p} \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} + \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} \right)^2}{(P+2)lr} - \frac{4 \left(\sum_{i=1}^{p} \sum_{j>i}^{p} \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} \right)^2}{P(P+2)\ lr}$$

$$SS_{(f)} = \frac{\sum_{i=1}^{p} \sum_{j>i}^{p} \left(\sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} \right)^2}{lr} - \frac{\sum_{i=1}^{p} \left(\sum_{j>1}^{p} \sum_{k=1}^{l} \sum_{m=1}^{r} X_{ijkm} + \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} \right)^2}{(P+2)lr}$$

$$+ \frac{2 \left(\sum_{i=1}^{p} \sum_{j>i}^{p} \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} \right)^2}{P(P+1)\ (P+2)\ lr}$$

$$SS_{(l)} = \frac{2 \sum_{k=1}^{l} \left(\sum_{i=1}^{p} \sum_{j>i}^{p} \sum_{m=1}^{r} x_{ijkm} \right)^2}{P\ (P+1)r} - \frac{2 \left(\sum_{i=1}^{p} \sum_{j>i}^{p} \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} \right)^2}{P(P+1)\ lr}$$

$$SS_{(gl)} = \frac{\sum_{k=1}^{l} \sum_{i=1}^{P} \left(\sum_{j>1}^{P} \sum_{m=1}^{r} x_{ijkm} + \sum_{M=1}^{r} x_{ijkm} \right)^2}{(P+2)r} - \frac{4 \sum_{K=1}^{l} \left(\sum_{i=1}^{p} \sum_{j>i}^{p} \sum_{m=1}^{r} x_{ijkm} \right)^2}{P(P+2)\ r}$$

$$- \frac{\sum_{i=1}^{p} \left(\sum_{jl}^{P} \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} + \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} \right)^2}{(P+2)lr} + \frac{4 \left(\sum_{i=1}^{p} \sum_{j>i}^{p} \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} \right)^2}{P(P+2)\ lr}$$

$$SS(sl) = \sum_{i=1}^{p} \sum_{j>i}^{p} \sum_{k=1}^{l} \left(\sum_{m=1}^{r} x_{ijkm} \right)^2 - \frac{\sum_{k=1}^{l} \sum_{i=1}^{P} \left(\sum_{j>1}^{P} \sum_{m=1}^{r} x_{ijkm} + \sum_{m=1}^{r} x_{iikm} \right)^2}{(P+2)r}$$

$$+ \frac{2 \sum_{k=1}^{l} \left(\sum_{i=1}^{P} \sum_{j>i}^{P} \sum_{m=1}^{r} x_{ijkm} \right)^2}{(P+1)\ (P+2)r} - \frac{\sum_{i=1}^{p} \sum_{j>i}^{p} \left(\sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} \right)^2}{lr}$$

$$+ \frac{\sum_{i=1}^{P} \left(\sum_{j>1}^{P} \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} + \sum_{k=1}^{l} \sum_{m=1}^{r} x_{iikm} \right)^2}{(P+2)lr} - \frac{2 \left(\sum_{i=1}^{P} \sum_{j>i}^{P} \sum_{k=1}^{l} \sum_{m=1}^{r} x_{ijkm} \right)^2}{(P+1)\ (P+2)lr}$$

$A_e = M_4$ Where = Error mean sum of square from ANOVA of experimental design (Table 4)

Estimation of g.c.a. and s.c.a. effects :

General combining ability and specific combining ability effects were determined as follows:

$$Population\ mean\ (\hat{\mu}) = \frac{2\sum_{i=1}^{P}\sum_{J>1}^{P}\sum_{k=1}^{l}\sum_{m=1}^{r} x_{ijkm}}{P(P+2)lr}$$

$$g.c.a.\ effect\ of\ the\ i^{th}\ parent\ (\hat{g}_i) =$$

$$\frac{\left(\sum_{J>1}^{P}\sum_{k=1}^{l}\sum_{m=1}^{r} x_{iJkm} + \sum_{k=1}^{l}\sum_{m=1}^{r} x_{iikm}\right)}{(P+2)lr}$$

$$- \frac{2\left(\sum_{i=1}^{P}\sum_{J>i}^{P}\sum_{k=1}^{l}\sum_{m=1}^{r} x_{iJkm}\right)}{Pr}$$

$$S.c.a.\ effect\ of\ the\ iJ^{th}\ cross\ (\hat{S}_{ij}) = \frac{\sum_{k=1}^{l}\sum_{m=1}^{r} x_{ijkm}}{lr}$$

$$- \frac{\sum_{J>1}^{P}\sum_{k=1}^{l}\sum_{m=1}^{r} x_{ijkm} + \sum_{k=1}^{l}\sum_{m=1}^{r} x_{iikm} + \sum_{i=1}^{P}\sum_{k=1}^{l}\sum_{m=1}^{r} x_{ijkm} + \sum_{k=1}^{l}\sum_{m=1}^{r} x_{jkm}}{(P+2)\ lr}$$

$$+ \frac{2\left(\sum_{i=1}^{P}\sum_{J>1}^{P}\sum_{k=1}^{l}\sum_{m=1}^{r} x_{iJkm}\right)}{(P+1)\ (P+2)lr}$$

Variance of effects were estimated as follows :

$$Var \quad \hat{g}_i = \frac{P - 1}{P(P+2)l}\sigma^2$$

$$Var \ \hat{S}_{ij} = \frac{P^2 + P + 2}{(P+1)\ (P+2)l}\sigma^2$$

Stability Analysis

Phenotypic stability of a genotype for the different yield and morphophysiological traits was estimated by two different approaches, (i) conventional pooled analysis of variance as given in table 3.3 of analysis of means and (ii) regression analysis according to Eberhart and Russel (1966). Consistent high performance together with (i) the regression of each variety in an experiment on an environmental index and (ii) a function of the squared deviation from this regression provided the estimates of the desired stability parameters. These parameters are defined in a linear model as follows:

$Y_{ij} = \mu_i + B_i I_j + \sigma_{ij}$

Where,

Y_{ij}	=	Variety mean of the i^{th} variety at the j^{th} environment, (i = 1,2,........v, i = 1,2.................n)
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
σ_{ij}	=	Deviation from regression of the i^{th} variety at this j^{th} environment and
I_j	=	Environmental index of the mean of all varieties at the j^{th} environment minus the grand mean;

$$I_j = (\sum_1 Y_{ij} / v) - (\sum_i \sum_j Y_{ij} / vn). \sum_j I_j = 0$$

The first stability parameter is a regression coefficient estimated in the usual maner, as:

$$b_i = \sum_j Y_{ij} I_j / \sum_j I_j^2$$

The performance of each variety was predicted by using the estimates of the parameters where

$Y_{ij} = X_i + b_i I_j$,

Where,

X_i is an estimate of the μ_i.

The deviation mean square (S^2d_i) as proposed by Eberhart and Russel (1966) can be estimated as below :

$$S^2d_i = \left[\sum_j \sigma_{ij}^2 / (n-2) - S_e^2 / r\right]$$

Where,

S^2_e/r is the estimate of the pooled error and

$$\sum_j \sigma_{ij}^2 = \left[(\sum_j Y_{ij}^2 - Y_i^2 . / n)\right] - \left[(\sum_j Y_{ij} I_j^2 / \sum_j i_j^2)\right]$$

The pooled error mean square can be calculated as below:

Pooled error m.s. $=1/sr\ (\sigma_i^2 + \sigma_2^2 + \ldots\ldots\ldots\ldots\ldots\ldots + \sigma_j^2)$

Where,

σ_j^2 is the error variance corresponding to the j^{th} environment, and r is the number of replication within each environment.

The model for analysis of variance partioning of sums of squares due to environment and variety x environments into environments (linear), varieties x environments (linear) and deviations from the regression, is given in table 7.

A stable variety is one which has $b_i = 1$ and $S^2d_i = o$. The significance of differences among varietal means is tested by F test ($F = MS_1/MS_3$) with homogeneous deviation mean squares since MS is the pooled deviation. Genetic differences among varieties for their regression on environmental index are also tested by F test ($=MS_2/MS_3$). The test of deviations from regression for each variety is obtained as $F=\Sigma/j\ \sigma_{ij}^2/(1-2)$/pooled error.

Table 7. Pooled analysis of variance for estimating the stability parameters

Source	d.f.	S.S.	M.S.
Total	ng-1	$\sum_i \sum_j y_{ij}^2 - C.F.$	
Genotypes (G)	g-1	$\frac{1}{n} \sum_i y_i^2 - C.F.$	MS_1
Environment (Env.)	n-1	$\frac{1}{g} \sum_j y_j^2 - C.F.$	
G x Env.	(g-1) (n-1)	$\sum_i \sum_j Y_{ij}^2 - Y_i^2 / n - \sum Y_j^2 / g + C.F.$	MS_2
Env. (Linear)	1	$\frac{1}{g} (\sum_j Y_j I_j)^2 / \sum_j I_j^2$	
G x Env. (Linear)	g-1	$\sum_i \left[(\sum_j Y_{ij} I_j)^2 / (\sum_j I_j^2)\right] - Env.(linear\ S.S.)^{MS}$	MS_3
Pooled derivation	g (n-2)	$\sum_i \sum_j \sigma_{ij}^2$	MS_4
Variety -i (v_i)	(n-2)	$\left[\sum_j Y_{ij}^2 - \frac{(Y_{i.})^2}{n}\right] - \left[(\sum_j Y_{ij.} I_j)^2 / \sum_j I_j^2\right] = \sum_j \sigma_{ij}^2$	
Pooled error (P-1) (g-1)	n (p-1) (g-1)	$\sigma^2 e$	

The regression coefficient (b_i) for each variety was tested by 't' test as stated below:

$$t = \frac{1 - b_i}{S.E.(b_1)}$$

Where,

$$S.E.(B_1) = \sqrt{\frac{M.S. due\ to\ deviation\ of\ i^{th}\ genotype}{\sum_j I_j^2}}$$

Experimental Results and Discussion

The present piece of work was undertaken to study "combining ability and stability studies in bitter gourd (*Momordica charantia* Linn.)" comprising of ten parents and their crosses in dialled set (excluding reciprocals) grown in four environments created by various levels of fertilizer application at Horticultural farm, Rajasthan College of Agriculture, Udaipur. The results obtained from the investigation are presented under the following headings:-

1. Analysis of Variance for experimental design.
2. Heterobeltiosis and economic heterosis
3. Combining ability analysis
4. Stability parameters.

4.1 ANALYSIS OF VARIANCE FOR EXPERIMENTAL DESIGN: (Table 8 and 9)

Highly significant mean sum of squares due to genotype in individual as well as over the environment except percentage fruit set in E_4 revealed the existence of adequate genetic variability in the experimental material. The mean sum of squares due to environment was significant for all the characters except percentage fruit set, suggested that the environments considerably differed from one another. The influence of environmental fluctuations on the genotypes were observed for all the traits, Since the mean sum of squares due to genotype X environment was significant for all the attributes, which indicated phenotypic instability of the genotypes.

4.2 HETEROBELTIOSIS AND ECONOMIC HETEROSIS

The exploitation of heterosis in vegetable crops is one of the major break through in the field of plant breeding. Heterosis now being utilized commercially in the array of commercially important vegetables (including cucurbits) and cross pollinated vegetables and to a limited extend in self pollinated vegetables.

The concept of heterosis given by Shull (1914) was for the superiority of hybrids over better parent, but to test the potential of genotype, the superiority over best available check might be fruitful. According to modern concept, heterosis is the

Table 8. Analysis of variance for individual environment showing mean square for 13 characters in Bitter gourd

Source	Environment	d.f.	Days taken to the appearance of first female flower	Node no. at which first female flower appear	Length of main shoot (cm)	No. of lateral branches per plant	No of male flower per plant	No. of female flower per plant	Percentage fruit set	No. of fruits per vine	Length of fruit (cm)	Girth of fruit (cm)	Weight of fruit (g)	Fruit yield per vine (g)	No. of seed per fruit
Replication	E_1	2	00.72	00.18	80.63	00.09	57.00	00.41	00.26	00.73	01.85	00.04	10.00	16.00	00.70
	E_2	2	01.68	00.03	47.49	00.02	15.00	00.73	00.04	00.38	00.57	01.04	00.51	88.00	00.06
	E_3	2	11.93*	25.52	18.00	00.45	26.00	00.07	00.04	09.11	00.26	00.05	00.62	33.00	00.06
	E_4	2	20.83*	00.11	48.36	10.58	15.00	00.70	37.09	00.02	00.04	00.01	00.55	54.00	00.79
Treatments	E_1	55	37.54**	27.92**	14.00**	58.44**	15.00**	33.00**	23.58**	26.00**	17.62**	15.89**	16.00**	12.00**	24.00**
	E_2	55	37.25**	28.36**	14.00**	61.74**	11.00**	29.00**	23.24**	25.00**	19.44**	18.68**	66.00**	15.00**	24.00**
	E_3	55	40.62**	61.23**	16.00**	75.70**	11.00**	34.00**	19.91**	32.00**	13.87**	17.21**	96.00**	23.00**	26.00**
	E_4	55	36.82**	39.53**	16.00**	75.31**	41.00**	45.00**	42.08	41.00**	24.64**	10.72**	12.00**	22.00**	25.00**
Error	E_1	110	01.16	02.22	27.00	00.60	24.00	04.27	00.98	03.41	00.88	00.73	11.00	61.00	01.56
	E_2	110	01.16	02.26	62.00	00.60	11.00	02.57	00.92	02.11	01.38	00.89	00.02	43.00	01.17
	E_3	110	03.82	23.27	80.00	00.52	35.00	02.30	00.86	18.62	01.18	00.73	03.99	98.00	01.30
	E_4	110	05.23	01.31	52.00	09.71	12.00	03.55	41.72	02.41	00.94	00.53	05.58	17.00	01.64

* Significant at 5% level
** Significant at 1% level

Table 9. Analysis of variance over the environments showing mean square for 13 characters in Bitter gourd

Source	d.f.	Days taken to the appearance of first female flower	Node no. at which first female flower appear	Length of main shoot (cm)	No. of lateral branches per plant	No. of male flower per plant	No. of female flower per plant	Percentage fruit set	No. of fruits per vine	Length of fruit (cm)	Girth of fruit (cm)	Weight of fruit (g)	Fruit yield per vine (g)	No. of seeds per fruit
Environment	3	342.36**	19.15*	164295.30**	328.49**	112500.48**	2363.48**	12.95	2046.39**	239.30**	211.59**	4916.11**	16264678.00**	12.33**
Repl/Env.	8	7.14	6.61	48.54	2.50	450.18	0.66	9.44	1.80	0.93	0.30	260.87	2728.88	0.76
Genotype	55	35.71**	22.00**	18630.07**	52.49**	118683.82**	635.68**	34.92**	556.81**	18.73**	14.84**	1046.97**	2591887.20**	264.31**
Environment x Genotype	165	35.67**	46.08**	14768.58**	74.74**	93987.19**	255.00**	24.36**	226.95**	19.18**	15.99**	1143.63**	1558677.60**	226.19**
Error	440	2.85	7.29	550.68	4.28	2119.29	3.20	11.12	6.66	1.09	0.72	265.43	9227.34	1.42

* Significant at 5% level
** Significant at 1% level

expression of joint action of favourable genes and interaction among allelic, non-allelic and mitochondrial genes, brought together from the parents to heterozygote.

In the present investigation, the extent of heterobeltiosis and economic heterosis were expressed as percent increase in hybrid performance in comparison to better parent and standard check (viz. Mahyco Long Green), respectively. Heterobeltiosis and economic heterosis were estimated for all the traits in individual as well as over the environments and are discussed character wise as under:-

Days Taken to the Appearance of First Female Flower : (Table 10)

Out of 45 hybrids significant heterobeltiosis for earliness was observed for 14, 10, 12, 9, and 6 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. It ranged from -1.88 (P_5xP_6) to -22.91 (P_5xP_8) in E_1; -0.85 (P_2xP_4) to -28.07 (P_2xP_{10}) in E_2; -0.25 (P_9xP_{10}) to -25.53 (P_2xP_{10}) in E_3; -0.65 (P_2xP_6) to -25.09 (P_3xP_9) in E_4 and -0.38 (P_4xP_8) to -18.91 (P_2xP_{10}) percent over the environments. Hybrids possessed heterobeltiosis also had significant economic heterosis for this character in all the environments. Crosses P_2xP_8 and P_2xP_9 showed significant heterobeltiosis and economic heterosis in all the environments, suggested that these hybrids were superior over better parent as well as standard check.

Bhattacharya *et al.* (1970) also suggested heterotic effect for early appearance of female flower in muskmelon.

Node Number at Which First Female Flower Appear : (Table 11)

Out of 45 hybrids significant heterobeltiosis in desired direction was recorded for 8, 9, 2, 8, and 2 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. The heterobeltiosis varied from -2.86 (P_5xP_{10}) to -45.54 (P_2xP_5) in E_1; -0.07 (P_2xP_9) to -52.28 (P_2xP_5) in E_2; -0.06 (P_7xP_{10}) to -54.86 (P_2xP_5) in E_3; -0.65 (P_5xP_8) to -36.19 (P_6xP_9) in E_4 and -1.80 (P_4xP_9) to -50.28 (P_2xP_5) percent over the environments crosses P_2xP_5 and P_5xP_9 possessed significant heterobeltiosis in all as well as over the environments, indicated that these hybrids are superior than better parent.

Similarly significant economics heterosis was observed for 40, 32, 40 and 28 hybrids out of 45 hybrids in E_1, E_2, E_4 and pooled, respectively. It ranged -8.65 (P_2xP_7) to -55.98 (P_3xP_4) in E_1; -0.46 (P_7xP_9) to -46.14 (P_3xP_4) in E_2; 0.92 (P_3xP_9) to -

Table 10. Heterosis percentage over better parent (BP) and check variety (EH) for days taken to the appearance of first female flower in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	-	-9.22**	-	-12.68**	-	-12.70*	-11.40**	-19.02**	-	-13.60**
P_1xP_3	-	-	-	-	-	-1.71	-	-4.08	-	-
P_1xP_4	-	-6.93*	-	-5.36*	-	-1.49	-18.18**	-23.61**	-	-9.81*
P_1xP_5	-	-13.12**	-	-12.33**	-	-10.04*	-	-10.01*	-	-11.30**
P_1xP_6	-	-6.24*	-	-10.26**	-	-17.07**	-	-6.19	-	-9.84*
P_1xP_7	-	-	-	-2.88	-	-	-	-9.01*	-	-2.82
P_1xP_8	-	-2.19	-	-5.35*	-	-9.33*	-	12.39*	-	-7.50*
P_1xP_9	-	-	-	-	-	-	-	-1.76	-	-
P_1xP_{10}	-	-2.02	-	-1.31	-	-	-4.28*	-14.87**	-	-4.31
P_2xP_3	-	-7.24*	-	-5.14*	-	-9.07*	-	-14.96**	-	-9.32*
P_2xP_4	-4.88**	-4.58*	-0.85	-2.49	-	-6.00	-6.60**	-14.64**	-3.65	-7.20*
P_2xP_5	-2.94**	-4.44*	-7.66**	-10.11**	-16.42**	-16.73**	-	-17.05**	-6.81**	-12.28**
P_2xP_6	-	-	-	-0.99	-6.08**	-6.29	-0.65	-13.18*	-	-4.73
P_2xP_7	-	-	-	-4.22	-	-	-	-15.08**	-	-1.68
P_2xP_8	-3.60**	-7.32*	-2.67*	-11.71**	-16.12**	-18.31**	-5.21*	-21.37**	-7.05*	-14.94**
P_2xP_9	-17.22**	-16.95**	-13.38**	-14.20**	-12.72**	-10.03*	-5.07*	-13.24*	-13.06**	-13.57**
P_2xP_{10}	-19.78**	-19.05**	-28.07**	-26.50**	-25.53**	-23.58**	-2.05	-12.88*	-18.91**	-20.25**
P_3xP_4	-	-9.22**	-	-1.96	-	-8.69*	-1.94	-23.14**	-	-11.19**
P_3xP_5	-	-4.17	-	-12.44**	-	-10.78*	-	-4.65	-	-7.90*
P_3xP_6	-	-14.46**	-	-10.18*	-	-15.48**	-	-13.24**	-	-13.13**
P_3xP_7	-	-1.36	-	-4.87*	-	-11.09*	-	-	-	-3.19
P_3xP_8	-	-	-	-2.98	-	-00.95	-	-	-	-
P_3xP_9	-	-	-	-	-	-4.04	-	-4.78	-	-1.65
P_3xP_{10}	-	-1.73	-	-5.36*	-	-9.16*	-	-13.31*	-	-7.60*
P_4xP_5	-	-	-	-	-	-	-	-6.33	-	-
P_4xP_6	-3.02**	-6.78*	-	-	-	-4.87	-	-10.13*	-0.12	-5.22

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	-	-	-	-	-	-2.35	-	-08.38*	-	-1.09
P_4xP_8	-8.52**	-12.04**	-	-4.65*	-	-1.09	-	-16.63**	-0.38	-8.83*
P_4xP_9	-6.57**	-6.27*	-9.59**	-11.10**	-2.87*	-8.98*	-	6.09	-4.52	-8.04*
P_4xP_{10}	-3.83**	-3.51**	-7.50**	-9.04**	-3.29*	-9.36*	-	-8.95*	-4.23	-7.76*
P_5xP_6	-1.88*	-5.68*	-2.58*	-5.24*	-1.37	-1.71	-	-6.89	-	-4.94
P_5xP_7	-	-16.31**	-	-15.40**	-	-14.01**	-4.12*	-20.80**	-	-16.76**
P_5xP_8	-22.91**	-5.87*	-14.03**	-22.02**	-21.77**	-23.79**	-2.66	-19.59**	-15.53**	-22.70**
P_5xP_9	-5.66**	-7.10*	-7.40**	-9.84**	-6.89**	-7.12	-	-15.36**	4.43	-10.04*
P_5xP_{10}	-	-	-	-	-4.32*	-4.65	-	-11.97**	-	-3.79
P_6xP_7	-	-11.15**	-	-7.24*	-	-3.01	-	-8.59*	-	-7.59**
P_6xP_8	-13.19**	-16.56**	-4.23**	-13.11**	-18.77**	-20.87**	-	-12.66*	-7.89**	-15.71**
P_6xP_9	-	-00.95	-1.42	-4.12	-18.30**	-18.50**	-	-2.52	-1.74	-6.76*
P_6xP_{10}	-	-	-	-	-	-	-11.22**	-22.41**	-	-2.38
P_7xP_8	-	-16.34**	-	-20.17**	-	-19.07**	-	-15.36**	-	-17.64**
P_7xP_9	-	-6.29*	-	-02.45	-	-	-2.20	-17.22**	-	-6.26*
P_7xP_{10}	-	-	-	-	-	-4.20	-	-6.54	-	-1.98
P_8xP_9	-	-	-	-	-2.48	-5.01	-25.09**	-37.85**	-1.17	-9.56*
P_8xP_{10}	-	-2.34	-	-4.13	-1.74	-4.30	-	-6.75	-	-4.52
P_9xP_{10}	-4.51**	-4.19	-	-00.51	-0.25	-	-	-5.42	-0.38	-2.03
S.E.±	0.87	00.89	0.92	00.93	01.54	01.56	1.89	0.91	1.315	1.32

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

Table 11. Heterosis percentage over better parent (BP) and check variety (EH) for node number at which first female flower appear in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	-	-37.42**	-7.24*	-34.10**	-8.12	-30.49	-20.35**	-63.75**	-7.26	-41.94*
P_1xP_3	-	-49.70**	-	-41.99**	-	-40.54	-	-40.00**	-	-43.11*
P_1xP_4	-	-33.45**	-	-29.66**	-	-29.57	-	-32.70**	-	-31.38*
P_1xP_5	-	-17.00*	-	-05.99	-	-24.11	-	-05.00	-	-12.99
P_1xP_6	-	-27.31**	-	-07.83	-	-16.92	-	-27.50**	-	-20.33
P_1xP_7	-	-39.49**	-	-27.82**	-	-34.86	-	-40.00**	-	-35.82*
P_1xP_8	-	-38.83**	-9.05*	-35.37**	-19.93	-39.40	-	-42.50**	-2.78	-39.14*
P_1xP_9	-	-34.15**	-	-19.35*	-3.53	-27.02	-	-20.00**	-	-25.25
P_1xP_{10}	-	-37.02**	-	-35.19**	-	-40.49	-	-47.45**	-	-24.35
P_2xP_3	-	-49.35**	-	-39.86**	-	-36.97	-	-04.85	-	-32.38*
P_2xP_4	-	-12.47	-	-04.61	-	-02.65	-	-23.25**	-	-11.09
P_2xP_5	-45.54**	-52.87**	-52.28**	-42.05**	-54.86**	-43.05	-36.08**	-42.50**	-50.28*	-44.80*
P_2xP_6	-	-29.17**	-2.95	-24.08*	-1.69	-29.73	-	-27.50**	-	-27.68*
P_2xP_7	-	-8.65	-	-	-	-02.05	-	-13.35*	-	-4.54
P_2xP_8	-11.81**	-35.36**	-15.03**	-27.67**	-17.94	-25.67	-	-27.50**	-10.28	-28.21*
P_2xP_9	-	-28.47**	-0.07	-32.08**	-02.07	-18.92	-29.01**	-45.00**	-6.58	-27.99*
P_2xP_{10}	-3.06	-42.60**	-	-27.52**	-	-33.81	-	-33.70**	-	-34.81*
P_3xP_4	-	-55.98**	-	-46.14**	-	-45.94	-	-60.00**	-	-52.29**
P_3xP_5	-	-26.36**	-	-13.59**	-	-17.13	-	-21.70**	-	-19.91
P_3xP_6	-	-46.63**	-	-38.13**	-	-33.35	-	-52.50**	-	-42.94*
P_3xP_7	-	-37.52**	-	-39.11**	-	-44.16	-	-45.00**	-	-41.47*
P_3xP_8	-	-14.48*	-	-03.51	-	-05.40	-	-10.00*	-	-8.55
P_3xP_9	-	-	-	-	-	-00.92	-	-	-	-
P_3xP_{10}	-	-53.12**	-	-43.26**	-	-	-	-48.80**	-	-47.65**
P_4xP_5	-	-09.05	-	-	-	-	-	-02.55	-	-1.53
P_4xP_6	-	-36.12**	-	-28.28**	-	-28.37	-	-25.00**	-2.55	-29.48*

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	-	-34.25**	-	-30.70**	-	-32.93	-	-33.35**	-	-32.75*
P_4xP_8	-	-15.74*	-	-	-	-06.32	-	-20.00**	-	-10.77
P_4xP_9	-	-45.07**	-4.15	-33.47**	-2.33	-38.76	-	-29.60**	-1.80	-36.76*
P_4xP_{10}	-	-36.97**	-	-22.52**	-	-22.16	-	-38.30**	-	-30.37*
P_5xP_6	-18.38**	-42.50**	-9.23	-28.97**	-15.75	-39.78	-4.79*	-33.35**	-11.97	-36.29*
P_5xP_7	-	-22.08*	-	-07.72	-	-10.81	-	-22.50**	-	-16.11
P_5xP_8	-16.63**	-38.88**	-19.24**	-27.48**	-22.40	-29.73	-0.65	-33.19**	-15.29	-32.11*
P_5xP_9	-28.17**	-52.21**	-31.91**	-43.83**	-44.52*	-54.05	-34.75**	-44.45**	-35.09*	-49.97**
P_5xP_{10}	-2.86	-42.50**	-	-29.15**	-	-38.92	-	-28.95**	-	-34.92*
P_6xP_7	-	-32.44	-	-18.84*	-	-33.30	-	-15.00*	-	-24.88
P_6xP_8	-27.52**	-48.94**	-23.05**	-39.80**	-18.77	-19.36	-9.82**	-38.00**	-20.29	-42.31*
P_6xP_9	-19.95**	-46.73**	-19.07**	-36.69**	-13.01	-13.01	-36.19**	-55.35**	-23.36	-44.53*
P_6xP_{10}	-	-33.70**	-	-23.10*	-	-22.54	-	-36.80**	-	-29.32*
P_7xP_8	-	-22.99*	-	-11.58	-	-12.54	-	-27.50**	-	-18.96
P_7xP_9	-	-15.94*	-	-0.46	-	-16.21	-	-02.45	-	-8.87
P_7xP_{10}	-	-41.85**	-	-27.13**	-0.06	-42.43	-	-26.70**	-	-34.60*
P_8xP_9	-8.84**	-39.33**	-26.26**	-39.17**	-25.98	-38.70	-20.00**	-45.00**	-22.96	-40.62*
P_8xP_{10}	-	-26.60**	-	-11.75	-	-18.05	-	-18.35**	-	-18.91
P_9xP_{10}	-	-23.84**	-	-11.23	-	-22.11	-	-32.00**	-	-22.66
S.E.±	1.25	01.28	1.17	01.19	6.40	06.42	0.86	00.89	2.42	2.44

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

54.05 (P_5xP_9) in E_3; -2.45 (P_7xP_9) to -63.75 (P_1xP_2) in E_4 and -4.54 (P_2xP_7) to -52.29 (P_3xP_4) percent in pooled analysis.

Similar findings in muskmelon were reported by Bhattacharya *et al.* (1970).

Length of Main Shoot (cm) : (Table 12)

Out of 45 hybrids significant positive heterobeltiosis was observed for 6, 4, 5, 2 and 2 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. It varied from 1.40 (P_6xP_8) to 29.46 (P_5xP_{10}) in E_1; 2.08 (P_3xP_9) in E_2; 3.15 (P_7xP_{10}) to 47.21 (P_7xP_9) in E_3; 0.51 (P_1xP_7) to 11.16 (P_4xP_5) in E_4 and 4.61 (P_3xP_{10}) to 25.88 (P_5xP_{10}) percent over the environments. Only one cross (P_4xP_5) 27.49 percent showed significant economic heterosis in E_4.

Srivastava (1970) and Nandpuri *et al.* (1974) suggested hybrid vigour for this traits in Bitter gourd and muskmelon, respectively.

Number of Lateral Branches Per Plant : (Table 13)

Among 45 hybrids significant heterobeltiosis was recorded for 11, 11, 15, 15 and 11 In E_1, E_2, E_3, E_4 and pooled, respectively. Heterosis over better parent varied from 1.11 (P_6xP_{10}) to 125.95 ((P_2xP_9) in E_1; 9.74 (P_2xP_5) to 133.57 (P_7xP_{10}) in E_2; 0.64 (P_6xP_{10}) to 116.07 (P_7xP_{10}) in E_3; 3.33 (P_1xP_8) to 85.78 (P_3xP_6) in E_4 and 2.19 (P_8xP_9) to 84.89 (P_7xP_{10}) percent in pooled analysis. Crosses P_1xP_2, P2xP5, P_2xP_{10} and P_7xP_9 showed significant heterobeltiosis in all as well as over the environments in desired direction.

Out of 45 hybrids significant positive economic heterosis was observed for 7, 7, 8, 6 and 9 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. It ranged from 5.92 (P_1xP_2) to 105.23 (P_7xP_{10}) in E_1; 1.12 (P_4xP_7) to 103.96 (P_7xP_{10}) in E_2; 1.33 (P_4xP_7) to 101.66 (P_7xP_{10}) in E_3; 0.71 (P_3xP_8) to 113.07 (P_6xP_7) in E_4 and 5.88 (P_1xP_2) to 79.13 (P_7xP_{10}) in pooled analysis. Crosses P_2xP_{10} and P_7xP_9 showed significant economic heterosis in all as well as over the environments.

Number of Male Flower Per Plant : (Table 14)

Out of 45 hybrids 2, 3, 5, 4 and 1 hybrid in E_1, E_2, E_3, E_4 and pooled, respectively depicted significant heterobeltiosis in desired direction. It ranged from -

Table 12. Heterosis percentage over better parent (BP) and check variety (EH) for length of main shoot (cm) in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	-	-	-	-	-	-	-	-	-	-
P_1xP_3	-	-	-	-	-	-	-	-	-	-
P_1xP_4	-	-	-	-	-	-	-	-	-	-
P_1xP_5	-	-	-	-	-	-	-	-	-	-
P_1xP_6	-	-	-	-	-	-	-	-	-	-
P_1xP_7	10.49**	-	6.44*	-	14.27**	-	0.51	-	7.64	-
P_1xP_8	-	-	-	-	-	-	-	-	-	-
P_1xP_9	-	-	-	-	-	-	-	-	-	-
P_1xP_{10}	-	-	-	-	-	-	-	-	-	-
P_2xP_3	-	-	-	-	-	-	-	-	-	-
P_2xP_4	-	-	-	-	-	-	-	-	-	-
P_2xP_5	-	-	-	-	-	-	-	-	-	-
P_2xP_6	-	-	-	-	-	-	-	-	-	-
P_2xP_7	-	-	-	-	-	-	-	-	-	-
P_2xP_8	-	-	-	-	-	-	-	-	-	-
P_2xP_9	-	-	2.66	-	3.61*	-	-	-	-	-
P_2xP_{10}	-	-	-	-	-	-	-	-	-	-
P_3xP_4	-	-	-	-	-	-	-	-	-	-
P_3xP_5	-	-	-	-	-	-	-	-	-	-
P_3xP_6	-	-	-	-	-	-	-	-	-	-
P_3xP_7	-	-	-	-	-	-	-	-	-	-
P_3xP_8	-	-	-	-	-	-	-	-	-	-
P_3xP_9	7.44**	-	2.08	-	-	-	-	-	-	-
P_3xP_{10}	-	-	-	-	-	-	-	-	-	-
P_4xP_5	-	-	-	-	-	-	11.16**	27.49**	-	-
P_4xP_6	-	-	-	-	-	-	-	-	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	-	-	-	-	-	-	-	-	-	-
P_4xP_8	-	-	-	-	-	-	-	01.25	-	-
P_4xP_9	-	-	-	-	-	-	-	-	-	-
P_4xP_{10}	-	-	-	-	-	-	-	-	-	-
P_5xP_6	-	-	-	-	-	-	-	-	-	-
P_5xP_7	2.96*	-	-	-	-	-	-	-	-	-
P_5xP_8	-	-	-	-	-	-	-	-	-	-
P_5xP_9	1.60	-	-	-	-	-	-	-	-	-
P_5xP_{10}	29.46**	-	17.32**	-	36.71**	04.30	-	-	25.88**	-
P_6xP_7	-	-	-	-	-	-	-	-	-	-
P_6xP_8	1.40	-	-	-	-	-	-	04.52	-	-
P_6xP_9	-	-	-	-	-	-	-	-	-	-
P_6xP_{10}	-	-	-	-	-	-	-	-	-	-
P_7xP_8	-	-	-	-	-	-	-	-	-	-
P_7xP_9	25.83**	-	26.60**	-	47.21**	-	7.21*	-	25.66**	-
P_7xP_{10}	-	-	-	-	3.15	-	-	-	-	-
P_8xP_9	-	-	-	-	-	-	-	-	-	-
P_8xP_{10}	-	-	-	-	-	-	-	-	-	-
P_9xP_{10}	9.47**	-	11.69*	-	10.50**	-	-	-	4.61	-
S.E.±	12.14	12.19	26.79	27.10	22.27	22.27	19.04	19.35	20.10	20.23

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

Table 13. Heterosis percentage over better parent (BP) and check variety (EH) for number of lateral branches per plant in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	52.41**	5.92	51.43**	5.68	29.15**	-	10.00*	17.85	24.29**	5.88
P_1xP_3	-	-	-	7.03	6.89**	6.86	16.69**	25.00	16.09*	9.78
P_1xP_4	-	-	-	-	-	-	-	-	-	-
P_1xP_5	-	-	-	-	-	-	6.71	14.35	-	-
P_1xP_6	-	-	-	-	-	-	-	-	-	-
P_1xP_7	13.41**	-	14.68**	-	31.82**	-	-	7.14	13.74	-
P_1xP_8	29.18**	-	31.29**	-	18.48**	-	3.33	10.71	18.17*	-
P_1xP_9	-	-	-	-	9.39**	-	3.40	10.78	-	-
P_1xP_{10}	-	-	-	-	25.07**	16.73**	-	-	-	-
P_2xP_3	-	-	-	-	-	-	-	-	-	-
P_2xP_4	-	-	-	-	-	-	-	-	-	-
P_2xP_5	4.82*	17.00*	9.74**	24.68**	50.31**	60.53**	22.31**	18.00	31.04**	30.94**
P_2xP_6	-	-	-	-	-	-	7.43	3.64	-	-
P_2xP_7	22.90**	-	27.25**	-	6.98**	-	-	-	7.15	-
P_2xP_8	-	-	-	-	-	-	4.02	3.57	-	-
P_2xP_9	125.95**	64.11**	105.01**	50.11**	115.92**	56.46**	-	-	66.36**	31.52**
P_2xP_{10}	51.95**	39.86**	57.52**	37.55**	58.81**	48.20**	31.73**	50.57*	48.91**	44.27**
P_3xP_4	-	-	-	-	-	-	-	-	-	-
P_3xP_5	-	-	-	-	-	-	13.91*	-	-	-
P_3xP_6	-	07.62	-	6.80	6.67**	6.66	85.78**	7.21	13.10	6.95
P_3xP_7	-	-	-	-	-	-	-	-	-	-
P_3xP_8	-	-	-	-	-	-	74.40**	0.71	-	-
P_3xP_9	-	-	-	-	-	-	-	-	-	-
P_3xP_{10}	-	-	-	-	-	-	-	-	-	-
P_4xP_5	-	08.27	-	2.24	-	-	41.51**	103.57**	7.15	27.10**
P_4xP_6	-	-	-	-	-	-	-	-	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	-	-	-	1.12		1.33	-	28.92	-	7.39
P_4xP_8	-	-	-	-	-	-	-	-	-	-
P_4xP_9	51.59**	62.41**	50.14**	59.91**	23.27**	42.60**	-	-	16.31*	37.97**
P_4xP_{10}	-	-	-	-	-	-	-	-	-	-
P_5xP_6	-	-	-	-	-	-	55.28**	7.14	-	-
P_5xP_7	16.49**	30.03**	15.60**	31.34**	32.15**	41.13**	-	17.85	32.19**	32.10**
P_5xP_8	-	-	-	-	-	-	39.72**	-	-	-
P_5xP_9	-	07.57	-	7.03	-	-	-	-	-	-
P_5xP_{10}	-	-	-	-	-	-	21.85**	39.28*	-	-
P_6xP_7	-	-	-	-	-	-	49.17**	113.07**	33.33**	75.36**
P_6xP_8	-	-	-	-	-	-	25.87*	-	-	-
P_6xP_9	-	-	-	-	-	-	-	-	-	-
P_6xP_{10}	1.11	-	-	-	0.64	-	-	-	-	-
P_7xP_8	-	-	-	-	-	-	-	-	-	-
P_7xP_9	96.85**	42.98**	86.38**	36.50**	97.03**	42.80**	7.50*	53.57*	82.13**	43.98**
P_7xP_{10}	123.31**	105.23**	133.57**	103.96**	116.07**	101.66**	-	7.14	84.89**	79.13**
P_8xP_9	-	-	-	-	-	-	35.37**	32.14*	2.19	-
P_8xP_{10}	-	-	-	-	-	-	-	3.64	-	-
P_9xP_{10}	-	-	-	-	-	-	-	-	-	-
S.E.±	0.62	00.64	00.66	00.69	0.56	00.585	2.03	02.15	0.97	1.02

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

Table 14. Heterosis percentage over better parent (BP) and check variety (EH) for number of male flowers per plant in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	-	-49.28^{**}	-	-45.22^{**}	-	-25.31^{**}	-	-	-	-29.95^{**}
P_1xP_3	-	-28.81^{**}	-	-20.15^{**}	-	-	-10.49^{**}	-7.54	-	-9.09
P_1xP_4	-	-28.41^{**}	-	-26.67^{**}	-	-	-	-	-	-7.55
P_1xP_5	-	-49.26^{**}	-	-46.80^{**}	-	-39.83^{**}	-	-	-	-30.36^{**}
P_1xP_6	-	-	-	-	-	-	-	-	-	-
P_1xP_7	-	-33.91^{**}	-	-34.66^{**}	-	-27.85^{**}	-	-	-	-17.19^{*}
P_1xP_8	-	-	-	-	-	-	-	-	-	-
P_1xP_9	-	-22.19^{**}	-	-17.39^{**}	-	-22.86^{**}	-	-	-	-14.27^{*}
P_1xP_{10}	-	-	-	-	-	-	-	-	-	-
P_2xP_3	-	-29.99^{**}	-	-35.70^{**}	-11.56^{**}	-33.61^{**}	-	-	-	-23.09^{**}
P_2xP_4	-	-22.66^{**}	-	-24.50^{**}	-	-	-	-	-	-8.89
P_2xP_5	-	-	-	-	-	-	-	-	-	-
P_2xP_6	-9.33^{*}	-49.85^{**}	-17.02^{**}	-53.56^{**}	-42.10^{**}	-56.54^{**}	-	-	-	-36.22^{**}
P_2xP_7	-	-44.22^{**}	-	-39.09^{**}	-	-20.20^{*}	-	-	-	-
P_2xP_8	-	-	-	-	-	-	-	-	-	-
P_2xP_9	-	-	-	-	-	-	-	-1.15	-	-27.92^{**}
P_2xP_{10}	-6.34	-48.22^{**}	-6.85^{*}	-47.86^{**}	-11.97^{**}	-33.92^{**}	-	-	-	-24.42^{**}
P_3xP_4	-29.12^{**}	-31.67^{**}	-31.20^{**}	-35.76^{**}	-10.17^{**}	-18.11^{*}	-11.55^{**}	-8.62	-21.05^{**}	-
P_3xP_5	-	-8.73	-	-37.64^{**}	-	-	-	-	-	-
P_3xP_6	-	-	-	-	-	-	-4.69^{*}	-9.31	-	-
P_3xP_7	-	-	-	-	-	-28.85^{**}	-5.84^{**}	-2.75	-	-22.16^{**}
P_3xP_8	-	-38.50^{**}	-	-40.77^{**}	-17.27^{**}	-26.02^{**}	-	-	-	-2.38
P_3xP_9	-	-9.10	-	-07.37	-	-	-2.45	-	-	-
P_3xP_{10}	-	-	-	-	-	-	-	-	-	-
P_4xP_5	-	-10.34	-	-27.03^{**}	-	-37.51^{**}	-	-	-	-12.06^{*}
P_4xP_6	-	-	-	-	-	-	-0.05	-4.88	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	-	-4.62	-	-05.58	-	-6.44	-	-	-	-2.08
P_4xP_8	-	-30.30**	-	-35.60**	-	-6.24	-	-	-	-17.72*
P_4xP_9	-	-16.98*	-	-18.00**	-	-	-	-	-	-11.35*
P_4xP_{10}	-	-	-	-4.67	-	-	-	-	-	-
P_5xP_6	-	-8.05	-	-	-	-4.28	-	-	-	-
P_5xP_7	-	-	-	-	-	-	-	-	-	-
P_5xP_8	-	-16.02*	-	-21.28**	-	-14.36**	-	-	-	-00.69
P_5xP_9	-	-	-	-	-	-	-	-	-	-
P_5xP_{10}	-	-	-	-	-	-	-	-	-	-
P_6xP_7	-	-15.89*	-	-18.78**	-	-21.48*	-	-	-	-5.63
P_6xP_8	-	-	-	-	-	-	-	-	-	-
P_6xP_9	-	-	-	-	-	-	-	-	-	-
P_6xP_{10}	-	-	-	-	-	-	-	-	-	-
P_7xP_8	-	-	-	-1.76	-	-	-	-	-	-
P_7xP_9	-	-34.19**	-	-32.92**	-	-16.61*	-	-	-	-10.19
P_7xP_{10}	-	-	-	-	-	5.99	-	-	-	-
P_8xP_9	-	-28.21**	-	28.87**	-	-	-	-	-	5.92
P_8xP_{10}	-	-	-	-	-	-	1.06	-	-	-
P_9xP_{10}	-	-	-	-	-	-	-	-	-	-
S.E.±	43.79	43.82	28.15	28.19	40.88	40.91	29.52	29.20	35.62	35.53

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

6.34 (P_2xP_{10}) to -29.12 (P_3xP_4) in E_1; -6.85 (P_2xP_{10}) to 31.20 (P_3xP_4) in E_2; -10.17 (P_3xP_4) to -42.10 (P_2xP_6) in E_3; -0.05 (P_4xP_6) to -11.55 (P_3xP_4) in E_4 and only one - 21.05 (P_3xP_4) percent over the environments. Cross P_3xP_4 showed significant heterobeltiosis in all as well as over environments.

Out of 45 hybrids significant economic heterosis in desired direction was recorded for 19, 21, 15 and 12 hybrids in E_1, E_2, E_3 and pooled, respectively. It varied from -4.62 (P_4xP_7) to -49.85 (P_2xP_6) in E_1; -1.76 (P_7xP_8) to 53.56 (P_2xP_6) in E_2; -4.28 (P_5xP_6) to -56.54 (P_2xP_6) in E_3, -1.15 (P_2xP_9) to -9.31 in (P_3xP_6) in E_4 and -0.69 (P_5xP_8)to -36.22 (P_2xP_6) percent in pooled analysis.

Number of Female Flower Per Plant : (Table 15)

Out of 45 hybrids significant heterobeltiosis in desired direction was recovered for 25, 27, 32, 28 and 29 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. It varied from 1.92 (P_4xP_{10}) to 263.75 (P_1xP_8) in E_1; 1.79 (P_2xP_7) to 254.63 (P_1xP_8) in E_2; 0.48 (P_5xP_8) to 145.67 (P_5xP_9) in E_3; 0.14 (P_4xP_{10}) to 116.78 (P_4xP_6) in E_4 and 0.74 (P_1xP_3) to 173.87 (P_1xP_8) in pooled analysis. Crosses P_1xP_5, P_1xP_6, P_1xP_7, P_1xP_8, P_1xP_9, P_2xP_3, P_2xP_5, P_2xP_8, P_3xP_9, P_3xP_{10}, P_5xP_{10}, P_7xP_9, P_7xP_{10}, P_8xP_9 and P_9xP_{10} showed significant heterobeltiosis in all as well as over the environments. Similarly significant economic heterosis was observed for 26, 28, 35, 37 and 35 hybrids among 45 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively.The economic heterosis varied from 3.33 (P_3xP_5) to 138.24 (P_1xP_6) in E_1; 0.46 (P_5xP_6) to 138.35 (P_1xP_6) in E_2; 2.06 (P_2xP_7) to 145.19 (P_1xP_6) in E_3; 4.36 (P_3xP_6) to 179.94 (P_1xP_8) in E_4 and 0.63 (P_2xP_{10}) to 149.01 (P_1xP_6), in pooled analysis crosses P_1xP_6, P_1xP_8, P_1xP_9, P1xP_{10}, P_2xP_3, P_2xP_5, P_2xP_8, P_3xP_{10}, P_4xP_5, P_4xP_7, P_4xP_{10}, P_5xP_6, P_5xP_7, P_5xP_9, P_5xP_{10}, P_6xP_7, P_6xP_8, P_6xP_9, P_7xP_8, P_7xP_{10} and P_9xP_{10} showed significant heterobeltiosis in all as well as over the environments.

The present findings are similar to the work done earlier by Tyagi (1973) who reported heterosis for the number of pistillate flower per plant in Bottle gourd.

Percentage Fruit Set : (Table 16)

Out of 45 hybrids significant heterobeltiosis was recorded for 29, 33, 28, 14 and 10 hybrids in E_1, E_2, E_3, E_4, and pooled, respectively. It varied from 0.17 (P_5xP_6) to 6.89 (P_2xP_5) in E_1; 0.43 (P_4xP_9) and 7.95 (P_5xP_7) in E_2; 0.76 (P_2xP_5) to 9.43 (P_2xP_5)

Table 15. Heterosis percentage over better parent (BP) and check variety (EH) for number of female flower per plant in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	-	-	3.31	-	6.44*	-	-	18.81*	5.09	-
P_1xP_3	-	-	-	-	40.91**	27.08**	-	-	0.74	-
P_1xP_4	-	-	-	-	5.32**	24.88**	8.93**	63.62**	-	17.60
P_1xP_5	47.48**	-	57.33**	3.74	76.82**	14.76*	68.39**	152.95**	81.98**	39.44**
P_1xP_6	66.74**	138.24**	72.06**	138.35**	68.92**	145.19**	84.20**	176.65**	86.74**	149.01**
P_1xP_7	22.54**	5.03	23.68**	-	49.47**	6.70	36.62**	105.17**	34.32**	25.87**
P_1xP_8	263.75**	130.64**	254.63**	114.64**	121.85**	136.95**	86.38**	179.94**	173.87**	139.63**
P_1xP_9	191.18**	40.35**	185.25**	41.35**	100.32**	29.44**	24.26**	86.61**	95.16**	48.38**
P_1xP_{10}	57.96**	51.16**	45.72**	35.88**	46.25**	49.61**	-	30.18**	35.64**	41.97**
P_2xP_3	25.85**	26.33**	24.35**	17.42**	31.73**	18.81**	107.45**	107.61**	46.62**	40.82**
P_2xP_4	-	-	-	-	1.37	20.20**	-	18.81*	-	3.56
P_2xP_5	96.71**	31.10**	109.12**	34.64**	125.89**	73.76**	22.74**	39.76**	90.19**	45.72**
P_2xP_6	-	-	-	-	-	-	106.33**	114.79**	-	7.15
P_2xP_7	-	-	1.79	-	32.68**	2.06	18.15**	74.26**	13.13*	6.01
P_2xP_8	121.00**	40.10**	124.05**	35.83**	46.93**	56.94**	31.64**	58.48**	62.89**	47.78**
P_2xP_9	112.57**	26.25**	92.12**	16.51**	103.59**	56.60**	-	-	70.24**	25.39**
P_2xP_{10}	-	-	-	-	-	-	35.31**	75.33**	-	0.63
P_3xP_4	-	-	-	-	-	-	-	-	-	28.64**
P_3xP_5	2.94	3.33	25.29**	18.30**	47.77**	33.27**	14.46**	30.31**	26.42**	21.48**
P_3xP_6	-	35.06**	9.16**	51.14**	10.41**	60.28**	0.48	4.36	4.12	38.84**
P_3xP_7	55.10**	2.26	58.75**	49.90**	-	-	-	-	22.77**	17.92*
P_3xP_8	-	-	3.09	-	14.77**	22.60**	77.35**	113.55**	35.66**	30.30**
P_3xP_9	10.74**	11.17	20.20**	13.53*	42.14**	27.95**	7.23**	20.86*	23.47**	18.59*
P_3xP_{10}	35.81**	36.33**	44.53**	36.48**	44.65**	47.96**	14.60**	48.48**	35.98**	42.32**
P_4xP_5	17.59**	44.29**	13.43**	36.61**	1.67	20.57**	116.78**	164.21**	35.47**	63.76**
P_4xP_6	3.41**	47.24**	4.37**	44.51**	4.44**	51.60**	-	7.52	3.97	38.65**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	-	15.76*	-	12.25*	-	9.27*	-	25.01**	-	15.27*
P_4xP_8	-	-	-	-	-	7.76	063	22.66**	-	-
P_4xP_9	-	-	-	-	-	5.11	0.39	22.36*	-	5.73
P_4xP_{10}	1.92	25.07*	-	21.88**	25.06**	48.28**	0.14	29.76**	8.83	31.56**
P_5xP_6	-	19.91*	-	31.56**	-	25.83**	84.82**	110.43**	9.04*	45.41**
P_5xP_7	41.36**	18.32*	50.74**	17.76**	118.87**	56.24**	-	25.54**	38.79**	30.06**
P_5xP_8	54.68**	3.86	56.01**	0.46	0.48	7.32	68.91**	103.37**	45.07**	26.94**
P_5xP_9	138.64**	60.29**	131.90**	49.32**	145.67**	59.44**	93.03**	119.75**	123.18**	71.00**
P_5xP_{10}	118.66**	109.22**	118.54**	103.65**	100.34**	104.93**	82.66**	136.68**	103.51**	113.01**
P_6xP_7	-	18.69*	-	22.19**	-	16.16**	44.94**	113.76**	5.66	40.90**
P_6xP_8	-	36.45**	-	33.45**	27.74**	85.42**	29.19**	55.54**	14.92*	53.24**
P_6xP_9	-	32.06**	-	31.40**	7.34**	55.83**	15.92**	30.65**	3.44	37.93**
P_6xP_{10}	-	12.96	-	9.44*	-	8.94*	-	-	-	7.91
P_7xP_8	51.65**	26.94**	50.95**	17.92**	26.58**	35.18**	-	34.76**	37.27**	28.64**
P_7xP_9	9.29*	-	20.08**	-	70.32**	21.57**	61.72**	138.52**	43.18**	34.17**
P_7xP_{10}	134.69**	124.58**	37.40**	28.13**	12.64**	15.24**	32.40**	95.29**	56.38**	63.69**
P_8xP_9	39.99**	-	46.39**	-	20.32**	28.52**	44.37**	73.83**	36.07**	19.07*
P_8xP_{10}	42.83**	36.69**	49.87**	39.73**	25.34**	33.86**	-	5.21	23.65**	29.43**
P_9xP_{10}	34.44**	28.64**	42.43**	32.79**	42.65**	45.93**	3.72*	34.37**	29.63**	35.68**
S.E.±	01.78	01.75	1.28	01.18	1.19	01.12	1.51	01.47	1.45	1.37

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

Table 16. Heterosis percentage over better parent (BP) and check variety (EH) for percentage fruit set in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	0.80*	-	-	-	-	-	-	-	-	-
P_1xP_3	0.24	-	1.69**	0.20	2.18**	0.53	-	-	0.52	-
P_1xP_4	0.50	1.28	1.43**	1.96*	-	0.21	1.22	0.44	0.73	0.97
P_1xP_5	-	-	-	-	4.39**	0.04	8.06**	7.23	3.22	0.14
P_1xP_6	2.93**	4.65**	3.88**	4.06**	1.55**	4.53**	8.50**	7.66	4.41*	5.23*
P_1xP_7	3.15**	-	2.40**	-	3.33**	-	6.28**	5.49	3.81*	-
P_1xP_8	-	-	5.21**	4.50**	6.11**	4.41**	8.12**	7.87	4.66*	3.96*
P_1xP_9	6.54**	4.07**	5.64**	1.92*	6.32**	1.42	2.52	3.24	5.23*	2.66
P_1xP_{10}	1.43**	2.54*	0.84*	2.10*	1.28**	1.84*	0.97	1.83	1.12	2.08
P_2xP_3	-	-	0.51	-	0.76*	-	2.57	3.18	0.98	0.08
P_2xP_4	1.34**	2.13*	1.64**	2.16*	-	0.20	-	0.27	0.95	1.19
P_2xP_5	6.89**	4.87**	7.49**	4.73**	9.43**	4.87**	1.41	2.00	7.34**	4.13*
P_2xP_6	-	-	-	-	-	-	2.40	3.01	-	-
P_2xP_7	4.87**	-	3.31**	-	4.03**	-	1.07	1.67	3.64	-
P_2xP_8	3.60**	3.40**	3.61**	2.91**	3.59**	1.93*	0.91	1.51	3.13	2.44
P_2xP_9	6.22**	3.75**	6.84**	3.08**	7.06**	2.14*	-	0.56	4.95*	2.24
P_2xP_{10}	-	-	-	-	-	-	2.28	3.16	-	0.08
P_3xP_4	-	-	-	-	-	-	-	-	-	-
P_3xP_5	1.52**	1.20	2.50**	0.99	6.51**	2.08*	0.95	0.76	2.17	1.26
P_3xP_6	2.44**	4.16**	3.50**	3.69**	-	2.64*	-	-	1.12	1.92
P_3xP_7	-	-	-	-	-	-	-	-	-	-
P_3xP_8	2.46**	2.26*	1.95**	1.26	1.92**	0.29	7.15**	6.95	3.38	2.68
P_3xP_9	3.81**	3.49**	4.78**	3.24**	7.11**	2.18*	-	-	2.88	1.88
P_3xP_{10}	2.49**	3.62**	0.91*	2.18*	2.81**	3.38**	2.18	3.05	2.09	3.06
P_4xP_5	1.65**	2.44*	1.20**	1.72*	-	0.91	6.35**	3.28	2.09	2.34
P_4xP_6	0.69*	2.37*	2.81**	3.34**	-	2.71*	1.00	-	1.15	1.94

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	2.49**	3.29**	1.94**	2.46*	-	0.63	0.28	-	1.23	1.48
P_4xP_8	0.32	1.10	-	0.38	-	-	0.63	0.39	0.02	0.44
P_4xP_9	0.33	1.11	0.43	0.94	-	-	-	-	-	0.07
P_4xP_{10}	2.29**	3.42**	2.21**	3.50**	1.81**	1.19	-	-	1.25	2.21
P_5xP_6	0.17	1.84*	1.70**	1.88*	-	2.25*	6.19**	4.42	1.80	2.60
P_5xP_7	6.88**	3.69**	7.95**	5.18**	7.33**	2.58*	0.02	-	6.25*	3.08
P_5xP_8	-	2.62*	-	-	2.41**	0.77	4.41*	4.16	1.43	00.75
P_5xP_9	4.75**	2.76*	5.48**	2.78**	7.71**	3.23**	6.27**	6.92	6.55*	3.94*
P_5xP_{10}	2.30**	3.43**	1.97**	3.26**	2.72**	3.30**	-	-	-	-
P_6xP_7	-	0.79	-	-	-	-	5.45*	4.84	0.51	5.04*
P_6xP_8	3.75**	6.07**	5.16**	5.36**	2.07**	4.13**	4.49*	4.24	4.23*	-
P_6xP_9	1.67**	7.51**	3.54**	3.37**	1.17**	4.13**	-	-	1.53	-
P_6xP_{10}	1.84**	0.66	0.66*	1.92*	-	1.01	-	2.94	-	-
P_7xP_8	0.34	0.66	3.82**	3.12**	2.51**	0.87	1.68	1.44	2.08	-
P_7xP_9	3.36**	0.95	3.61**	-	5.37**	1.10	3.73*	3.29	4.16*	-
P_7xP_{10}	-	-	-	-	-	-	3.64*	-	-	-
P_8xP_9	1.54**	1.34	2.53**	1.84*	2.50**	0.86	3.65*	4.36	2.79	-
P_8xP_{10}	3.36**	4.49**	2.45**	3.85**	1.46**	2.02*	-	-	1.42	-
P_9xP_{10}	4.05**	5.19**	2.89**	4.19**	2.78**	3.35**	2.83	3.71	3.14	-
S.E.±	0.79	0.76	0.73	0.69	0.79	0.75	4.15	4.11	1.59	1.56

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

in E_3; 0.02 (P_5xP_7) to 8.50 (P_1xP_6) in E_4 and 0.02 (P_4xP_8) to 0.7.34 (P_2xP_5) percent in pooled, respectively. Crosses P_1xP_6, P_1xP_7, P_5xP_9 and P_7xP_9 depicted significant heterobeltiosis in all as well as over the environments. While among 45 hybrids significant economic heterosis was observed for 24, 27, 19 and 5 hybrids in E_1, E_2, E_3, and pooled, respectively. The economics heterosis ranged from 0.66 (P_6xP_{10} and P_7xP_8) to 7.51 (P_6xP_9) in E_1; 0.20 (P_1xP_3) to 5.36 (P_6xP_8) in E_2; 0.04 (P_1xP_5) to 4.87 (P_2xP_5) in E_3; 0.27 (P2xP4) to 7.87 (P_1xP_8) in E_4 and 0.08 (P_2xP_3) to 5.23 (P_4xP_6) percent in pooled analysis.

Nath and Dutta (1970). suggested hybrid vigor for percent fruit set over better parent in watermelon.

Number of Fruits Per Vine : (Table 17)

The significant heterobeltiosis in desired direction among 45 hybrids was recorded for 25, 30, 29, 28 and 27 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. The heterobeltiosis varied from 0.17 (P_1xP_2) to 261.71 (P_1xP_8) in E_1; 2.43 (P_6xP_8) to 273.50 (P_1xP_8) in E_2; 2.01 (P_5xP_8) to 165.49 (P_5xP_9) in E_3; 0.60 (P_4xP_9) to 166.0 (P_2xP_6) in E_4 and 0.28 (P_1xP_3) to 139.42 (P_5xP_9) percent in pooled analysis. Crosses P_1xP_5, P_1xP_6, P_1xP_7, P_1xP_8, P_1xP_9, P_2xP_3, P_2xP_5, P_2xP_8, P_3xP_9, P_3xP_{10}, P_5xP_9, P_5xP_{10}, P_7xP_9, P_7xP_{10}, P_8xP_9 and P_9xP_{10} showed significant heterobeltiosis in all as well as over the environment. Similarly out of 45 hybrids significant economic heterosis in desired direction was recorded for 28, 29, 24, 37 and 34 hybrids in E_1, E_2, E_3, E_4 and pooled, respectivley. It ranged from 0.37 (P_4xP_9) to 149.52 (P_1xP_6) in E_1; 13.40 (P_6xP_{10}) to 148.23 (P_1xP_5) in E_2; 1.82(P_2xP_7) to 156.28 (P_1xP_6) in E_3; 1.34 (P_3xP_6) to 201.74 (P_1xP_8) in E_4 and 1.37 (P_2xP_{10}) to 162.20 (P_1xP_6) percent in pooled analysis. Crosses P_1xP_6, P_1xP_8, P_1xP_9, P_1xP_{10}, P_2xP_5, P_2xP_8, P_3xP_9, P_3xP_{10}, P_4xP_{10}, P_5xP_6, P_5xP_7, P_5xP_9, P_5xP_{10}, P_6xP_8, P_6xP_9, P_7xP_8 and P_9xP_{10} showed significant economic heterosis in all as well as over the environments.

Similar findings about heterotic effect for number of fruit per vine in various cucurbits was also suggested by Nath and Dutta (1970), Singh *et al.* (1970), Gill*et al* (1971), Tyagi (1973), Sachan and Nath (1976), Dixit and Kalloo (1983), Mishra and Seshadri (1985), Sidhu and Brar (1985), Jankiram and Sirohi (1989) and Lawarnde and Patil (1990).

Table 17. Heterosis percentage over better parent (BP) and check variety (EH) for number of fruits per vine in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	0.17	-	4.63	-	-	-	-	17.91*	1.95	-
P_1xP_3	-	-	-	-	37.46**	27.76*	-	-	0.28	-
P_1xP_4	-	-	-	-	3.89	25.18*	10.15**	64.19**	-	19.05*
P_1xP_5	45.19**	-	54.22**	-	84.51**	14.77	81.87**	171.08**	95.83**	42.00**
P_1xP_6	71.61**	149.52**	78.78**	148.23**	71.50**	156.28**	99.73**	197.72**	94.43**	162.20**
P_1xP_7	26.20**	-	31.63**	-	54.45**	5.80	45.14**	116.32**	41.16**	28.03**
P_1xP_8	261.71**	128.59**	273.50**	124.52**	135.29**	147.44**	102.42**	201.74**	187.24**	149.61**
P_1xP_9	210.26**	46.22**	202.03**	44.30**	121.88**	31.32*	29.17**	92.56**	110.23**	52.45**
P_1xP_{10}	60.20**	55.05**	47.08**	38.90**	48.06**	52.35**	-	32.59**	37.11**	45.02**
P_2xP_3	24.95**	25.19*	25.05**	18.80**	26.68**	17.73	114.30**	114.03**	46.83**	41.46**
P_2xP_4	-	-	-	-	-	20.40	-	19.09*	-	4.72
P_2xP_5	110.09**	38.70**	122.07**	41.09**	150.47**	80.18**	29.80**	42.50**	104.06**	51.99**
P_2xP_6	-	-	-	-	-	-	166.00**	120.58**	-	6.04
P_2xP_7	-	-	5.11*	-	40.01**	1.82	20.95**	77.03**	17.07	6.18
P_2xP_8	129.54**	45.08**	132.89**	40.02**	52.07**	59.92**	33.92**	60.86**	74.27**	51.44**
P_2xP_9	138.53**	30.86**	121.36**	23.13**	19.78**	59.89**	-	-	84.02**	29.32**
P_2xP_{10}	-	-	-	-	-	-	38.39**	80.85**	-	1.37
P_3xP_4	-	-	-	-	-	-	-	-	-	-
P_3xP_5	4.42	4.63	28.55**	19.65**	46.39**	36.05*	19.50**	31.20**	27.81*	23.13*
P_3xP_6	-	40.78**	12.96**	56.85**	10.10**	64.54**	-	1.34	5.47	42.23**
P_3xP_7	49.49**	49.81**	57.52**	46.63**	-	-	-	-	16.40*	13.79
P_3xP_8	-	-	5.98*	-	83.93**	-	90.07**	128.27**	59.63**	53.78**
P_3xP_9	14.90**	15.12*	26.01**	17.10*	40.94**	30.98*	5.35*	19.54*	25.63*	21.02*
P_3xP_{10}	41.03**	41.30**	47.78**	39.57**	48.65**	52.98**	17.09**	82.99**	38.76**	46.77**
P_4xP_5	-	23.72*	17.99**	43.32**	0.96	21.62	130.55**	175.24**	34.55**	63.21**
P_4xP_6	4.12*	51.41**	7.64**	49.30**	4.24	13.18	-	6.84	5.16	41.82**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	-	19.56*	-	15.14*	-	12.69	-	24.35**	-	17.73*
P_4xP_8	-	-	-	-	-	7.62	2.52	23.11**	-	-
P_4xP_9	-	0.37	-	-	-	5.08	0.60	20.09*	-	5.45
P_4xP_{10}	4.67*	29.49**	3.98*	26.30**	27.26**	53.32**	-	27.68**	11.06	34.72**
P_5xP_6	-	22.26*	-	34.12**	-	28.69*	99.97**	119.54**	10.86	49.52**
P_5xP_7	56.73**	24.10*	63.66**	22.46**	134.84**	60.85**	-	24.85**	47.57**	33.85**
P_5xP_8	56.14**	3.07	56.49**	-	2.01	7.28	76.29**	111.75**	47.76**	28.40**
P_5xP_9	149.68**	64.84**	141.78**	53.64**	165.49**	65.17**	107.18**	135.11**	139.42**	78.33**
P_5xP_{10}	123.74**	118.59**	123.05**	40.63**	105.69**	111.68**	94.86**	154.61**	110.39**	122.53**
P_6xP_7	-	19.75*	-	22.20**	-	15.99	52.82**	123.71**	6.31	43.38**
P_6xP_8	-	43.95**	2.43	42.25**	30.38**	94.84**	34.93**	62.05**	19.73*	61.47**
P_6xP_9	-	36.81**	-	38.00**	8.60*	62.29**	12.81**	28.02**	5.29	42.00**
P_6xP_{10}	-	17.01*	-	13.40**	-	10.07	-	-	-	8.84
P_7xP_8	60.73**	27.27**	62.70**	21.75**	29.68**	36.39*	-	36.71**	43.93**	30.55**
P_7xP_9	16.75**	-	25.34**	-	79.39**	22.89	59.95**	134.12**	47.47**	33.76**
P_7xP_{10}	127.89**	120.60**	33.52**	26.08**	11.80*	15.06	39.37**	104.01**	55.09**	64.04**
P_8xP_9	91.11**	-	52.63**	-	23.23**	29.58*	51.68**	82.19**	40.95**	22.49*
P_8xP_{10}	47.60**	42.86**	53.71**	45.15**	29.91**	36.61*	-	4.36	25.68*	32.94**
P_9xP_{10}	39.85**	35.40**	48.15**	39.88**	46.57**	50.32**	6.58**	39.29**	33.91**	41.64**
S.E.±	1.56	1.49	1.15	1.11	2.85	02.78	1.31	01.29	1.73	1.67

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

Length of Fruit (cm) : (Table 18)

Out of 45 hybrids significant positive heterobeltiosis was records for 17, 19, 18, 15 and 9 hybrids in E_1, E_2, E_3, E_4, and pooled, respectively. It ranged from 2.12 (P_7xP_{10}) to 58.02 (P_3xP_8) in E_1; 1.50 (P_4xP_{10}) to 54.85 (P_7xP_9) in E_2; 3.18 (P_2xP_7) to 63.78 (P_6xP_8) in E_3; 0.64 (P_1xP_6) to 43.48 (P_1xP_3) in E_4 and 3.26 (P_5xP_7) to 41.33 (P_3xP_8) percent over the environments. Crosses P_1xP_3, P_5xP_{10} and P_7xP_8 showed significant heterobeltiosis in desired direction in all as well as over the environments. Among 45 hybrids significant economic heterosis was observed for 25, 22, 11, 1 and 9 hybrids in E_1, E_2, E_3, E_4, and pooled, respectively. It ranged from 0.10 (P_2xP_5) to 96.43 (P_3xP_8) in E_1; 3.03 (P_3xP_9) to 92.06 (P_3xP_8) in E_2, 2.47 (P_1xP_2), to 33.76 (P_3xP_{10}) in E_3, only one 17.65 (P_7xP_8) in E_4 and 0.42 (P_2xP_8) to 35.89 (P_3xP_8) percent in pooled analysis. Crosses P_1xP_3, P_1xP_8 P_4xP_8, P_4xP_9, P_4xP_{10} and P_5xP_{10} showed significant economic heterosis in first three (E_1, E_2, and E_3) as well as over the environments, suggested these crosses superior over check.

Hence the present findings are in confirmation to work reported by Gill *et al.* (1971), Sachan and Nath (1976) and Jankiram and Sirohi (1989) in summer squash watermelon and Bottle gourd, respectively.

Girth of Fruit (cm) : (Table 19)

Out of 45 hybrids significant heterobeltiosis was obtained for 23, 13, 15, 24 and 7 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. It ranged from 1.22 (P_2xP_6) to 61.88 (P_3xP_6) in E_1; 1.75 (P_6xP_7) to 99.39 (P_3xP_6) in E_2; 5.73 (P_5xP_{10}) to 75.00 (P_3xP_6) in E_3, 1.18 (P_1xP_6) to 50.37 (P_3xP_5) in E_4 and 0.39 (P_1xP_3) to 75.96 (P_3xP_5) percent in pooled analysis. Crosses P_3xP_6 and P_3xP_{10} exhibited significant heterobeltiosis in all the environments. Similarly significant economic heterosis in desired direction among 45 hybrids were recorded for 23, 17, 29, 41 and 31 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. It ranged from 1.16 (P_2xP_4) to 58.08 (P_3xP_6) in E_1; 2.63 (P_6xP_9) to 84.23 (P_3xP_6) in E_2; 7.33 (P_2xP_4) to 63.24 (P_1xP_{10}) in E_3; 4.70 (P_3xP_7) to 89.00 (P_1xP_3) in E_4 and 1.99 (P_4xP_5) to 51.56 (P_3xP_6) percent in pooled analysis. Crosses P_1xP_2, P_1xP_5, P_1xP_6, P_2xP_9, P_3xP_6, P_3xP_{10}, P_4xP_{10}, P_7xP_9 and P_9xP_{10} showed significant economic heterosis in all as well as over the environments.

Table 18. Heterosis percentage over better parent (BP) and check variety (EH) for length of fruit (cm) in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	-	31.99**	-	30.69*	6.78*	2.47	-	-	-	-
P_1xP_3	26.88**	75.11**	22.16**	75.84**	27.77**	22.61*	43.48**	-	30.92**	32.28**
P_1xP_4	-	52.68**	-	51.69**	-	10.11	-	-	-	12.90
P_1xP_5	-	14.08	-	18.09	-	-	-	-	-	-
P_1xP_6	-	18.09*	-	20.18	-	-	-	-	-	-
P_1xP_7	-	-	-	-	-	-	13.08**	-	-	-
P_1xP_8	10.43**	52.42**	7.89*	55.31**	20.00**	15.13*	0.64	-	16.34*	18.03*
P_1xP_9	17.31**	61.87**	17.00**	68.38**	27.97**	27.39**	-	-	10.53	12.13
P_1xP_{10}	-	33.18**	1.59	46.21**	14.11**	9.47	4.76	-	4.29	5.81
P_2xP_3	-	0.81	-	3.5	-	-	21.24**	-	-	-
P_2xP_4	-	-	-	-	-	-	-	-	-	-
P_2xP_5	-	0.10	-	18.69	10.57**	7.48	7.72**	-	-	0.94
P_2xP_6	-	0.04	-	16.69	16.42**	3.50	34.00**	-	11.17	2.05
P_2xP_7	-	0.12	-	3.85	3.18	-	-	-	-	-
P_2xP_8	13.36**	30.99**	11.40*	29.99*	8.36*	-	-	-	18.47	0.42
P_2xP_9	-	-	-	-	-	-	-	-	-	-
P_2xP_{10}	10.83**	28.11*	21.10**	17.97	25.37**	11.46	2.10	-	14.62	5.21
P_3xP_4	-	-	-	-	-	-	-	-	-	-
P_3xP_5	-	-	-	-	-	-	-	-	-	-
P_3xP_6	4.08	29.38*	12.00**	43.76**	26.92**	-	2.20	-	11.46	7.18
P_3xP_7	-	15.20	-	5.83	-	18.23*	-	-	-	-
P_3xP_8	58.02**	96.43**	49.61**	92.06**	43.58**	-	-	-	41.33**	35.89**
P_3xP_9	-	2.30	-	3.03	-	33.76**	-	-	-	-
P_3xP_{10}	-	6.46	-	22.75*	11.08**	3.50	4.35	-	-	-
P_4xP_5	-	-	-	-	-	-	-	-	-	-
P_4xP_6	-	29.26**	-	43.17**	-	16.80*	-	-	-	11.45

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	4.87**	68.78**	11.90**	82.84**	-	13.45	-	-	-	21.70*
P_4xP_8	-	38.25**	-	45.86**	3.42	23.73*	-	-	-	15.47*
P_4xP_9	-	42.63**	2.71	67.79**	9.83**	31.37**	-	-	-	21.96*
P_4xP_{10}	-	50.58**	1.50	65.81**	-	19.11*	-	-	-	23.33*
P_5xP_6	-	-	-	-	-	-	-	-	-	-
P_5xP_7	-	8.18	-	5.02	21.35**	11.46	11.56**	-	3.26	-
P_5xP_8	5.81*	20.28*	2.97	24.15*	-	-	-	-	-	-
P_5xP_9	2.63	16.70*	-	20.30	-	-	12.69**	-	3.88	0.77
P_5xP_{10}	36.41**	55.07**	32.65**	59.98**	18.78**	15.44*	28.21**	-	28.46**	24.61*
P_6xP_7	23.44**	15.09	44.57**	18.09	-	-	12.39**	-	9.86	-
P_6xP_8	19.62**	-	20.00**	-	63.78**	6.93	-	-	22.04*	-
P_6xP_9	39.43**	45.85**	37.54**	38.51*	-	-	18.48**	-	31.09*	521
P_6xP_{10}	22.65**	29.15*	46.61**	43.87**	-	-	16.48**	-	19.48*	-
P_7xP_8	18.05**	10.02*	28.72**	26.02*	7.05*	-	41.27**	17.65*	21.31*	4.10
P_7xP_9	47.28**	54.03**	54.85**	55.66**	-	-	38.73**	-	38.45**	18.80*
P_7xP_{10}	2.12	7.48	12.60*	10.50	12.68**	3.50	1.73	-	13.81	-
P_8xP_9	-	4.37	10.78*	11.55	-	-	5.93*	-	20.34*	-
P_8xP_{10}	17.21**	23.38*	20.93**	18.67	-	-	-	-	14.64	-
P_9xP_{10}	43.54**	51.15**	46.54**	47.61**	-	-	26.63**	-	32.16**	9.57
S.E.±	0.73	00.71	01.02	00.98	00.83	00.87	0.82	00.85	0.86	0.85

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

Table 19. Heterosis percentage over better parent (BP) and check variety (EH) for girth of fruit (cm) in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	20.53**	46.66**	17.10**	40.98**	7.13**	37.12**	1.67	22.00**	12.92*	36.94**
P_1xP_3	-	8.52	-	7.42	-	13.86*	34.06**	89.00**	0.39	21.75
P_1xP_4	-	-	-	-	-	11.45	8.00**	35.00**	-	7.21*
P_1xP_5	7.27**	25.75**	13.22**	36.28**	-	27.91**	-	17.50*	4.25	17.16**
P_1xP_6	17.42**	36.66**	-	15.88*	-	16.28*	1.18	20.00*	0.94	22.41*
P_1xP_7	-	16.17*	-	16.25*	-	-	-	30.00**	-	12.44
P_1xP_8	-	15.68*	-	12.78	-	27.64**	-	38.60**	1.96	23.65**
P_1xP_9	8.26**	26.91**	9.29**	31.58**	-	47.23**	-	6.00	5.95	28.49**
P_1xP_{10}	14.84**	34.66**	-	-	6.57**	63.24*	5.40*	25.00**	2.58	24.40**
P_2xP_3	6.15*	29.14**	-	-	49.60**	33.81**	8.33**	30.00**	4.91	17.66*
P_2xP_4	-	1.16	-	12.78	-	7.33	18.00**	47.50**	-	16.81*
P_2xP_5	-	10.65	-	36.30**	54.87**	56.53**	22.94**	47.50**	18.13*	33.05**
P_2xP_6	1.22	23.14*	-	-	30.03**	16.28*	22.92**	47.50**	7.45	20.51*
P_2xP_7	-	-	-	-	-	07.33	-	31.20**	-	-
P_2xP_8	-	-	-	-	36.42**	-	4.17*	45.00**	6.26	19.18*
P_2xP_9	19.65**	45.59**	21.33**	44.36**	-	34.44**	-	25.00**	-	37.51**
P_2xP_{10}	-	-	-	-	19.15**	35.06**	-	-	-	4.08
P_3xP_4	-	13.94*	-	13.06*	-	7.42	-	25.00**	4.97	14.72*
P_3xP_5	-	5.23	-	6.48	-	-	50.37**	75.90**	75.96**	18.23*
P_3xP_6	61.88**	58.08**	99.39**	84.23**	75.00**	56.53**	29.52**	36.00**	-	51.56*
P_3xP_7	-	-	-	-	-	-	-	4.70	9.08	-
P_3xP_8	-	-	3.89	3.00	52.37**	45.80**	-	30.00**	-	19.75**
P_3xP_9	-	-	-	-	-	-	16.19**	22.00**	27.38**	-
P_3xP_{10}	25.85**	25.17**	41.98**	29.70**	16.73**	32.38**	23.81**	30.00**	-	29.44**
P_4xP_5	-	15.00*	-	-	-	-	16.00**	45.00**	4.66	1.99
P_4xP_6	-	-	15.04**	31.58**	-	25.22**	39.20**	74.00**	-	25.64**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	16.92**	34.46**	-	-	-	16.28*	-	20.00*	1.89	16.71*
P_4xP_8	7.91**	14.42*	-	10.05	-	7.33	1.65	50.00**	15.90*	22.31*
P_4xP_9	-	11.71	28.02**	46.43**	-	54.74**	13.47**	41.80**	11.71*	39.13**
P_4xP_{10}	26.26**	45.21**	8.71**	24.34**	-	21.64**	17.20**	46.50**	-	34.09**
P_5xP_6	8.83**	26.43**	-	-	13.27**	14.49*	11.62**	30.60**	-	9.21
P_5xP_7	-	-	-	-	7.32**	18.07*	-	30.00**	-	4.37
P_5xP_8	-	-	-	-	-	-	-	32.00**	-	2.66
P_5xP_9	-	-	-	-	-	36.85**	-	50.00**	2.53	19.18*
P_5xP_{10}	-	-	24.44**	45.49**	5.73*	19.86*	28.21**	48.30**	11.97	26.11**
P_6xP_7	25.87**	43.66**	1.75	14.75*	-	8.23	26.78**	32.50**	-	24.41**
P_6xP_8	16.24**	15.00*	-	-	61.87**	54.93**	-	34.40**	13.37*	24.79**
P_6xP_9	28.08**	25.85**	40.94**	2.63	-	31.75**	35.00**	35.00**	6.53	23.84**
P_6xP_{10}	-	-	-	-	-	-	42.65**	44.50**	-	-
P_7xP_8	-	06.68	-	4.32	13.96**	25.40**	4.62**	70.00**	6.79	32.76**
P_7xP_9	14.59**	30.78**	14.67**	29.32**	-	16.28*	-	60.00**	7.49	33.62**
P_7xP_{10}	-	-	-	-	-	-	-	41.70**	-	-
P_8xP_9	-	-	-	-	-	14.49*	4.34*	54.00**	-	8.26
P_8xP_{10}	-	-	-	-	-	-	-	23.30**	-	-
P_9xP_{10}	17.26**	16.65*	13.89**	15.60*	-	15.92*	35.54**	37.30**	4.24	21.17*
S.E.±	0.73	00.71	0.76	00.72	00.66	00.65	0.60	00.58	0.69	0.67

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

Sachan and Nath (1976) in watermelon and Jankiram and Sirohi (1989) in Bottle gourdreported heterotic effect over parent for size and width of fruit, which indirectly support the present findings.

Weight of Fruit (gm) : (Table 20)

Significant heterobeltiosis in desired direction was depicted for 7, 20, 14, 25 and 12 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively, out of 45 hybrids. Heterobeltiosis varied from 2.83(P_1xP_2) to 338.86 (P_2xP_7) in E_1; 7.34 (P_5xP_9) to 229.65 (P_6xP_8) in E_2; 8.05 (P_3xP_8) to 221.41 (P_6xP_8) in E_3; 1.33 (P_1xP_5) to 206.07 in E_4 and 4.93 (P_2xP_{10}) to 123.33 (P_6xP_8) percent over the environments. Crosses P_1xP_6, P_1xP_8, P_5xP_{10}, P_6xP_8 and P_7xP_8, showed significant heterobeltiosis in all as well as over the environments. Out of 45 hybrids significant positive economic heterosis was observed for 2, 41, 39, 9, and 18 hybrids in E_1, E_2, E_3, E_4 and pooled respectively. It ranged from 2.0 (P_4xP_7) to 487.01 (P_2xP_7) in E_1; 18.35 (P_1xP_4) to 255.78 (P_3xP_6) in E_2; 2.60 (P_2xP_3) to 209.17 (P_3xP_6) in E_3; 0.51 (P_7xP_9) to 75.73 (P_4xP_6) in E_4 and 0.89 (P_6xP_9) to 110.64 (P_2xP_7) percent in pooled analysis. Crosses P_2xP_7 and P_3xP_6 depicted significant economic heterosis in first three (e.g. E_1, E_2 and E_3) as well as over the environments.

Hence present findings are in confirmation to work reported by Bhattacharya *et al.* (1970), Nath and Dutta (1970), Tyagi (1973), Nandpuri *et al.* (1974), Sachan and Nath (1976), Mishra and Seshadri (1985), Sidhu and Brar (1985), Jankiram and Sirohi (1989) and Lawande and Patil (1990) in different cucurbits.

Fruit Yield Per Vine (gm) : (Table 21)

Out of 45 hybrids significant positive heterobeltiosis was recorded for 29, 41, 38, 26 and 29 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. It ranged from 1.32 (P_8xP_{10}) to 741.92 (P_1xP_8) in E_1, 3.63 (P_3xP_9) to 561.50 (P_1xP_8) in E_2, 5.37 (P_2xP_{10}) to 405.31 (P_1xP_8) in E_3, 5.60 (P_4xP_9) to 231.71 (P_5xP_{10}) in E_4 and 5.24 (P_3xP_5) to 501.64 (P_1xP_6) percent in pooled analysis. Crosses P_1xP_5, P_1xP_6, P_1xP_7, P_1xP_8, P_1xP_9, P_2xP_5, P_2xP_8, P_2xP_{10}, P_3xP_{10}, P_5xP_6, P_5xP_8, P_5xP_9, P_5xP_{10}, P_6xP_8, P_7xP_8, P_7xP_9 and P_9xP_{10} depicted significant heterobeltiosis in all as well as over the environments. Which indicates the superiority of these hybrids over better parent. Among 45 hybrids

Table 20 Heterosis percentage over better barent (BP) and check variety (EH) for weight of fruit (g) in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	2.83	37.53	14.50**	125.04**	-	81.10**	-	-	-	25.66
P_1xP_3	20.63	53.79	51.59**	198.14**	57.16**	150.67**	92.07**	37.98**	64.81**	90.06**
P_1xP_4	-	35.47	-	81.35**	-	32.90**	-	-	-	16.17
P_1xP_5	39.04	53.51	32.55**	160.53**	30.69**	102.92**	1.33	-	36.69*	39.71*
P_1xP_6	83.15**	102.19	34.35**	164.07**	34.34**	108.61**	206.07**	12.25**	71.47**	75.25**
P_1xP_7	-	2.63	-	58.16**	-	11.02*	-	-	-	1.56
P_1xP_8	70.04*	87.71	28.90**	153.32**	21.61**	88.82**	19.75**	-	54.78*	58.19*
P_1xP_9	-	18.83	6.56**	109.45**	-	187.42**	-	-	-	33.64*
P_1xP_{10}	58.39*	74.85	12.78**	147.58**	23.98**	92.50**	-	-	35.35*	38.34*
P_2xP_3	-	-	-	52.46**	-	2.60	-	-	-	5.51
P_2xP_4	-	22.13	-	57.47**	-	15.08*	-	-	-	15.23
P_2xP_5	-	7.94	-	75.47**	-	49.46**	35.90**	-	-	22.33
P_2xP_6	-	15.24	-	82.34**	-	60.51**	10.20**	-	-	19.58
P_2xP_7	338.86**	487.01**	-	52.59**	-	106.83**	-	-	57.02**	110.64**
P_2xP_8	7.50	43.79	31.55**	143.17**	-	102.70**	31.32**	2.04	14.88	54.11*
P_2xP_9	14.93	65.61	16.72**	115.76**	-	78.97**	-	-	-	26.78
P_2xP_{10}	30.82	74.98	42.64**	163.69**	-	93.23**	-	-	4.93	40.75*
P_3xP_4	-	-	-	-	-	39.45**	20.71**	27.54**	-	7.92
P_3xP_5	-	-	-	29.58**	-	3.53	13.28**	-	-	-
P_3xP_6	34.45	271.42**	127.37**	255.78**	93.79**	209.17**	-	-	59.53**	82.96**
P_3xP_7	-	-	-	20.20**	-	22.49**	-	-	-	-
P_3xP_8	-	10.00	8.06**	69.08**	8.05**	72.33**	32.35**	2.84	12.18	29.36
P_3xP_9	-	-	-	28.80**	-	60.23**	-	-	-	-
P_3xP_{10}	5.24	34.17	32.36**	118.13**	12.55**	79.54**	12.93**	-	16.61	34.47*
P_4xP_5	-	-	-	-	-	-	-	4.09	-	4.24
P_4xP_6	-	75.99	-	121.89**	-	66.33**	66.32**	75.73**	-	80.97**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	-	2.00	-	76.46**	-	52.00**	-	-	-	21.76
P_4xP_8	-	53.16	-	103.63**	-	92.91**	88.62**	99.29**	-	88.87**
P_4xP_9	-	28.36	-	82.56**	-	68.55**	4.64**	10.55*	-	37.77*
P_4xP_{10}	-	5.97	-	41.62**	-	44.88**	-	-		9.54
P_5xP_6	49.86	-	80.73**	64.03**	65.66**	88.03**	6.41*	-	47.6*	10.82
P_5xP_7	31.44	27.15	54.71**	84.15**	53.35**	71.50**	14.66**	-	35.74*	28.56
P_5xP_8	43.51	15.24	63.08**	48.01**	27.75**	42.69**	-	-	33.38	4.89
P_5xP_9	-	36.52	7.34**	95.68**	-	92.53**	30.63**	-	-	30.71
P_5xP_{10}	109.99**	101.30	64.87**	171.72**	54.70**	102.46**	69.76**	9.19*	72.41**	74.31**
P_6xP_7	-	-	-	-	-	-	13.62**	-	-	-
P_6xP_8	138.15**	91.23	229.65**	191.36**	221.41**	155.72**	9.27**	-	123.33**	75.63**
P_6xP_9	-	-	-	41.54**	-	51.46**	124.26**	-	-	0.89
P_6xP_{10}	10.38	5.81	-	20.89**	-	-	32.20**	-	-	-
P_7xP_8	56.66*	51.54	120.05**	161.96**	100.92**	135.89**	53.87**	19.55**	82.75**	73.08**
P_7xP_9	-	19.50	-	78.71**	-	91.13**	32.11**	0.51	-	35.87*
P_7xP_{10}	-	-	-	18.82**	-	11.85*	-	-	-	-
P_8xP_9	-	-	-	60.79**	-	21.82**	40.10**	8.86*	-	17.33
P_8xP_{10}	-	-	-	-	-	-	-	-	-	-
P_9xP_{10}	-	27.02	-	56.08**	-	49.78**	19.75**	-	-	15.29
S.E.±	20.69	20.48	1.03	1.01	1.60	1.55	1.90	1.98	6.33	6.26

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

Table 21. Heterosis percentage over better parent (BP) and check variety [EH] for fruit yield per vine (g) in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	2.93	-	21.35**	26.07*	-	38.58*	-	-	-	-
P_1xP_3	-	11.18	77.84**	158.97**	115.42**	220.04**	77.91**	27.52**	68.99**	92.71**
P_1xP_4	-	29.51*	-	72.45**	-	66.37**	-	21.40	-	42.10**
P_1xP_5	198.71**	50.46**	196.58**	154.90**	152.01**	132.76**	150.67**	53.50**	178.01**	88.19**
P_1xP_6	437.41**	419.49**	499.90**	566.00**	350.69**	434.33**	515.16**	234.71**	501.64**	373.37**
P_1xP_7	34.28**	5.42	74.03**	55.40**	27.21**	17.49	44.97**	63.41**	49.23**	39.49**
P_1xP_8	741.92**	341.87**	561.50**	468.54**	405.31**	366.72**	200.64**	180.81**	444.40**	304.29**
P_1xP_9	157.74**	78.55**	257.54**	212.25**	114.34**	276.99**	27.36**	-	139.67**	103.44**
P_1xP_{10}	191.79**	178.89**	97.62**	207.71**	114.93**	193.02*	-	-	89.04**	108.52**
P_2xP_3	-	-	21.72**	77.25**	-	20.84	105.10**	48.43**	15.08	31.23*
P_2xP_4		23.00*	-	38.88**	-	38.53*	-	14.94*	-	26.03*
P_2xP_5	104.60**	54.45**	137.84**	147.08**	67.72**	172.31**	94.19**	37.23**	93.11**	90.37**
P_2xP_6	-	-	18.65**	31.72*	-	11.25	144.06**	72.47**	35.99**	34.06**
P_2xP_7	40.13**	10.02	15.64**	20.13	29.72**	110.61**	-	-	25.04*	23.27*
P_2xP_8	184.08**	114.42**	277.80**	240.54**	99.60**	224.05**	75.60**	64.02**	144.15**	140.69**
P_2xP_9	195.56**	123.13**	132.68**	141.72**	62.77**	185.58**	-	-	73.53**	71.07**
P_2xP_{10}	34.93**	28.97*	20.56**	87.72**	5.37*	71.08**	11.80**	-	21.87*	34.43**
P_3xP_4		-	-	-	-	-	-	3.40	-	-
P_3xP_5		-	6.35*	54.85**	-	40.76**	49.21**	6.94	5.24	20.00*
P_3xP_6	88.48**	148.15**	282.99**	457.70**	242.04**	408.16**	-	-	151.20**	186.44**
P_3xP_7	-	9.38	18.55**	72.62**	-	-	-	-	-	-
P_3xP_8	-	9.76	14.41**	66.59**	42.33**	111.57**	151.54**	134.94**	69.02**	92.74**
P_3xP_9	-	15.50	3.63	50.91**	19.22**	109.70**	-	-	9.90	25.33*
P_3xP_{10}	48.15**	95.66**	95.26**	204.03**	84.82**	174.59**	48.47**	24.54*	78.42**	103.44**
P_4xP_5	-	161.44**	-	34.68*	-	17.27	127.06**	186.65**	-	121.99**
P_4xP_6	4.73**	173.81**	-	231.49**	-	159.32**	49.47**	88.69**	-	145.96**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	-	25.72*	-	102.98**	-	66.75**	-	19.82*	-	45.62**
P_4xP_8	-	27.99*	-	54.70**	-	107.66**	94.30**	145.30**	-	97.74**
P_4xP_9	-	32.65**	-	80.00**	-	77.11**	5.60*	33.31**	-	51.08**
P_4xP_{10}	-	41.03**	-	78.57**	-	122.28**	-	4.47	-	51.66**
P_5xP_6	30.28**	25.93*	98.15**	119.98**	101.05**	138.36**	112.78**	30.29**	115.30**	69.40**
P_5xP_7	106.80**	62.36**	155.48**	128.14**	259.18**	175.73**	-	9.24	91.01**	78.55**
P_5xP_8	133.69**	22.65*	147.53**	40.76**	103.69**	52.86**	47.15**	37.45**	86.61**	38.58**
P_5xP_9	234.72**	131.87**	243.69**	200.15**	80.57**	217.60**	180.13**	71.53**	181.67**	139.11**
P_5xP_{10}	369.29**	348.55**	267.16**	471.68**	218.36**	343.31**	231.71**	178.24**	260.39**	297.54**
P_6xP_7	12.12**	8.38	8.47*	20.42*	-	-	71.70**	93.49**	50.47**	40.65**
P_6xP_8	190.88**	181.17**	268.97**	309.69**	319.75**	397.64**	47.54**	37.81**	276.02**	195.86**
P_6xP_9	3.43	-	73.68**	92.82**	39.40**	145.11**	152.23**	-	74.24**	47.92**
P_6xP_{10}	32.04**	27.63*	21.53**	34.92*	-	6.70**	-	-	-	5.39
P_7xP_8	152.20**	97.99**	256.81**	218.62**	319.65**	222.15**	45.22**	63.36**	149.43**	133.16**
P_7xP_9	44.46**	13.41	87.21**	67.71**	33.42**	134.67**	109.08**	135.62**	113.29**	99.37**
P_7xP_{10}	107.86**	98.68**	-	49.79**	-	28.91*	-	1.76	23.06*	35.75**
P_8xP_9	31.14**	-	65.87**	44.85**	-	58.14**	112.59**	68.57**	86.51**	58.34**
P_8xP_{10}	1.32	-	-	27.62*	-	33.35*	-	-	-	00.27
P_9xP_{10}	84.96**	76.79**	38.86**	116.21**	28.59**	120.12**	28.01**	7.38	51.56**	67.18**
S.E.±	58.50	58.41	52.64	52.56	32.28	82.19	92.14	92.07	71.41	71.32

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

significant economic heterosis was depicted for 29, 43, 38, 26 and 40 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. The economic heterosis varied from 5.42 (P_1xP_7) to 419.49 (P_1xP_6) in E_1; 20.13 (P_2xP_7) to 566 (P_1xP_6) in E_2; 6.70 (P_6xP_{10}) to 434.33 (P_1xP_6) in E_3, 1.76 (P_7xP_{10}) to 234.71 (P_1xP_6) in E_4 and 0.27 (P_8xP_{10}) to 373.37 (P_1xP_6) percent in pooled analysis. Crosses P_1xP_5, P_1xP_6, P_1xP_8, P_2xP_4, P_2xP_5, P_2xP_8, P_3xP_{10}, P_4xP_6, P_4xP_7, P_4xP_8, P_4xP_9, P_5xP_6, P_5xP_8, P_5xP_9, P_5xP_{10}, P_6xP_8 and P_7xP_8 exhibited significant economic heterosis in all as well as over the environments, suggested that these hybrids were superior over standard check.

Hybrid vigour for fruit yield per vine was also observed for various cucurbits by Hayes and Jones (1911), Foster (1967), Bhattacharya *et al.* (1970), Nath and Dutta (1970), Srivastava (1970), Nandpuri *et al.* (1974), Dixit and Kalloo (1983), Mishra and Seshadri (1985), Jankiram and Sirohi (1989) and Lawande and Patil (1990).

Number of Seeds Per Fruit : (Table 22)

Out of 45 hybrids significant heterobeltiosis in desired direction was recorded for 11, 8, 8, 6 and 6 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. It ranged from -2.72 (P_1xP_{10}) to -58.37 (P_3xP_5) in E_1; -0.79 (P_1xP_{10}) to -60.55 (P_3xP_5) in E_2; -0.56 (P_1xP_{10}) to -60.98 (P_3xP_5) in E_3; -0.27 (P_2xP_5) to -61.65 (P_3xP_5) in E_4 and -6.76 (P_1xP_5) to -44.49 (P_2xP_{10}) percent in pooled analysis. Crosses P_2xP_{10}, P_4xP_6, P_4xP_7, P_5xP_8, and P_5xP_9 showed significant heterobeltiosis in all as well as over the environments. Similarly out of 45 hybrid economic heterosis was observed for 29, 30, 31, 26 and 10 hybrids in E_1, E_2, E_3, E_4 and pooled, respectively. It ranged from -0.58 (P_9xP_{10}) to 71.13 (P_4xP_7) in E_1; -0.46 (P_5xP_{10}) to -71.78 (P_4xP_7) in E_2; -2.80 (P_5xP_{10}) to -69.73 (P_4xP_7) in E_3, -1.94 (P_9xP_{10}) to 68.65 (P_2xP_{10}) in E_4 and -4.88 (P_2xP_4) to -50.76 (P_8xP_9) percent in pooled analysis. Crosses P_1xP_5, P_1xP_6, P_1xP_7, P_1xP_{10}, P_2xP_3, P_2xP_5, P_2xP_6, P_2xP_7, P_2xP_8, P_2xP_{10}, P_3xP_4, P_3xP_5, P_3xP_6, P_3xP_7, P_3xP_8, P_3xP_{10}, P_4xP_5, P_4xP_6, P_4xP_7, P_4xP_{10}, P_5xP_6, P_5xP_9, P_6xP_7, P_7xP_8 and P_7xP_{10} showed significant economic heterosis in all the environments

Similar findings were also reported by Tyagi (1973) in Bottle gourd.

A perusal of table 23 revealed that hybrids P_1xP_6, P_1xP_8, P_2xP_5, P_2xP_8, P_3xP_{10}, and P_5xP_{10} were superior, since all the six hybrids exhibited over the better parent as well as standard check for number of female flower per plant, Number of fruits per

Table 22. Heterosis percentage over better parent (BP) and check variety (EH) for number of seeds per fruit in Bitter gourd

Crosses	Environment									
	E_1		E_2		E_3		E_4		Pooled	
	BP	EH	BP	EH	BP	EH	BP	EH	BP	EH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_1xP_2	-	-5.45	-	-3.69	-	-5.43	-	-2.95	-	-
P_1xP_3	-	-	-	-	-	-	-	-	-	-10.59*
P_1xP_4	-	-32.17**	-	-36.53**	-	-40.80**	-	-34.03**	-	-
P_1xP_5	-6.26**	-20.30**	-6.54**	-21.15**	-11.36**	-24.72**	-2.10	-15.49**	-6.76	-
P_1xP_6	-	-29.95**	-	-32.62**	-	-34.21**	-	-24.48**	-	-
P_1xP_7	-	-40.22**	-	-40.28**	-	-49.21**	-	-44.01**	-	-
P_1xP_8	-	-	-	-	-	-	-	-	-	-11.44**
P_1xP_9	-	-12.92**	-1.81	-17.15**	-	-11.13*	-	-5.10	-	-
P_1xP_{10}	-2.72	-18.79**	-0.79	-17.75**	-0.56	-16.48**	-	-13.37**	-	-
P_2xP_3	-	-29.31**	-	-32.72**	-	-31.97**	-	-38.57**	-	-
P_2xP_4	-	-	-	-	-	-	-	-	-	-4.88
P_2xP_5	-20.86**	-45.99**	-10.81**	-44.03**	-11.20**	-46.97**	-0.27	-43.54**	-11.17*	-
P_2xP_6	-	-29.44**	-	-33.97**	-	-37.57**	-	-30.98**	-	-
P_2xP_7	-9.32**	-56.19**	-	-50.84**	-	-55.70**	-	-49.30**	-	-
P_2xP_8	-	-8.56**	-	-11.22**	-	-14.96**	-	-9.80*	-	-
P_2xP_9	-	-	-	-	-	-	-	-	-	-11.47**
P_2xP_{10}	-48.31**	-64.72**	-44.62**	-65.25**	-40.05**	-64.20**	-44.62**	-68.65**	-44.49**	-
P_3xP_4	-	-19.05**	-	-17.34**	-	-18.38**	-	-16.55**	-	-
P_3xP_5	-58.37**	-62.41**	-60.55**	-64.53**	-60.98**	-65.63**	-61.65**	-66.81**	-13.91	-
P_3xP_6	-9.01**	-40.60**	-	-26.31**	-	-30.48**	-	-25.26**	-	-
P_3xP_7	-	-48.07**	-	-45.06**	-	-45.88**	-	-43.23**	-	-
P_3xP_8	-3.49*	-6.99*	-	-5.72*	-	-8.12*	-	-12.41**	-	-
P_3xP_9	-	-	-	-	-	-	-	-	-	-32.95**
P_3xP_{10}	-	-13.56**	-	-13.06**	-	-12.19**	-	-16.01**	-	-
P_4xP_5	-	-25.46**	-	-23.68**	-	-21.43**	-	-19.13**	-	-
P_4xP_6	-36.09**	-61.03**	-39.94**	-63.93**	-25.13**	-56.30**	-38.56**	-61.58**	-35.03**	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
P_4xP_7	-40.24**	-71.13**	-38.28**	-71.78**	-27.80**	-69.73**	-35.41**	-68.65**	-35.65**	-
P_4xP_8	-	-	-	-	-	-	-	-	-	-21.76**
P_4xP_9	-	-	-	-	-	-	-	-	-	-14.97**
P_4xP_{10}	-	-16.77**	-	-15.62**	-	-17.73**	-	-12.81**	-	-
P_5xP_6	-	-28.70**	-	-28.12**	-	-28.30**	-	-24.57**	-	-
P_5xP_7	-	-	-	-	-	-	-	-	-	-5.22
P_5xP_8	-46.71**	-51.89**	-44.39**	-50.00**	-35.87**	-47.12**	-32.20**	-4.40	-41.59**	-
P_5xP_9	-22.38**	-29.92**	-21.55**	-29.47**	-25.32**	-34.21**	-16.58**	-27.99**	-21.49**	-
P_5xP_{10}	-	-00.58	-	-0.46	-	-2.80	-	-3.73	-	-
P_6xP_7	-	-45.25**	-	-44.43**	-	-44.01**	-	-50.23**	-	-
P_6xP_8	-	-10.77*	-	-11.81**	-	-9.14*	-	-4.66	-	-
P_6xP_9	-	-2.98	-	-5.90*	-	-9.76*	-	-3.58	-	-
P_6xP_{10}	-	-	-	-	-	-	-	-	-	-28.60**
P_7xP_8	-	-22.00**	-	-27.53**	-	-30.35**	-	-37.07**	-	-
P_7xP_9	-	-	-	-	-	-	-	-	-	-30.95**
P_7xP_{10}	-	-20.20**	-	-19.00**	-	-18.41**	-	-12.44**	-	-
P_8xP_9	-	-	-	-	-	-	-	-	-	-50.76**
P_8xP_{10}	-	-	-	-	-	-	-	-	-	-37.07**
P_9xP_{10}	-	0.58	-	-3.12	-	-6.68*	-	1.94	-	-
S.E.±	0.97	1.08	0.90	00.87	1.07	1.02	0.96	00.89	0.98	0.97

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

ıle 23. Superior hybrids over better parent and standard check for thirteen traits in Bitter gourd

ıaracter	Heterobeltiosis	Economic heterosis
ıys taken to the pearance of first female ›wer	(P_2xP_8), (P_2xP_9)	(P_1xP_2), (P_1xP_5), (P_2xP_3), (P_2xP_5), (P_2xP_8), (P_2xP_9), (P_2xP_{10}), (P_3xP_6), (P_5xP_7), (P_5xP_8), (P_6xP_8), (P_7xP_8)
›de number at which ˈst female flower appear	(P_2xP_5), (P_5xP_9)	-
ːngth of main shoot (cm)	(P_5xP_{10})	-
umber of lateral branches ›r plant	(P_1xP_2), (P_2xP_5), (P_2xP_{10}), (P_7xP_9)	(P_2xP_{10}), (P_7xP_9)
umber of male flower ːr plant	(P_3xP_4)	-
umber female flower per ant	(P_1xP_5), (P_1xP_6), (P_1xP_7), (P_1xP_8), (P_1xP_9), (P_2xP_3), (P_2xP_5), (P_2xP_8), (P_3xP_9), (P_3xP_{10}), (P_5xP_{10}), (P_7xP_9), (P_7xP_{10}), (P_8xP_9), (P_9xP_{10})	(P_1xP_6), (P_1xP_8), (P_1xP_9), (P_1xP_{10}), (P_2xP_3), (P_2xP_5), (P_2xP_8), (P_3xP_{10}), (P_4xP_5), (P_4xP_7), (P_4xP_{10}), (P_5xP_6), (P_5xP_7), (P_5xP_9), (P_5xP_{10}), (P_6xP_7), (P_6xP_8), (P_6xP_9), (P_7xP_8), (P_7xP_{10}), (P_9xP_{10})
ercentage fruit set	(P_1xP_6), (P_1xP_7), (P_5xP_9), (P_7xP_9)	
ˈumber of fruits per vine	(P_1xP_5), (P_1xP_6), (P_1xP_7), (P_1xP_8), (P_1xP_9), (P_2xP_3), (P_2xP_5), (P_2xP_8), (P_3xP_9), (P_3xP_{10}), (P_5xP_9), (P_5xP_{10}), (P_7xP_9), (P_7xP_{10}), (P_8xP_{10}), (P_9xP_{10})	(P_1xP_6), (P_1xP_8), (P_1xP_9), (P_1xP_{10}), (P_2xP_5), (P_2xP_8), (P_3xP_9), (P_3xP_{10}), (P_4xP_{10}), (P_5xP_6), (P_5xP_7), (P_5xP_9), (P_5xP_{10}), (P_6xP_8), (P_6xP_9), (P_7xP_8), (P_9xP_{10})
.ength of fruit (cm)	(P_1xP_3), (P_5xP_{10}), (P_7xP_8)	(P_1xP_3), (P_1xP_8), (P_4xP_8), (P_4xP_9), (P_4xP_{10}), (P_5xP_{10})
›irth of fruit (cm)	(P_3xP_6), (P_3xP_{10})	(P_1xP_2), (P_1xP_5), (P_1xP_6), (P_2xP_9), (P_3xP_6), (P_3xP_{10}), (P_4xP_{10}), (P_7xP_9), (P_9xP_{10})
Veight of fruit (g)	(P_1xP_6), (P_1xP_8), (P_5xP_{10}), (P_6xP_8), (P_7xP_8)	(P_2xP_7) (P_3xP_6)
ˈruit yield per vine (g)	(P_1xP_5), (P_1xP_6) (P_1xP_7), (P_1xP_8), (P_1xP_9), (P_2xP_5), (P_2xP_8), (P_2xP_{10}), (P_3xP_{10}), (P_5xP_6), (P_5xP_8), (P_5xP_9), (P_5xP_{10}), (P_6xP_8), (P_7xP_8), (P_7xP_9), (P_9xP_{10})	(P_1xP_5), (P_1xP_6), (P_1xP_8), (P_2xP_4), (P_2xP_5), (P_2xP_8), (P_3xP_{10}), (P_4xP_6), (P_4xP_7), (P_4xP_8), (P_4xP_9), (P_5xP_6), (P_5xP_8), (P_5xP_9), (P_5xP_{10}), (P_6xP_8), (P_7xP_8)
Number of seeds per fruit	(P_2xP_{10}), (P_4xP_6), (P_4xP_7), (P_5xP_8), (P_5xP_9)	(P_1xP_5), (P_1xP_6), (P_1xP_7), (P_1xP_{10}), (P_2xP_3), (P_2xP_5), (P_2xP_6), (P_2xP_7), (P_2xP_8), (P_2xP_{10}), (P_3xP_4), (P_3xP_5), (P_3xP_6), (P_3xP_7), (P_3xP_8), (P_3xP_{10}), (P_4xP_5), (P_4xP_6), (P_4xP_7)

vine and Fruit yield per vine, while hybrids (P_5xP_9) for number of fruits per vine and Fruit yield per vine, Hybrid P_7xP_9 was better for number of lateral branches, number of female flower per plant, percentage fruit set, Number of fruits per vine and Fruit yield per vine over better parent.

4.3 COMBINING ABILITY ANALYSIS

The combining ability analysis is a powerful tool to discriminate good as well as poor combiner and for selecting appropriate parental lines to formulate an efficient breeding programme. At the same time, it also elucidates the nature of gene action involved in the inheritance of traits. The nature of gene action for yield and its component traits has a bearing on the development of efficient breeding procedure. General combining ability is attributed to additive, additive X additive and higher degree of additive X additive interaction are fixable in nature, on the other hand, specific combining ability is attributable to non-additive (i.e. dominance: dominance X dominance and additive X dominance) gene action and are non-fixable (Srivastava, 1973 and 1983).

The model-I (fixed effect), method-2 (parents and their F_1s (with out reciprocals) proposed by Griffing (1956b) was followed to estimates the combining ability effects for each environments as well as over the environments (pooled analysis).

Analysis of Variance for Combining Ability : (Table 24 and 25)

The analysis of variance indicated that mean sum of squares due to GCA and SCA was significant for all the attributes under study under individual environment as well as pooled over the environments, except GCA for node number at which first female flower appear observed non significant under pooled over the environments, suggested the existence of both additive and non-additive type of gene action in the experimental material. However the mean sum of squares due to SCA generally higher their corresponding GCA except days to the appearance of first female flower, length of main shoot, number of male flower per plant, Girth of fruit and number of seeds per fruit, revealed that non-additive component of variation was prominent in comparison to additive gene action. Similar trends were also reported by Chadha and

Table 24. Analysis of variance for combining ability under different environments, for 13 characters in Bitter gourd

Source	Environment	d.f.	Days taken to the appearance of first female flower	Node no. at which first female flower appear	Length of main shoot (cm)	No. of lateral branches per plant	No. of male flower per plant	No. of female flower per plant	Percentage fruit set	No. of fruits per vine	Length of fruit (cm)	Girth of fruit (cm)	Weight of fruit (g)	Fruit yield per vine (g)	No. of seeds per fruit
GCA	E_1	9	9.88**	8.65**	9132.88**	19.85**	78029.05**	106.02**	16.47**	90.58**	7.08**	4.86**	356.86**	310356.55**	218.57**
	E_2		12.21**	11.79**	9651.62**	18.97**	56906.94**	106.65**	13.14**	91.38**	7.70**	5.94**	197.14**	348333.24**	204.28**
	E_3		10.96**	35.91**	9789.92**	290.38**	35200.88**	117.54**	10.47**	114.18**	3.98**	7.15**	296.88**	510511.18**	220.37**
	E_4		8.08**	14.06**	9936.96**	30.15**	23690.43**	186.24**	11.76**	171.37**	15.75**	3.64**	903.45**	734278.40**	211.43**
SCA	E_1	44	13.03**	9.44**	3879.83**	19.41**	42538.19**	109.68**	6.14**	86.41**	5.63**	5.39**	564.58**	427097.25**	52.85**
	E_2		12.46**	8.98**	3909.82**	20.90**	31386.95**	96.82**	6.67**	83.15**	6.23**	6.28**	224.15**	520260.64**	54.15**
	E_3		14.06**	17.31**	4604.51**	244.70**	36591.52**	110.54**	5.86**	103.80**	4.75**	5.45**	323.23**	805910.33**	58.39**
	E_4		13.11**	12.99**	4367.35**	24.10**	11659.44**	141.43**	14.48**	129.56**	6.70**	3.56**	303.62**	750075.68**	58.20**
Error	E_1	108	0.39	0.74	90.49	0.20	803.25	1.42	0.32	1.14	0.29	0.24	350.03	2036.11	0.59
	E_2		0.38	0.75	207.26	0.18	379.62	0.86	0.31	0.70	0.46	0.30	0.73	1439.28	0.39
	E_3		1.27	7.79	266.00	0.17	1181.61	0.77	0.28	6.20	0.39	0.24	1.33	3273.00	0.43
	E_4		1.74	0.44	171.87	3.23	402.00	1.18	13.90	0.80	0.31	0.18	1.86	5653.87	0.55

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

Table 25. Analysis of variance for combining ability over the environment for 13 characters in Bitter gourd

Source	d.f.	Days taken to the appearance of first female flower	Node no. at which first female flower appear	Length of main shoot (cm)	No. of lateral branches per plant	No. of male flower per plant	No. of female flower per plant	Percentage fruit set	No. of fruits per vine	Length of fruit (cm)	Girth of fruit (cm)	Weight of fruit (g)	Fruit yield per vine (g)	No. of seeds per fruit
Environment	3	114.14**	638*	54769.06**	109.49**	37501.72**	787.78**	4.10	682.11**	79.77**	70.52**	1638.73**	5421630.60**	4.12**
GCA	9	12.44++	5.40	11543.60++	15.31++	59513.80++	190.36++	10.09+	162.05++	2.56++	5.32++	219.58+	599280.80++	118.16++
SCA	44	11.79++	7.72++	5143.51++	17.93++	35570.86++	216.20++	11.93++	190.31++	6.98++	4.87++	374.87++	916902.84++	82.09++
GCA x Environments	27	9.86**	21.43**	5337.58**	16.38**	31518.79**	104.11**	11.81**	92.19**	8.08**	5.16**	285.37**	471280.48**	121.30**
SCA x Environments	133	12.30**	14.14**	4839.82**	26.62**	31291.11*	811.79**	7.39**	72.34**	6.06**	5.36**	400.38**	52213.45**	66.21**
Error	432	0.95	2.43	183.56	1.42	706.43	1.07	3.71	2.22	0.36	0.24	88.47	3075.78	0.47

* Significant at 5% level

** Significant at 1% level

\+ Significant against respective environment at 5% level

++ Significant against respective environment at 1% level

Nandpuri (1980) Sirohi *et al* (1987) Sivakami *et al.* (1987) and Chaudhari and Kale (1991) in various cucurbits.

The mean sum of square due to interaction of environmental condition with GCA and SCA were highly significant for all characters, revealed that expression of additive and non additive gene action were highly influenced by the environmental fluctuations, while significant mean sum of squares due to environment suggested considerable differences among the environments.

Character wise results for general combining ability effects of parents (gi) and specific combining ability effects of crosses (Sij) was as follows:

Days Taken to the Appearance of First Female Flower : (Table 26 and 28)

Table of GCA revealed that out of 10 parents GCA was significant for early appearance of first female flower for 5, 3, 4, 2 and 4 parents in E_1 E_2, E_3, E_4 and pooled analysis, respectively. Mc 84 (P_8) showed significant GCA effects in each as well as over the environments. It revealed that this parent is good general combiner for early appearance of first female flower.

Results of SCA effects indicated that out of 45 hybrids 14 each in E_1 and E_2; 13 in E_3; 8 in E_4 and 11 in pooled exhibited significant SCA effects in desired direction. The highest SCA effects were observed in crosses P_2xP_{10} (-7.38), P_2xP_{10} (-9.39), P_2xP_{10} (-7.91), P_1xP_4 (-6.39) and P_3xP_4 (-4.82) under E_1, E_2, E_3, E_4 and pooled analysis, respectively. Cross P_5xP_7 showed significant SCA effects in all the four environments, which indicates that this hybrids shall be better in desirable direction.

Hence the present finding are in confirmative to work reported by Anek-Bangka (1986) and Sivakami *et al.* (1987) i.e. presence of significant GCA as well SCA in cucumber and bottle gourd, respectively for early female flowering.

Table 26. Estimation of general combining ability (GCA) effect over the environments for Ist to 7th character in Bitter gourd

Parents	Environments	Days taken to the appearance of first female flower	Node number at which first female flower appear	Length of main shoot (cm)	No. of lateral branches per plant	No. of male flower per plant	No. of female flower per plant	Percentage fruit set
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
P_1	E_1	-0.37*	-0.49*	-39.35**	-0.47	-104.67**	0.18	-1.77**
	E_2	-0.89**	-0.68**	-41.54**	-0.32**	-77.21**	0.50*	-1.49**
	E_3	-0.25	-0.88**	-29.77	-0.07	-49.76**	1.52**	-1.08
	E_4	0.87**	-1.54*	-30.42	0.49**	26.54**	5.86**	1.33**
	Pooled	0.30*	-0.28	-26.15	-0.29	-32.76**	1.34**	-0.26
P_2	E_1	-0.61**	0.80*	31.49**	0.60	-116.55**	-5.37**	-1.67**
	E_2	-0.14	1.31**	33.41**	0.55**	-101.26**	-5.22**	-1.62**
	E_3	-0.46	4.17**	32.71**	1.24*	-39.80**	-3.44**	-1.43
	E_4	-1.06**	1.79*	16.61**	0.04	-23.84*	-2.03**	0.36*
	Pooled	0.10	0.30	10.59**	-0.20	-44.04**	-1.79**	-0.36
P_3	E_1	-0.31	-1.25**	39.16**	-0.11	14.77	-1.45**	-0.09
	E_2	0.10	-1.79**	37.42**	-0.04	33.47**	-0.46	-0.44**
	E_3	-1.10**	-1.96**	45.63**	-0.83**	-30.35**	-2.55**	-0.46
	E_4	0.78*	-0.98	56.87**	-2.15**	-77.09**	-6.01**	-0.70**
	Pooled	-0.28*	-0.39	27.47**	0.49**	-32.62**	-3.48**	-0.90**
P_4	E_1	0.61**	-0.12	22.36**	0.70	-11.44	-1.47**	0.60**
	E_2	1.56**	-0.04	22.00**	0.73**	-13.44*	-1.54**	0.58**
	E_3	1.19**	0.08	23.44**	0.26	-3.72	-1.77**	0.16
	E_4	0.02	0.10	31.31**	0.94**	-52.47**	-4.43**	-1.18**
	Pooled	1.14**	0.74**	0.58	0.89**	-6.83	-0.87**	0.11
P_5	E_1	-0.46**	1.53**	5.71*	0.55	5.83	1.00**	0.36*
	E_2	0.49**	1.40**	10.83**	0.65**	12.25**	1.73**	0.32*
	E_3	-0.01	1.10**	5.89	0.50	-0.41	1.07	0.53
	E_4	-0.62	1.30*	23.12**	1.09**	73.91**	5.90**	-0.70**
	Pooled	-0.64	-0.03	6.41**	0.09	-5.88	-1.36**	0.32
P_6	E_1	-0.10	-0.64**	-5.53*	-1.61**	106.86**	4.67**	1.18**
	E_2	-1.29**	-0.60*	-6.84	-1.72**	119.60**	5.88**	0.96**
	E_3	-0.15**	-1.02**	-0.92	-2.04**	83.00**	5.29**	1.39
	E_4	0.42	-0.59	-8.35	-1.29**	-14.44	0.24	0.02
	Pooled	-0.27*	-0.37	12.24**	-0.55**	53.01**	2.71**	0.40

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
P_7	E_1	-1.72**	0.25	-9.66**	0.80*	27.32**	0.39	-1.34**
	E_2	0.49**	0.29	-12.34**	0.86**	-18.31**	-1.48**	-0.99**
	E_3	-0.76**	-0.37*	-14.31**	1.22*	-85.48**	-4.57**	-0.95
	E_4	0.14	0.46	-11.40*	3.42**	42.12**	1.87**	0.34*
	Pooled	-0.45**	0.06	-5.43**	-0.39*	32.85**	0.65**	-0.22
P_8	E_1	-0.64**	0.49*	41.52**	-2.76**	-22.38**	-0.22	0.54**
	E_2	-1.21**	0.52*	40.74**	-2.68**	-26.15**	-0.39	1.03**
	E_3	-1.11**	0.58**	44.62**	-3.06**	44.41**	3.39**	0.58
	E_4	-1.54**	0.21	-25.59**	-1.05**	13.04	1.56**	1.35**
	Pooled	-0.29*	0.07	16.91**	-0.58**	16.84**	1.98**	0.46
P_9	E_1	1.07**	0.37	9.89**	1.25**	-39.05**	-2.08**	0.93**
	E_2	1.12**	0.39	11.35**	0.96**	-24.32**	-1.70**	0.59**
	E_3	1.28**	-0.21	6.04	0.95	10.50*	-0.54	0.32
	E_4	0.73*	0.45	-12.03**	-0.94**	-01.24	-1.12**	0.65**
	Pooled	0.15	-0.03	9.61**	-0.35*	-27.04**	-1.00**	0.13
P_{10}	E_1	1.31*	-0.93**	-17.25**	1.04**	139.31**	4.35**	1.26**
	E_2	1.00**	-0.80**	-20.20**	1.02**	95.39**	2.67**	1.05**
	E_3	1.36**	-1.47**	-22.06**	1.82**	71.61**	1.60**	0.94
	E_4	0.26	-1.21*	22.43**	0.55**	13.46	-1.83**	-1.48**
	Pooled	0.24	-0.07	3.85**	0.89**	45.88**	1.82**	0.57*
SE ± (gi)	E_1	0.1700	0.2358	2.6052	0.3874	7.7617	0.3268	0.1562
	E_2	0.1700	0.2379	3.9426	0.1175	5.3359	0.2536	0.1514
	E_3	0.3615	0.1808	3.5903	0.4928	5.4909	0.5459	1.0213
	E_4	0.3091	0.7644	4.4666	0.1139	9.4139	0.2400	0.1467
	Pooled	0.1335	0.2134	1.0376	0.1635	3.6394	0.1414	0.2636
SE ± (gi -gj)	E_1	0.2537	0.3516	3.8836	0.1826	11.5705	0.4872	0.2330
	E_2	0.2535	0.3547	5.8774	0.1752	7.9543	0.3780	0.2258
	E_3	0.4608	1.1395	6.6584	0.1698	14.0333	0.3578	0.2187
	E_4	0.5389	0.2696	5.3521	0.7346	8.1854	0.4442	1.5225
	Pooled	0.1990	0.3181	2.7656	0.2437	5.4253	0.2108	0.3930

* Significant at 5% level
** Significant at 1% level

Table 28. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for days taken to the appearance of first female flower in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	-1.67**	-1.79**	-1.72	-3.14*	0.50
P_1xP_3	5.04**	4.45**	3.55*	2.08	2.23**
P_1xP_4	-0.73	-0.48	1.35*	-6.39**	-1.23**
P_1xP_5	-2.20**	-1.26*	-1.05	0.68	-0.68
P_1xP_6	0.26	-1.42*	-3.87**	1.44	0.73
P_1xP_7	4.81**	3.40**	4.15**	0.38	-1.36**
P_1xP_8	2.46**	2.30**	0.34	0.47	-0.20
P_1xP_9	3.82**	4.94**	2.96**	3.23**	2.17**
P_1xP_{10}	0.59	1.76**	2.78**	-2.49*	1.20**
P_2xP_3	-0.92	0.52	0.66	-1.13	1.40**
P_2xP_4	-0.75	-0.04	-0.34	-0.22	1.09*
P_2xP_5	0.38	-1.09	-3.65**	-0.72	0.42
P_2xP_6	2.98**	1.65**	0.88	0.07	0.32
P_2xP_7	3.75**	4.74**	7.17**	0.55	0.13
P_2xP_8	-0.62	-1.07	-3.22**	-1.84	0.29
P_2xP_9	-6.28**	-4.43**	-2.12**	-0.27	-0.69
P_2xP_{10}	-7.38**	-9.39**	-7.91**	0.38	-4.16**
P_3xP_4	-1.73**	0.13	-0.83	-6.08**	-4.82**
P_3xP_5	1.41	-2.10**	-0.51	3.30**	-0.46
P_3xP_6	-3.17**	-2.19**	-2.35*	-1.80	-1.35**
P_3xP_7	3.82**	1.78**	0.12	6.48**	-1.03*
P_3xP_8	4.78**	2.48**	4.73**	9.17**	1.56**
P_3xP_9	1.77**	2.30**	1.04	1.89	0.44
P_3xP_{10}	0.65	-0.71	-1.19	-1.67	3.73**
P_4xP_5	3.45**	5.82**	7.23**	3.27**	2.82**
P_4xP_6	-0.95	1.00	-0.17	0.42	1.32**
P_4xP_7	3.67**	4.98**	1.50	1.53	2.62**
P_4xP_8	-2.56**	0.13	2.38	-0.68	0.67
P_4xP_9	-1.91**	-4.85**	-3.33**	2.03	-0.56
P_4xP_{10}	-1.01	-3.89**	-3.57**	1.15	-0.69
P_5xP_6	0.57	0.28	2.35*	2.60*	-0.20
P_5xP_7	-2.16**	-2.13**	-2.21*	-3.69**	0.47
P_5xP_8	-7.16**	-4.93**	-5.99**	-1.44	-1.24**
P_5xP_9	-1.18*	-2.24**	-1.35	-1.71	-1.49**
P_5xP_{10}	1.60**	2.91**	-0.39	0.36	-2.25
P_6xP_7	-0.56	0.21	2.57*	1.03	0.03
P_6xP_8	-3.71**	-2.28**	-4.61**	0.82	-0.88*
P_6xP_9	0.43	-0.90	-6.00**	3.31**	0.11
P_6xP_{10}	2.25**	3.06**	4.95**	-5.61**	-0.02
P_7xP_8	-2.00**	-3.41**	-3.23**	-0.20	-0.53
P_7xP_9	0.41	1.57**	3.51**	-3.36**	1.39**
P_7xP_{10}	4.12**	2.79**	0.56	2.17	-1.05*
P_8xP_9	4.01**	3.99**	0.64	-11.42**	2.46**
P_8xP_{10}	0.71	0.79	0.87	3.76**	1.01*
P_9xP_{10}	-1.75**	0.07	1.28	2.11	0.73
S.E. ± (S_{ij})	0.5725	0.5720	1.0440	1.2160	0.4490
SED ± (S_{ij}-S_{ik})	0.8416	0.8409	1.5283	1.7875	0.6601
SED ± (S_{ij}-S_{kl})	0.8024	0.8017	1.4572	1.7043	0.6294

* Significant at 5% level

** Significant at 1% level

Node Number at which First Female Flower Appear : (Table 26 and 29)

Results of GCA indicated that out of 10 parents GCA was significant for 5, 4, 5 and 2 parents in E_1, E_2, E_3 and E_4 respectively. Udaipur local (P_1) and Puse Do Mousami (P_{10}) exhibited significant GCA effects in all the environments, suggested good general combining ability for early number of node at which first female appear.

Table of SCA revealed that out of 45 hybrids 15 in E_1; 14 in E_2; 3 in E_3; 15 in E_4 and 9 in pooled depicted significant SCA effects in desired direction. The highest SCA effects was recorded in cross P_5xP_9 (-5.70), P_2xP_5 (-6.10), P_2xP_5 (-8.61), P_1xP_2 (-6.93) and P_1xP_4 (-2.54) under E_1, E_2, E_3, E_4 and pooled analysis, respectively. Cross P_2xP_5 depicted significant SCA effects in all as well as over the environments, indicated superiority of this hybrid under varying environmental conditions.

Bhattacharya *et al.* (1970), Swamy (1985) and Anek-Bangka (1986) also reported similar findings in their investigation for appearance of first female flower at early node number in various cucurbitaceous vegetables.

Length of Main Shoot (cm) : (Table 26 and 30)

Table of GCA revealed that out of 10 parents GCA was significant for 5, 5, 4, 4 and 6 parents in E_1, E_2, E_3, E_4 and pooled, respectively, for more length of main shoot. NBPGR/TCR-72 (P_2) exhibited significant GCA effect in all as well as over the environments and thus revealed that this parent was good combiner for length of main shoot.

Results of SCA effects indicated that out of 45 hybrids 21 in E_1; 13 in E_2; 11 in E_3; 8 in E_4 and 8 in pooled exhibited significant SCA effects in desired direction. The highest SCA effects was observed in cross P_5xP_{10} (118.90), P_5xP_{10} (115.98), P_5xP_{10} (160.19), P_4xP_5 (161.60) and P_1xP_4 (42.43) under E_1, E_2, E_3, E_4 and pooled analysis, respectively. Crosses P_5xP_{10} and P_6xP_9 depicted significant SCA effects in all as well as over the environments, indicated these hybrid shall be better in varying environments.

Sirohi and Chaudhary (1977), Bhagchandani (1980) and Swamy (1985) had also reported similar findings for this trait in bitter gourd, summer squash and muskmelon, respectively.

Table 29. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for node number at which first female flower appear in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	-1.17	-2.63**	-4.30	-6.93**	-0.59
P_1xP_3	-1.57*	-0.91	-0.03	0.67	-1.13
P_1xP_4	0.58	-0.51	-0.05	1.01	-2.54**
P_1xP_5	2.16**	2.16**	-0.05	5.34**	-1.66*
P_1xP_6	2.28**	3.83**	3.39	2.73*	0.90
P_1xP_7	-1.03	-0.52	-0.57	-0.81	0.40
P_1xP_8	-1.14	-2.07*	-2.37	-1.06	1.28
P_1xP_9	-0.10	0.85	0.72	3.21**	-0.67
P_1xP_{10}	0.63	-0.71	-0.51	-0.63	-0.92
P_2xP_3	-2.78**	2.52**	-4.42	4.32**	-2.03**
P_2xP_4	3.43**	1.85*	-0.11	-0.44	-1.02
P_2xP_5	-5.90**	-6.10**	-8.61**	-5.49**	-1.86**
P_2xP_6	0.62	-0.98	-4.02	-0.60	1.66*
P_2xP_7	3.82**	3.62**	0.45	1.19	0.25
P_2xP_8	-1.73*	-2.03*	-4.88	-1.40*	-0.06
P_2xP_9	-0.25	-0.83	-2.82	-5.14**	1.05
P_2xP_{10}	-1.76*	-1.37*	-4.46	-1.22*	0.27
P_3xP_4	-3.18**	-2.27**	-1.99	-5.01**	-1.33
P_3xP_5	1.05	1.94*	2.32	1.45*	-1.50*
P_3xP_6	-0.80	-0.32	1.44	-2.83*	-0.72
P_3xP_7	0.11	-1.37	-1.21	-2.37**	-1.74*
P_3xP_8	4.46**	4.57**	5.00	4.87**	0.52
P_3xP_9	9.68**	7.97**	6.63*	9.64**	1.40*
P_3xP_{10}	-1.81*	-1.00	-0.21	-1.46*	1.22
P_4xP_5	3.37**	3.42**	3.70	4.19**	1.66*
P_4xP_6	0.16	-0.36	0.31	1.59**	1.98**
P_4xP_7	-0.35	-1.66*	-1.08	-1.13	-0.86
P_4xP_8	3.09**	3.55**	2.79	1.79**	0.88
P_4xP_9	-2.63**	-2.24**	-2.41	-0.37	-0.43
P_4xP_{10}	0.28	0.85	1.91	-0.44	-0.67
P_5xP_6	-2.76**	-1.92*	-2.81	-1.28*	-0.25
P_5xP_7	0.41	0.88	1.90	-0.15	0.34
P_5xP_8	-3.17**	-2.78**	-2.56	-1.75**	-0.82
P_5xP_9	-5.70**	-5.48**	-6.26*	-5.53**	-0.66
P_5xP_{10}	-2.47**	-1.74*	-2.17	0.23	-1.18
P_6xP_7	0.52	0.95	-0.14	3.23**	-1.41*
P_6xP_8	-3.00**	-2.92**	-2.78	-1.12	-1.97**
P_6xP_9	-2.44**	-2.24**	-1.14	-4.83**	-1.40*
P_6xP_{10}	1.45	1.31	2.95	0.54	-0.30
P_7xP_8	1.28	1.10	2.09	-0.06	-0.68
P_7xP_9	2.79**	3.16**	2.21	4.71**	0.11
P_7xP_{10}	-1.06	-0.28	-1.38	1.52*	0.73
P_8xP_9	-2.10**	3.79**	-2.91	-3.56**	-0.05
P_8xP_{10}	1.73*	2.16**	2.17	3.44**	0.14
P_9xP_{10}	2.39**	2.39**	2.22	0.47	0.52
S.E. ± (S_{ij})	0.7934	0.8003	2.5712	0.6083	0.7178
SED ± $(S_{ij}-S_{ik})$	1.1662	1.1764	3.7796	0.8942	1.0512
SED ± $(S_{ij}-S_{kl})$	1.1119	1.1216	3.6037	0.8526	1.0060

* Significant at 5% level

** Significant at 1% level

Table 30. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for length of main shoot (cm) in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	-109.01**	-115.57**	-23.75	6.84	-31.83
P_1xP_3	42.79**	45.78**	29.92*	-0.35	-29.49*
P_1xP_4	-17.70**	15.65	-4.46	-25.99*	42.43**
P_1xP_5	-11.59**	0.11	-47.10**	-77.88**	-6.41
P_1xP_6	-71.94**	-64.03**	-5.11	-12.20	-48.31**
P_1xP_7	92.60**	80.66**	103.27**	66.70**	-10.40
P_1xP_8	-62.73**	-68.75**	-75.83**	17.82	-30.21*
P_1xP_9	-110.65**	-94.27**	-110.41**	-103.52**	-34.57**
P_1xP_{10}	33.78**	21.96	-3.98	-38.87**	-24.30*
P_2xP_3	27.28**	23.28	29.11	-4.91	-19.21*
P_2xP_4	60.48**	55.95**	48.04**	12.27	-27.81*
P_2xP_5	-21.36**	-35.84**	-29.66	-25.87*	6.37
P_2xP_6	16.18**	11.80	-2.67	-7.23	3.80
P_2xP_7	26.09**	-29.38*	-44.22**	-55.37**	19.89*
P_2xP_8	-03.45**	-2.48	-33.36*	-68.31**	-2.20
P_2xP_9	22.72**	52.59**	50.44**	62.29**	6.79
P_2xP_{10}	-1.68	-0.10	-11.46	-7.14	10.74
P_3xP_4	-64.02**	-68.21**	-96.62**	-91.42**	26.13*
P_3xP_5	-57.84**	-67.01**	-41.26**	-29.42*	-6.92
P_3xP_6	-16.68**	-4.62	0.61	-3.01	-46.00**
P_3xP_7	-42.22**	-33.56*	-30.21*	-19.96	-52.33**
P_3xP_8	27.70**	27.01*	29.98*	53.30**	-30.79*
P_3xP_9	18.25**	6.39	-7.22	5.99	-17.66*
P_3xP_{10}	-29.62**	-27.41*	-13.15	-43.52**	-18.38*
P_4xP_5	55.81**	53.56**	49.69**	161.60**	-13.07*
P_4xP_6	-121.13**	-124.26**	-133.50**	-148.03**	-52.83**
P_4xP_7	-93.05**	-95.16**	-100.10**	-134.88**	-41.85**
P_4xP_8	4.24**	12.26	11.13	37.84**	4.83
P_4xP_9	38.72**	34.59*	14.72	-18.16	-27.30*
P_4xP_{10}	-66.51**	-70.36**	-36.80*	18.29	-11.34
P_5xP_6	-88.05**	-89.49**	-100.92**	-35.57**	-23.78*
P_5xP_7	27.64**	27.93*	2.43	11.47	-25.77*
P_5xP_8	-33.10**	-44.41**	8.51	-28.65*	-19.92*
P_5xP_9	3.77**	-6.51	-5.77	1.05	-16.84*
P_5xP_{10}	118.90**	115.98**	160.19*	64.34**	40.29**
P_6xP_7	-8.81**	-7.36	-29.08	-2.82	19.64*
P_6xP_8	63.37**	53.10**	66.99**	2.66	27.34*
P_6xP_9	73.81**	71.89**	48.90**	47.10**	35.08**
P_6xP_{10}	-56.56**	-51.55**	-77.96**	-116.04**	4.45
P_7xP_8	-54.02**	-54.91**	-81.39**	-5.20	-18.95*
P_7xP_9	68.71**	72.51**	138.48**	70.63**	-12.89*
P_7xP_{10}	10.78**	8.88	25.50	-13.99	-23.59*
P_8xP_9	-9.79**	-13.74	-11.47	6.55	12.01
P_8xP_{10}	48.59**	47.86**	41.55**	4.71	15.37*
P_9xP_{10}	-0.14	1.26	0.11	16.30	10.07
S.E. ± (S_{ij})	0.8705	13.3612	15.0234	12.0760	6.2399
SED ± $(S_{ij}-S_{ik})$	12.8804	19.4932	22.0835	17.7510	9.1724
SED ± $(S_{ij}-S_{kl})$	12.2809	18.5860	21.0558	16.9249	8.7455

* Significant at 5% level

** Significant at 1% level

Number of Lateral Branches Per Plant : (Table 26 and 31)

Results in the table of GCA explained that out of 10 parent GCA was significant for 3, 6, 3, 4 and 3 parents in E_1, E_2, E_3, E_4 and pooled, respectively for more number of lateral branches. C.0-1 (P_7) showed significant GCA effect in all four environments, suggested this parent as good general combiner for this character.

Result of SCA effect indicated that out of 45 hybrids 18 in E_1; 17 in E_2; 13 in E_3; 9 in E_4 and 12 in pooled showed significant SCA effects in desired direction. The highest SCA effects was obtained in cross P_7xP_{10} (13.76), P_7xP_{10} (14.20), P_7xP_{10} (14.27), P_6xP_7 (14.08) and P_8xP_9 (5.66) under E_1, E_2, E_3, E_4 and pooled analysis, respectively. Crosses P_1xP_3 and P_2xP_{10} exhibited significant GCA effects in all as well as over the environments and hence indicating superiority under varying environment for more number of lateral branches per plant.

Bhagchandani *et al.* (1980) and Swamy (1985) earlier in summer squash and musckmelon had also reported similar findings for this trait.

Number of Male Flower Per Plant : (Table 26 and 32)

Table of GCA revealed that out of 10 parents GCA was significant for 4, 6, 4, 3 and 4 parents in E_1, E_2, E_3, E_4 and pooled, respectively in desired direction. Out of these NSPGR/TCR-72 (P_2) showed significant GCA effects in all as well as over the environments, which indicated that this parent is good general combiner for less number of male flower per plant.

Table of SCA effects indicated that out of 45 hybrids 17 in E_1; E_2 and E_4 each, 15 in E_3 and 18 in pooled analysis showed significant SCA effects for less number of male flower per plant. The highest SCA effects was observed in cross P_2xP_6 (-287.15), P_2xP_6 (-311.42), P_2xP_6 (-420.08), P_5xP_7 (-160.56) and P_1xP_2 (-104.29) under E_1, E_2, E_3, E_4 and pooled, respectively. Crosses P_1xP_2 and P_1xP_5 exhibited significant SCA effects in all as well as over the environments and hence indicated superiority under varying environment for less number of male flower per plant.

Table 31. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for number of lateral branches per plant in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	2.71**	2.72**	0.09	2.35	-0.64
P_1xP_3	2.60**	3.48**	3.99**	5.54**	1.27*
P_1xP_4	-3.15**	-3.47**	-3.00**	-3.53*	0.33
P_1xP_5	1.43**	1.83**	-0.30	0.81	1.26*
P_1xP_6	-0.75	-1.47**	-1.82**	-1.61	0.90
P_1xP_7	-0.95*	-1.02*	0.40	-2.54	-0.89
P_1xP_8	4.00**	4.07**	3.22**	2.43	0.52
P_1xP_9	-3.84**	-3.52**	-1.79**	2.34	-0.11
P_1xP_{10}	-0.31	-0.22	2.82**	-6.56**	-0.93
P_2xP_3	-2.57**	-2.50**	-1.84**	-2.51	-0.48
P_2xP_4	-2.54**	-1.96**	-3.94**	-2.49	0.09
P_2xP_5	3.11**	4.29**	9.40**	1.77	-1.05
P_2xP_6	-2.80**	-3.01**	-2.43**	2.14	-0.63
P_2xP_7	-2.05**	-1.92**	-3.90**	-5.58**	1.75**
P_2xP_8	-2.38**	-2.81**	-2.62**	1.44	-0.60
P_2xP_9	8.45**	7.38**	8.34**	-4.71**	1.71**
P_2xP_{10}	5.54**	5.63**	6.24**	7.97**	1.65**
P_3xP_4	-0.34	0.31	-1.37**	-1.91	3.19**
P_3xP_5	-4.87**	-6.10**	-7.01**	-1.55	-0.56
P_3xP_6	4.70**	4.86**	5.93**	4.85**	0.77
P_3xP_7	-2.90**	-3.10**	-3.32**	-3.39*	-2.54**
P_3xP_8	2.80**	3.35**	3.65**	3.68*	-0.43
P_3xP_9	-2.18**	-3.43**	-3.56**	0.97	-0.67
P_3xP_{10}	-4.42**	-4.68**	-3.92**	-3.21	-3.52**
P_4xP_5	1.89**	1.11**	0.40	12.85**	-1.90**
P_4xP_6	-3.32**	-3.72**	-3.17**	-4.18*	-2.07**
P_4xP_7	0.46	0.75	0.60	0.07	-2.41**
P_4xP_8	0.59	0.42	-1.05**	-3.51*	2.36**
P_4xP_9	8.15**	8.51**	7.23**	-1.08	0.95
P_4xP_{10}	-4.94**	-5.16**	-3.46**	-5.50**	0.08
P_5xP_6	-2.81**	-3.44**	-3.60**	1.59	-0.20
P_5xP_7	4.58**	4.87**	6.50**	-0.63	-0.01
P_5xP_8	-3.20**	-3.27**	-1.88**	-0.16	-1.87**
P_5xP_9	1.25**	1.52**	0.10	-7.76**	2.05**
P_5xP_{10}	-6.31**	-6.24**	-7.75**	5.35**	-1.56**
P_6xP_7	-1.70**	-1.56**	0.42	14.08**	-0.51
P_6xP_8	1.01*	1.11**	-0.33	-1.21	-3.61**
P_6xP_9	-5.25**	-5.36**	-4.62**	-3.18	0.01
P_6xP_{10}	1.96**	1.93**	1.37**	-3.32*	1.13*
P_7xP_8	-4.48**	-4.38**	-4.10**	-4.98**	-2.69**
P_7xP_9	5.55**	5.24**	6.30**	5.40**	-0.02
P_7xP_{10}	13.76**	14.20**	14.27**	-1.49	2.35**
P_8xP_9	1.36**	-1.24**	-0.83*	6.87**	5.66**
P_8xP_{10}	-0.33	0.15	-1.20**	2.49	4.69**
P_9xP_{10}	-2.91**	-2.49**	-3.21**	-2.71	-1.51**
S.E. ± (S_{ij})	0.4112	0.3953	0.3832	1.6574	0.5499
SED ± (S_{ij}-S_{ik})	0.6058	0.5811	0.5633	2.4363	0.8991
SED ± (S_{ij}-S_{kl})	0.5776	0.5540	0.5371	2.3229	0.7707

* Significant at 5% level

** Significant at 1% level

Table 32. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for number of male flower per plant in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	-71.42**	-55.88**	-75.11	-62.73**	-104.29**
P_1xP_3	-55.05*	-13.92	237.12**	-98.26**	-70.45**
P_1xP_4	-25.98	-12.97	64.75*	107.02**	-61.44**
P_1xP_5	-193.85**	-180.50**	-213.18**	-61.59**	-37.23**
P_1xP_6	214.57**	176.24**	152.75**	88.28**	-62.26**
P_1xP_7	-104.35**	-64.38**	-46.71	43.94*	-36.87**
P_1xP_8	264.24**	246.65**	106.43**	48.34*	66.01**
P_1xP_9	46.51	63.34**	-108.83**	-74.85**	50.49**
P_1xP_{10}	215.99**	162.21**	195.79**	-58.39**	92.96**
P_2xP_3	-51.71	-99.44**	-150.97**	74.24**	67.89**
P_2xP_4	27.45	26.41	104.62**	14.61	25.50*
P_2xP_5	251.93**	253.12**	369.41**	-52.59**	2.23
P_2xP_6	-287.15**	-311.42**	-420.08**	35.83**	-34.00**
P_2xP_7	-166.87**	-71.55**	-4.72	74.41**	-59.67**
P_2xP_8	295.92**	249.77**	173.93**	43.93*	-76.62**
P_2xP_9	362.64**	302.90**	423.06**	-87.62**	132.38**
P_2xP_{10}	-307.69**	-247.08**	-255.03**	74.01**	38.62**
P_3xP_4	-168.90**	-187.71**	-81.76*	-25.42	41.09**
P_3xP_5	-20.67	30.89	117.28**	-48.78**	-33.46**
P_3xP_6	109.40**	146.36**	-10.32	-67.30**	43.03**
P_3xP_7	408.73**	397.47**	-73.01*	-86.66**	169.78**
P_3xP_8	-207.22**	-210.32**	-183.61**	107.67**	57.89**
P_3xP_9	21.51	23.25	76.77*	-23.65	-79.12**
P_3xP_{10}	-50.96	-10.01	52.88	34.87	52.61**
P_4xP_5	-6.11	-104.97**	-243.46**	70.13**	63.59**
P_4xP_6	158.31**	146.18**	150.66**	-66.93**	-11.68
P_4xP_7	13.69	76.72**	52.67	-35.02	-25.07*
P_4xP_8	-121.88**	-127.37**	-74.22*	-29.48	42.25**
P_4xP_9	-9.11	-4.80	-77.14*	-28.69	-65.80**
P_4xP_{10}	-57.23*	-30.50	74.18*	-45.04*	-52.20**
P_5xP_6	-107.84**	-41.41*	-104.48**	181.88**	-68.91**
P_5xP_7	55.53*	99.89**	348.03**	-160.56**	31.69**
P_5xP_8	-36.14	-51.69**	-134.39**	151.44**	-28.19*
P_5xP_9	264.85**	173.30**	135.48**	184.57**	199.07**
P_5xP_{10}	282.40**	319.02**	276.18**	212.52**	72.43**
P_6xP_7	-186.10**	-149.35**	-136.23**	108.75**	103.38**
P_6xP_8	56.86*	33.79	210.58**	33.80	104.19**
P_6xP_9	49.73	26.99	98.47**	-51.46**	75.09**
P_6xP_{10}	-112.69**	-79.76**	-84.07**	-103.40**	83.22**
P_7xP_8	-112.83**	116.35**	140.71**	-78.98**	69.22**
P_7xP_9	-172.01**	-104.98**	-30.68	172.26**	-33.35**
P_7xP_{10}	444.67**	30.99	-19.59	165.32**	48.07**
P_8xP_9	-79.65**	-68.63**	-16.48	100.10**	-30.85*
P_8xP_{10}	146.51**	218.79**	77.21*	-129.95**	17.85
P_9xP_{10}	43.46	106.39**	118.00**	-20.28	153.50**
S.E. ± (S_{ij})	26.1065	17.9473	31.6635	18.4687	12.2412
SED ± (S_{ij}-S_{ik})	38.3749	26.3814	46.5434	27.1479	17.9939
SED ± (S_{ij}-S_{kl})	36.5890	25.1537	44.3774	25.8845	17.1565

* Significant at 5% level

** Significant at 1% level

Number of Female Flower Per Plant : (Table 26 and 33)

Results of GCA revealed that out of 10 parent GCA was significant for 3, 4, 4, 4 and 4 parents in E_1, E_2, E_3, E_4 and pooled, respectively for more number of female flower. B.G.-14 (P_6) and Pusa Do Mousami (P_{10}) depicted significant GCA effects in first three as well as over the environments, suggested that these parents considered as good general combiner for this character.

Results in the table of SCA indicated that out of 45 hybrids 17 in E_1, 21 in E_2; 24 in E_3, 20 in E_4 and 22 in pooled analysis depicted significant SCA effects in desired direction. The highest SCA effects was obtained in cross P_1xP_8 (28.26), P_1xP_8 (26.27), P_1xP_6 (25.77), P_4xP_5 (24.01) and P_1xP_8 (16.61) under E_1, E_2, E_3, E_4 and pooled, respectively. Crosses P_1xP_8, P_2xP_3 and P_5xP_{10} showed significant SCA effects in all as well as over the environments, thus revealed better performance of these hybrids under varying environments conditions.

Percentage Fruit Set : (Table 26 and 34)

Table of GCA revealed that out of 10 parents GCA was significant for 6, 6, 5 and 1 in E_1, E_2, E_4 and pooled, respectively. M.C-84 (P_8) and Jounpari long (P_9) exhibited significant GCA effects in three environments (e.g. E_1, E_2 and E_4) for higher percentage of fruit set, revealed these parents as good combiner.

Results of SCA effects indicated that out of 45 hybrids 18 in E_1; 19 in E_2;21 in E_3 and 9 in pooled showed significant SCA effects in desired direction. The highest SCA effects was recorded in cross P_2xP_5 (4.85), P_2xP_5 (4.88), P_2xP_5 (4.76), P_5xP_9 (5.24) and P_1xP_9 (3.12) under E_1, E_2, E_3, E_4 and pooled analysis, respectively. Crosses P_1xP_9, P_1xP_{10}, P_2xP_9, P_6xP_8 and P_9xP_{10} depicted significant SCA effects in first three (i.e. E_1, E_2 and E_3) as well as over the environments. It was observed that atleast one good general combiner was involved in most of the hybrids possessing high SCA effects.

Number of Fruits Per Vine : (Table 27 and 35)

Results of GCA revealed that out of 10 parents GCA was significant for 3, 3, 4, 4 and 3 in E_1, E_2, E_3, E_4 and pooled, respectively for more number of fruits per vine. B.G.-14 (P_6) and Pusa Do Mousami (P_{10}) depicted significant GCA effects in

Table 33. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for number of female flower per plant in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	-8.84**	-8.35**	-9.88**	-12.36**	-10.59**
P_1xP_3	-8.55**	-6.87**	1.52	-14.06**	-7.55**
P_1xP_4	-4.73**	-4.07**	0.13	0.52	-8.05**
P_1xP_5	-5.35**	-5.26**	-5.47**	11.07**	-4.23**
P_1xP_6	25.23**	26.13**	25.77**	22.29**	-0.79
P_1xP_7	-3.87**	-3.27**	-2.01*	3.94**	5.17**
P_1xP_8	28.26**	26.27**	25.42**	21.74**	16.61**
P_1xP_9	7.90**	8.57**	0.13	2.59*	13.67**
P_1xP_{10}	4.12**	2.77**	3.47**	-9.90**	11.43**
P_2xP_3	9.38**	6.84**	4.23**	20.29**	15.04**
P_2xP_4	0.16	-0.15	3.82**	-2.07*	4.84**
P_2xP_5	8.34**	9.11**	15.53**	-7.50**	0.59
P_2xP_6	-8.90**	-10.35**	-16.22**	15.58**	0.88
P_2xP_7	-5.49**	-1.99*	1.70*	4.60**	-2.65**
P_2xP_8	11.54**	11.54**	8.65**	1.22	-5.30**
P_2xP_9	9.98**	7.83**	12.48**	-10.21**	6.86**
P_2xP_{10}	9.80**	-8.17**	-7.78**	8.55**	0.84
P_3xP_4	-9.42**	-11.34**	-9.18**	-6.41**	0.98**
P_3xP_5	-2.66*	0.12	3.65**	-5.73**	-4.94**
P_3xP_6	1.46	4.49**	6.77**	-6.14**	0.16
P_3xP_7	10.84**	11.53**	-7.51**	-9.59**	4.17**
P_3xP_8	-3.63**	-3.20**	-1.58	18.08**	3.57**
P_3xP_9	2.34*	2.31**	3.88**	-0.92	-3.38**
P_3xP_{10}	2.11	3.89**	7.11**	6.25**	-0.59
P_4xP_5	7.44**	6.01**	-0.60	24.01**	9.19**
P_4xP_6	4.62**	3.85**	3.62**	-6.98**	1.27**
P_4xP_7	1.03	2.83**	1.98*	-4.53**	1.62**
P_4xP_8	-7.09**	-7.72**	-6.39**	-4.76**	4.89**
P_4xP_9	-0.58	-0.75	-3.19**	-2.15*	-5.37**
P_4xP_{10}	-0.64	1.18	6.41**	0.29	-4.27**
P_5xP_6	-4.71**	-2.79**	-6.22**	6.75**	-3.73**
P_5xP_7	-0.82	0.99	11.90**	-14.68**	1.79**
P_5xP_8	-3.76**	-4.59**	-9.35**	3.79**	-2.42**
P_5xP_9	11.97**	9.40**	8.73**	10.30**	9.69**
P_5xP_{10}	17.59**	19.61**	18.96**	14.97**	4.78**
P_6xP_7	-4.40**	-2.01*	-3.20**	11.57**	7.91*
P_6xP_8	0.58	-0.18	7.66**	-1.74	6.43**
P_6xP_9	1.36	0.60	3.54**	-4.88**	4.83**
P_6xP_{10}	-9.77**	-9.47**	-11.34**	-11.41**	4.07**
P_7xP_8	2.53*	3.15**	3.87**	-8.23**	-0.01
P_7xP_9	-4.35**	-1.79*	4.09**	18.72**	-3.30**
P_7xP_{10}	21.98**	2.73**	0.23	9.32**	0.48
P_8xP_9	-4.40**	-4.24**	-1.99*	3.90**	-3.04**
P_8xP_{10}	0.96	4.66**	-2.67**	-11.44**	0.16
P_9xP_{10}	0.84	4.18**	4.53**	-1.93	4.34**
S.E. ± (S_{ij})	1.0992	0.8530	0.8073	1.0022	0.4755
SED ± (S_{ij}-S_{ik})	1.6157	1.2539	1.1867	1.4733	0.6990
SED ± (S_{ij}-S_{kl})	1.5406	1.1955	1.1315	1.4047	0.6665

* Significant at 5% level

** Significant at 1% level

Table 34. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for percentage fruit set in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	-3.04**	-3.64**	-3.50**	-3.13	-2.19*
P_1xP_3	1.14*	1.58**	1.62**	-3.32	-0.72
P_1xP_4	1.61**	2.09**	0.71	-0.62	-1.33
P_1xP_5	-2.12**	-2.28**	0.21	4.75	-0.96
P_1xP_6	3.93**	3.53**	3.25**	4.40	-0.86
P_1xP_7	0.25	0.18	0.91	2.20	0.33
P_1xP_8	-0.27	3.84**	3.95**	3.24	1.11
P_1xP_9	3.68**	2.05**	1.62**	-0.04	3.12**
P_1xP_{10}	2.04**	1.75**	1.36**	0.87	2.22**
P_2xP_3	0.23	0.71	0.74	2.23	2.93**
P_2xP_4	2.24**	2.40**	1.05*	0.21	1.02
P_2xP_5	4.85**	4.88**	4.76**	1.22	1.19
P_2xP_6	-4.20**	-3.69**	-3.87**	1.36	0.13
P_2xP_7	1.55**	1.06*	1.83**	-0.11	-0.04
P_2xP_8	3.40**	2.61**	2.14**	-1.26	-0.65
P_2xP_9	3.31**	3.18**	2.58**	-1.38	1.96**
P_2xP_{10}	-0.78	-0.58	-1.19*	2.99	0.53
P_3xP_4	-2.78**	-3.23**	-3.64**	-1.14	0.44
P_3xP_5	0.10	0.46	1.36**	1.21	-0.59
P_3xP_6	1.82**	2.16**	0.98	-2.61	0.82
P_3xP_7	-2.60**	-2.77**	-2.77**	-3.89	0.40
P_3xP_8	0.83	-0.01	-0.26	4.49	0.17
P_3xP_9	1.50**	2.14**	1.66**	-1.71	-0.09
P_3xP_{10}	1.28**	0.77	2.07**	3.96	0.45
P_4xP_5	0.48	0.08	-0.29	4.71	1.96**
P_4xP_6	-0.40	0.84	0.42	-0.28	0.30
P_4xP_7	2.91**	2.03**	0.95	-0.42	1.81**
P_4xP_8	-0.86	-1.79**	-1.24*	-0.69	1.13
P_4xP_9	-1.23**	-0.86	-0.86	-1.89	-0.25
P_4xP_{10}	0.42	0.89	1.51**	0.47	-0.45
P_5xP_6	-0.61	-0.17	-0.34	3.64	-0.06
P_5xP_7	4.50**	4.63**	2.64**	-1.11	1.13
P_5xP_8	-2.30**	-2.77**	-0.82	2.08	-0.27
P_5xP_9	0.43	0.98	1.58**	5.24	1.20
P_5xP_{10}	0.67	0.93	1.02*	-17.09**	-0.12
P_6xP_7	0.18	-0.55	-0.94	2.30	1.71
P_6xP_8	2.34**	2.13**	2.05**	1.43	1.95*
P_6xP_9	0.13	1.16*	1.50**	-3.21	-3.60**
P_6xP_{10}	-0.05	-0.86	-1.83**	-2.87	2.13*
P_7xP_8	0.26	2.15**	0.74	-1.31	1.44
P_7xP_9	0.57	-0.14	1.21*	2.00	0.44
P_7xP_{10}	-2.12**	-1.98**	-0.54	4.18	-2.00*
P_8xP_9	-0.97	-0.53	-0.54	0.91	-0.43
P_8xP_{10}	1.40**	0.65	-0.14	-1.38	0.68
P_9xP_{10}	1.62**	1.47**	1.28*	3.18	2.07*
S.E. ± (S_{ij})	0.5257	0.5060	0.4935	3.4352	0.8867
SED ± (S_{ij}-S_{ik})	0.7728	0.7489	0.7254	5.0496	1.3034
SED ± (S_{ij}-S_{kl})	0.7369	0.7141	0.6917	4.8146	1.2427

* Significant at 5% level

** Significant at 1% level

first three (e.i. E_1, E_2 and E_3) as well as over the environments, revealed that these parents good general combiner for this character.

Table of SCA effects indicated that out of 45 hybrids 18 in E_1; 22 in E_2; 14 in E_3; 20 in E_4 and 23 in pooled exhibited significant SCA effects in desired direction. The highest SCA effects was recorded in cross P_1xP_8 (23.66), P_1xP_8 (24.29), P_1xP_6 (24.64), P_4xP_5 (22.25) and P_1xP_8 (15.40) under E_1, E_2, E_3, E_4 and pooled analysis, respectively. Hybrids P_1xP_8, P_3xP_{10}, P_5xP_9 and P_5xP_{10} showed significant SCA effects in all as well as over the environments, thus revealed better performance of these hybrids under varying environmental conditions.

Gill *et al.* (1971), Sirohi and Chaudhari (1971), Bhagchandani *et al.* (1980), Purdek (1984), Li and Shui (1985), Swamy (1985), Anek-Bangka (1986), Sivakami *et al.* (1987) and Kitroonriang *et al.* (1992) reported higher GCA and SCA effects in various cucurbits for number of fruits per vine.

Length of The fruit (cm) : (Table 27 and 36)

The result table of GCA revealed that out of 10 parents GCA was significant for 4, 3, 1, 3 and 2, in E_1, E_2, E_3, E_4 and pooled, respectively for more length of fruit. Coimbatore long (P_4) showed significant GCA effects in all as well as over the environments, which indicates that this parent was good general combiner for this attribute.

Results of SCA revealed that out of 45 hybrids 12 in E_1; 16 in E_2; 17 in E_3; 13 in E_4 and 18 in pooled analysis depicted significant SCA effects in desired direction. The highest SCA effects was recorded in cross P_3xP_8 (6.64), P_3xP_8 (5.88), P_3xP_8 (4.45), P_7xP_8) (5.99) and P_4xP_8 (2.77) under E_1, E_2, E_3, E_4 and pooled, respectively. Cross P_5xP_{10} exhibited significant SCA effects in all as well as over the environments in desired direction, revealed superiority of this hybrid under varying environmental condition.

Similar findings for this character in different cucurbitaceous vegetables were reported by Gill *et al.* (1971), Sirohi and Chaudhary (1977), Anek-Bangka (1986) and Sivakami *et al.* (1987).

Table 27. Estimation of general combining ability (GCA) effect over the environments for 8th to 13th character in Bitter gourd

Parents	Environments	No. of fruits per vine	Length of fruit (cm)	Girth of fruit (cm)	Weight of fruit (g)	Fruit yield per vine (g)	No. of seeds per fruit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
P_1	E_1	-0.02	1.33**	1.10**	3.49*	3.40	0.57**
	E_2	0.34	1.30**	-1.32**	-8.84**	265.89**	0.09
	E_3	0.77**	0.49	0.67**	6.09**	278.37**	-0.04
	E_4	5.69**	-0.93**	-0.64**	-6.44**	82.86**	0.67**
	Pooled	1.15	0.14	0.30**	1.70	130.59**	1.70**
P_2	E_1	-4.86**	-0.81**	0.41**	12.15**	-206.12**	-2.84**
	E_2	-4.91**	-0.87**	0.31*	2.52**	-199.12**	-3.20**
	E_3	-3.85**	-0.35	0.44**	2.69**	-176.56**	-3.34**
	E_4	-1.93**	-0.61**	-0.26	-6.03**	-278.49**	-3.75**
	Pooled	-1.65**	-0.42**	0.41**	2.52**	-107.21**	-0.96*
P_3	E_1	-1.31**	0.02	-0.78**	-5.62**	-190.88**	-0.17
	E_2	-0.67	0.06	-0.54**	-0.48*	-37.81**	0.37*
	E_3	-1.16**	0.15	-0.39**	0.14	-80.17**	0.46
	E_4	-5.59**	-0.71**	-0.37**	0.80*	-275.69**	-0.12
	Pooled	-3.01**	-0.29**	-0.08	-2.06	-194.28**	-1.23**
P_4	E_1	-1.54**	0.86**	0.26	0.64	82.77**	-2.35**
	E_2	-1.26**	1.04**	0.69**	2.41**	-3.59	-2.18**
	E_3	-1.85**	1.13**	-0.05	0.70	-93.15**	-1.88**
	E_4	-4.46**	2.68**	0.56**	19.77**	255.46**	-1.99**
	Pooled	-1.00**	0.29**	-0.21**	1.71	5.26	-0.95**
P_5	E_1	0.65*	-0.99**	-0.26	-5.55**	62.32**	-2.76**
	E_2	1.60**	-1.05**	0.00	-3.90**	-5.78	-2.54**
	E_3	-0.86**	-0.16	-0.45**	-4.25**	-37.84**	-2.61**
	E_4	5.70**	0.41**	0.36**	-2.92**	216.09**	-2.48**
	Pooled	-1.34**	-0.13	-0.15*	0.34	-18.96*	-0.18*
P_6	E_1	4.53**	-0.79**	0.77**	-2.72	182.19**	-2.98**
	E_2	5.39**	-0.70**	-0.70**	-0.12	262.66**	-2.75**
	E_3	4.88**	-0.84*	-0.20	-1.60**	278.44**	-2.95**
	E_4	0.22	-0.49**	-0.28*	-0.71*	38.24*	-2.07**
	Pooled	2.63**	-0.05	0.58**	1.03	181.08**	-1.28**
P_7	E_1	-0.07	-0.4**	-0.55**	4.60**	-182.91**	-5.18**
	E_2	-1.66**	-0.49**	-0.54**	-6.16**	-244.31**	-5.06**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	E_3	-4.57**	-0.68	-1.90**	-5.98**	-369.70**	-5.44**
	E_4	1.35*	0.27	0.65**	-1.99**	8.92	-5.37**
	Pooled	0.36	0.23**	-0.20**	2.21	-6.12	-1.56**
P_8	E_1	-0.06	-0.06	-0.68**	-2.03	33.01**	4.91**
	E_2	-0.07	-0.13	-0.67**	-0.21	43.23**	4.70**
	E_3	4.22**	-0.13	0.10	-2.12**	150.03**	4.66**
	E_4	1.76*	0.80**	0.87**	10.46**	413.18**	4.17**
	Pooled	1.75**	0.15	-0.38**	-2.28	72.28**	-0.29**
P_9	E_1	-1.45**	0.33*	0.11	-2.72	-122.01**	8.88**
	E_2	-1.27**	0.23	0.63**	-1.41**	-128.89**	8.49**
	E_3	-0.64**	0.31	1.69**	9.50**	124.48**	8.84**
	E_4	-1.17	-1.32**	-0.30*	-7.50**	-233.06**	8.91**
	Pooled	-0.81**	-0.06	-0.37**	-2.85*	-84.53**	1.86**
P_{10}	E_1	4.14**	0.51**	-0.38**	-2.23	138.24**	1.93**
	E_2	2.51**	0.61**	-0.48**	-1.48**	47.71**	2.08**
	E_3	1.34**	0.08	0.53*	-5.17**	-73.89**	2.32**
	E_4	-1.56*	-0.11	-0.57*	-5.44**	-227.50**	2.01**
	Pooled	1.93**	0.14	0.10	-2.32	21.89**	2.87**
SE ± (gi)	E_1	0.2919	0.1487	0.1349	1.5042	12.3575	0.1972
	E_2	0.4791	0.1857	0.1494	0.2344	10.3897	0.1710
	E_3	0.2452	0.3417	0.1156	0.3736	20.5922	0.4499
	E_4	0.6823	0.1714	0.1352	0.3161	15.6676	0.1814
	Pooled	0.2041	0.0826	0.0672	1.2880	7.5941	0.0943
SE ± (gi -gj)	E_1	0.4352	0.2215	0.2011	7.6380	18.4215	0.2942
	E_2	0.3422	0.2768	0.2227	0.3495	15.4880	0.2555
	E_3	1.0171	0.2556	0.2015	0.4713	23.3559	0.2685
	E_4	0.3656	0.2287	0.1724	0.5569	30.6971	0.3018
	Pooled	0.3043	0.1231	0.1002	1.9200	11.3207	0.1405

* Significant at 5% level
** Significant at 1% level

Table 35. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation number of fruits per vine in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	-8.29**	-8.12**	-11.08**	-11.98**	-9.87**
P_1xP_3	-7.37**	-5.92**	0.31	-13.46**	-7.17**
P_1xP_4	-3.61**	-3.16**	0.39	-0.12	-7.87**
P_1xP_5	-5.15**	-5.72**	-4.77	11.26**	-3.95**
P_1xP_6	23.50**	24.13**	24.64**	22.11**	-1.15
P_1xP_7	-3.56**	-2.35**	-1.47	4.57**	4.62**
P_1xP_8	23.66**	24.29**	23.21**	21.37**	15.40**
P_1xP_9	7.62**	7.51**	0.64	2.30**	13.11**
P_1xP_{10}	3.90**	2.53**	3.62	-9.40**	10.61**
P_2xP_3	7.87**	5.92**	2.56	18.67**	13.91**
P_2xP_4	0.83	0.20	3.88	-1.59	4.57**
P_2xP_5	8.77**	9.18**	15.77**	-7.04**	0.79
P_2xP_6	-8.93**	-10.01**	-14.88**	14.17**	0.59
P_2xP_7	-4.47**	-1.54*	2.21	4.27**	-1.54**
P_2xP_8	10.83**	10.61**	7.15**	0.59	-4.84**
P_2xP_9	9.22**	8.02**	12.00**	-9.00**	6.24**
P_2xP_{10}	-8.91**	-7.36**	-6.84**	7.94**	0.66
P_3xP_4	-8.27**	-10.42**	-10.12**	-5.61**	0.86
P_3xP_5	-2.00*	0.14	2.18	-5.66**	-4.68**
P_3xP_6	1.78	4.68**	4.89*	-6.21**	-0.18
P_3xP_7	8.29**	9.43**	-8.39**	-9.07**	3.37**
P_3xP_8	-2.97**	-2.89**	12.38**	17.85**	2.81**
P_3xP_9	2.33*	2.47**	2.48	-1.14	-3.53**
P_3xP_{10}	2.28*	3.68**	5.69*	5.99**	3.11**
P_4xP_5	2.28*	6.02**	-0.54	22.25**	7.83**
P_4xP_6	4.26*	3.61**	3.51	-6.22**	1.36*
P_4xP_7	2.13*	2.97**	2.78	-3.82**	2.12**
P_4xP_8	-6.01**	-7.35**	-7.22**	-4.48**	4.96**
P_4xP_9	-0.56	-1.13	-2.95	-2.15	-4.68**
P_4xP_{10}	0.01	1.30	6.47**	-0.24	4.05**
P_5xP_6	-4.10**	-2.69**	-5.60**	6.33**	-3.45**
P_5xP_7	0.89	1.76*	11.46**	-13.88**	2.05**
P_5xP_8	-3.57**	-4.99**	-10.00**	3.22**	-2.18**
P_5xP_9	10.89**	8.34	8.54**	10.86**	8.89**
P_5xP_{10}	16.24**	17.33**	17.54*	15.19**	3.97**
P_6xP_7	-3.91**	-2.10**	-3.16	11.52**	7.45**
P_6xP_8	1.20	0.80	6.67**	-1.32*	6.33**
P_6xP_9	1.08	1.05	3.84	-5.25**	4.96**
P_6xP_{10}	-8.70**	-8.63**	-10.48**	-11.39**	4.03**
P_7xP_8	2.28*	3.27**	2.31	-7.56**	0.52
P_7xP_9	-3.70**	-1.80*	3.98	15.02**	-3.00*
P_7xP_{10}	17.82**	1.65*	0.15	9.33**	-0.61
P_8xP_9	-4.21**	-3.84**	-3.22	4.13**	-3.08**
P_8xP_{10}	1.37	4.34**	-3.55	-11.16**	-0.51
P_9xP_{10}	1.17	4.36**	4.67**	-1.20	3.99**
S.E. ± (S_{ij})	0.9818	0.7721	2.2949	0.8249	0.6426
SED ± (S_{ij}-S_{ik})	1.4433	1.1350	3.3734	1.2125	1.0091
SED ± (S_{ij}-S_{kl})	1.3761	1.0822	3.2164	1.1561	0.9622

* Significant at 5% level

** Significant at 1% level

Table 36. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for length of fruit (cm) in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	0.47	0.12	0.39	-1.07	0.36
P_1xP_3	3.39**	3.06**	2.42**	5.19**	-0.27
P_1xP_4	0.61	0.02	-0.13	-1.95**	0.95**
P_1xP_5	-0.81	-0.78	-0.57	-0.43	0.63*
P_1xP_6	-0.74	-0.95	-0.98	-1.78**	1.04**
P_1xP_7	-3.38**	-3.35**	-4.05**	1.47**	-1.12**
P_1xP_8	1.51**	1.49**	1.76**	1.43**	-0.75**
P_1xP_9	1.95**	2.25**	2.86**	-2.69**	-0.32
P_1xP_{10}	-0.73	-0.03	0.84	-0.25	1.73**
P_2xP_3	-0.91	-0.97	-0.93	2.62**	2.05**
P_2xP_4	-3.36**	-3.76**	-2.62**	0.98	-1.97**
P_2xP_5	0.93	1.43*	1.67**	1.25*	-1.11**
P_2xP_6	0.15	0.91	1.86**	3.90**	-0.09
P_2xP_7	0.48	-0.39	0.60	-3.35**	0.96**
P_2xP_8	1.80**	1.49*	0.24	-1.14*	0.55*
P_2xP_9	-2.93**	-2.71**	-2.20**	-3.02**	0.39
P_2xP_{10}	0.96	1.71**	1.93**	0.23	-1.32**
P_3xP_4	-4.28**	-4.53**	-3.12**	-1.93**	-1.22**
P_3xP_5	-3.25**	-2.16**	-0.83	-0.24	-2.26**
P_3xP_6	1.55**	2.23**	3.22**	0.00	-0.89**
P_3xP_7	-0.08	-1.15	-3.30**	-4.01**	0.22
P_3xP_8	6.64**	5.88**	4.45**	0.26	1.95**
P_3xP_9	-1.92**	-2.11**	-0.50	-1.67**	0.20
P_3xP_{10}	-1.74**	-0.80	0.44	-0.13	-0.54*
P_4xP_5	-3.78**	-5.34**	-4.81**	0.61	-1.03**
P_4xP_6	0.70	1.28*	2.05**	-1.14*	-2.08**
P_4xP_7	3.74**	4.47**	1.46**	-3.50**	-0.20
P_4xP_8	0.76	0.94	2.20**	-2.43**	2.77**
P_4xP_9	0.75	2.46**	2.72**	-0.48	1.51**
P_4xP_{10}	1.25*	1.91**	1.41*	-0.03	1.88**
P_5xP_6	-1.13*	-1.71**	0.17	-1.38**	1.71**
P_5xP_7	0.33	-0.11	2.50**	0.87	-0.29
P_5xP_8	1.05*	1.17	-0.30	-5.16**	0.06
P_5xP_9	0.35	0.47	-0.43	2.61**	0.22
P_5xP_{10}	3.49**	3.49**	2.24**	3.41**	0.96**
P_6xP_7	0.72	0.66	-0.48	0.94	0.53
P_6xP_8	-1.22*	-1.42*	2.07**	-0.93	0.27
P_6xP_9	2.68**	1.68**	-0.14	1.89**	0.59*
P_6xP_{10}	1.04*	1.76**	-1.57**	0.46	0.92**
P_7xP_8	-0.44	0.77	0.82	5.99**	-0.45
P_7xP_9	2.99**	2.95**	0.06	4.97**	0.09
P_7xP_{10}	-1.24*	-1.30*	1.26**	-0.74	0.05
P_8xP_9	-1.65**	-1.19	-0.96	2.57**	1.07**
P_8xP_{10}	-0.19	-0.96	-2.54**	0.19	0.71*
P_9xP_{10}	1.83**	1.15*	-0.50	1.78**	0.91**
S.E. ± (S_{ij})	0.4997	0.6246	0.5766	0.5160	0.2777
SED ± (S_{ij}-S_{ik})	0.7346	0.9182	0.8476	0.7586	0.4082
SED ± (S_{ij}-S_{kl})	0.7004	0.8754	0.8082	0.7233	0.3892

* Significant at 5% level

** Significant at 1% level

Girth of Fruit (cm) : (Table 27 and 37)

Table of GCA indicated that out of 10 parents GCA was positive significant for 3, 3, 4, 4 and 3 in E_1, E_2, E_3, E_4 and pooled, respectively for more girth of fruit. NBPGR/TCR-72 (P_2) exhibited significant GCA effects in first three (eg. E_1, E_2 and E_3) as well as over the environments, revealed good general combining ability of this parent.

Results of SCA revealed that out of 45 hybrids 17 in E_1; 15 in E_2 and E_4 each; 20 in E_3 and 22 in pooled depicted significant SCA effects in desired direction. The highest SCA effects was observed in cross P_3xP_6 (5.02), P_3xP_6 (6.52), P_3xP_6 (4.98), P_3xP_5 (4.27) and P_5xP_6 (2.03) under E_1, E_2, E_3, E_4 and pooled analysis, respectively. Cross P_4xP_{10} showed significant SCA effects in all as well as over the environments hence revealed the expression of superiority for this hybrid.

Sirohi and Chaudhary (1977), Anek-Bangva (1984) and Sivakami *et al.* (1987) observed similar findings for this trait in bitter gourd, cucumber and bottle gourd, respectively.

Weight of Fruit (g) : (Table 27 and 38)

Result in table of GCA explained that out of 10 parents GCA was significant for 3, 2, 3, 3 and 1 in E_1, E_2, E_3, E_4 and pooled, respectively for higher weight of fruit. NBPGR/TCR-72 (P_2) depicted significant GCA effects in first three (e.g. E_1, E_2 and E_3) as well as over the environments, revealed good general combining ability for weight of fruit.

Table of SCA revealed that out of 45 hybrids 1 in E_1; 19 in E_2; 20 in E_3 ; 22 in E_4 and 7 in poled showed significant SCA effects in desired direction. The highest SCA effects was observed in cross P_2xP_7 (126.47), P_3xP_6 (40.75), P_3xP_6 (46.27), P_4xP_8 (43.56) and P_2xP_7 (32.32) under E_1, E_2, E_3, E_4 and pooled, respectively. Cross P_1xP_6 depicted significant SCA effects in last three (eg. E_2, E_3 and E_4) as well as over the environments.

Hence present findings in confirmation to work in various cucurbits reported by Bhattacharya *et al.* (1970), Sirohi and Chaudhary (1977), Prudek (1984), Li and Shu (1985), Swamy (1985), Sivakami *et al.* (1985) and Kitroongriang *et al.* (1992).

Table 37. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for girth of fruit (cm) in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	2.31^{**}	2.24^{**}	1.10	-0.23	1.52^{**}
P_1xP_3	-0.43	-0.47	-0.67	3.58^{**}	-0.19
P_1xP_4	3.68^{**}	2.92^{**}	-1.28^{**}	0.24	-0.81^{**}
P_1xP_5	0.82	2.06^{**}	0.97^{*}	-1.31^{**}	-0.30
P_1xP_6	1.03^{*}	0.59	-0.59	-0.42	1.20^{**}
P_1xP_7	0.13	0.46	-2.70^{**}	-0.34	0.75^{**}
P_1xP_8	0.21	0.23	0.57	0.29	0.16
P_1xP_9	0.58	0.93	0.92^{*}	-1.79^{**}	-0.34
P_1xP_{10}	1.87^{**}	-1.21^{*}	1.99^{**}	0.37	1.21^{**}
P_2xP_3	2.39^{**}	-2.64^{**}	1.79^{**}	0.30	1.08^{**}
P_2xP_4	-1.55^{**}	-0.13	-1.50^{**}	1.11^{**}	-1.24^{**}
P_2xP_5	-0.05	0.90	4.40^{**}	1.32^{**}	0.28
P_2xP_6	0.22	-0.47	-0.35	1.96^{**}	-0.65^{**}
P_2xP_7	-4.91^{**}	-3.18^{**}	-0.47	-0.60	-0.19
P_2xP_8	-0.98^{*}	0.23	1.14^{*}	0.56	-0.82^{**}
P_2xP_9	3.20^{**}	3.29^{**}	-0.21	-0.27	0.97^{**}
P_2xP_{10}	-1.47^{**}	-2.09^{**}	2.07^{**}	-2.51^{**}	0.55^{*}
P_3xP_4	0.97^{*}	0.76	-0.67	-1.03^{**}	0.64^{**}
P_3xP_5	0.59	0.74	-2.27^{**}	4.27^{**}	0.67^{**}
P_3xP_6	5.02^{**}	6.52^{**}	4.98^{**}	0.92^{*}	-0.27
P_3xP_7	-3.47^{**}	-3.22^{**}	-1.34^{**}	-3.15^{**}	-0.55^{*}
P_3xP_8	0.33	1.05^{*}	3.67^{**}	-0.83^{*}	1.30^{**}
P_3xP_9	-2.65^{**}	-2.81^{**}	-3.42^{**}	-0.46	-1.03^{**}
P_3xP_{10}	2.77^{**}	3.70^{**}	2.60^{**}	0.60	-0.18
P_4xP_5	0.56	-4.52^{**}	-3.31^{**}	0.24	0.60^{**}
P_4xP_6	-4.82^{**}	2.88^{**}	1.14^{*}	3.78^{**}	-2.10^{**}
P_4xP_7	2.86^{**}	-1.00^{*}	1.02^{*}	-2.55^{**}	0.77^{**}
P_4xP_8	1.92^{**}	0.57	-0.97^{*}	0.23	1.31^{**}
P_4xP_9	-0.14	3.14^{**}	2.54^{**}	0.58	1.80^{**}
P_4xP_{10}	3.80^{**}	1.90^{**}	1.06^{*}	1.32^{**}	1.57^{**}
P_5xP_6	1.23^{**}	-3.37^{**}	0.34	-0.36	2.03^{**}
P_5xP_7	-2.23^{**}	-1.09^{*}	1.63^{**}	-1.35^{**}	-1.05^{**}
P_5xP_8	-0.35	-0.84	-2.16^{**}	-1.37^{**}	0.10
P_5xP_9	-1.67^{**}	-1.35^{**}	0.95^{*}	1.60^{**}	-0.32
P_5xP_{10}	-1.28^{**}	4.84^{**}	1.27^{**}	1.70^{**}	1.33^{**}
P_6xP_7	3.30^{**}	3.32^{**}	0.28	-0.45	2.14^{**}
P_6xP_8	0.47	0.25	4.50^{**}	-0.58	0.74^{**}
P_6xP_9	0.80	-0.14	0.13	0.74	0.08
P_6xP_{10}	-1.71^{**}	-4.63^{**}	-3.89^{**}	1.96^{**}	0.01
P_7xP_8	0.93^{**}	1.18^{*}	2.08^{**}	2.14^{*}	-0.50^{*}
P_7xP_9	2.64^{**}	2.54^{**}	-0.72	2.32^{**}	0.04
P_7xP_{10}	-2.38^{**}	-1.90^{**}	-2.50^{**}	0.75	0.48^{*}
P_8xP_9	-1.00^{*}	-3.45^{**}	-1.91^{**}	1.49^{**}	0.55^{*}
P_8xP_{10}	-2.04^{**}	-0.74	-2.49^{**}	-1.31^{**}	1.69^{**}
P_9xP_{10}	1.01^{*}	1.03^{*}	-1.32^{**}	1.26^{**}	0.14
S.E. ± (S_{ij})	0.4538	0.5026	0.4546	0.3889	0.2262
SED ± (S_{ij}-S_{ik})	0.6671	0.7388	0.6683	0.5717	0.3325
SED ± (S_{ij}-S_{kl})	0.6360	0.7044	0.6372	0.5451	0.3170

* Significant at 5% level

** Significant at 1% level

Table 38. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for weight of fruit (g) in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	-13.96	-1.49	-4.27**	-4.17**	5.16
P_1xP_3	8.93	18.44**	20.19**	40.96**	-5.36
P_1xP_4	-3.10	-11.49**	-17.45**	-18.14**	2.28
P_1xP_5	8.77	13.15**	9.54**	-6.48**	2.35
P_1xP_6	21.27	10.19**	8.68**	26.32**	13.80**
P_1xP_7	-17.41	-8.30**	-17.66**	4.47**	0.46
P_1xP_8	16.01	7.79**	2.98	3.01*	3.21
P_1xP_9	-4.98	-1.18	22.39**	-14.77**	4.94
P_1xP_{10}	12.17	1.72*	7.18**	-0.44	6.61
P_2xP_3	-18.11	-8.98**	-2.04**	-3.01*	10.49*
P_2xP_4	-15.96	-10.71**	-19.67**	-4.63**	-11.58**
P_2xP_5	-14.24	-0.24	-3.90**	18.10**	-14.02**
P_2xP_6	-14.77	-2.43**	-3.06**	4.47**	-11.09*
P_2xP_7	126.47**	-3.28**	15.89**	14.93**	32.32**
P_2xP_8	-6.47	11.75**	10.74**	8.33**	1.07
P_2xP_9	1.09	6.60**	-8.36**	-7.42**	9.40*
P_2xP_{10}	3.55	17.77**	10.80**	-7.24**	2.51
P_3xP_4	-16.33	-21.77**	-15.45**	8.19**	4.21
P_3xP_5	-3.03	-7.86**	-15.81**	1.92	-9.62*
P_3xP_6	20.69	40.75**	46.27**	-11.17**	-6.94
P_3xP_7	-18.23	-7.77**	-8.11**	-19.88**	7.62
P_3xP_8	0.66	-2.41**	3.74**	2.01	10.47*
P_3xP_9	-2.58	-10.53**	-11.71**	-7.73**	-4.52
P_3xP_{10}	8.47	10.23**	9.04**	4.28**	-3.07
P_4xP_5	-11.55	-18.95**	-18.68**	-2.81*	-0.97
P_4xP_6	15.87	6.85**	0.76	39.94**	-6.67
P_4xP_7	-14.75	2.37**	0.62	-8.62**	-9.33*
P_4xP_8	7.99	2.70**	9.65**	43.56**	5.69
P_4xP_9	0.87	-0.97	-9.64**	5.83**	15.99**
P_4xP_{10}	-6.67	-10.39**	-2.42*	-14.30**	3.23
P_5xP_6	-1.80	-0.24	11.60**	-10.43**	12.67**
P_5xP_7	-0.64	10.46**	11.72**	8.37**	-0.88
P_5xP_8	2.24	-3.87**	-1.21	-18.15**	2.48
P_5xP_9	9.63	8.37**	2.85**	4.82**	-1.95
P_5xP_{10}	29.54	26.05**	21.59**	25.61**	7.48
P_6xP_7	-15.85	-13.12**	-19.66**	5.68**	-1.86
P_6xP_8	23.34	25.55**	31.73**	-7.74**	3.03
P_6xP_9	-13.74	-7.94**	-12.72**	4.24**	1.17
P_6xP_{10}	-3.36	-12.65**	-15.10**	8.24**	4.92
P_7xP_8	3.51	24.78**	29.86**	15.28**	-2.34
P_7xP_9	-5.82	6.70**	4.15**	21.29**	-1.88
P_7xP_{10}	-16.46	7.10**	-6.15**	-12.57**	2.66
P_8xP_9	-6.06	-3.40**	-21.53**	14.08**	6.93
P_8xP_{10}	-16.60	-20.14**	-14.56**	-13.53**	-2.91
P_9xP_{10}	3.32	-3.22**	-9.68**	10.01**	-8.90*
S.E. ± (S_{ij})	17.2335	0.7885	1.0633	1.2565	4.3321
SED ± (S_{ij}-S_{ik})	25.3322	1.1591	1.5630	1.8471	6.3680
SED ± (S_{ij}-S_{kl})	24.1534	1.1052	1.4902	1.7611	6.0716

* Significant at 5% level

** Significant at 1% level

Fruit Yield Per Vine (g) : (Table 27 and 39)

Results of GCA indicated that out of 10 parents GCA was significant for 5, 4, 4, 5 and 4 in E_1, E_2, E_3, E_4 and pooled, respectively for higher fruit yield. B.G. 14 (P_6) and M.C. -84 (P_8) exhibited significant GCA effects in all as well as over the environments, revealed good general combining ability for increasing fruit yield per vine.

Result in table of SCA revealed that out of 45 hybrids 18 in E_1; 18 in E_2; 19 in E_3, 22 in E_4 and 21 in pooled analysis depicted significant SCA effects in desired direction. The highest SCA effects was recorded in cross P_1xP_6 (1961.14), P_1xP_6 (1805.13), P_3xP_6 (1997.91), P_1xP_6 (2467.64) and P_2xP_3 (1076.38) under E_1, E_2, E_3, E_4 and pooled, respectively. Crosses P_1xP_6, P_1xP_8, P_5xP_9 and P_5xP_{10} exhibited significant SCA effects in all as well as over the environments for higher yield of fruits. It was observed that atleast one good general combiner was involved in most of the hybrids possessing high SCA effect.

Gill *et al.* (1971), Chekalina (1976), Sirohi and Chaudhary (1977), Bhagchandani *et al.* (1980), Singh and Joshi (1980), Swamy (1985), Sivakami *et al.* (1987), Lawande and Patil (1990) and Kitroong *et al.* (1992) reported higher GCA and SCA effects for fruit yield in different cucurbitaceous vegetable crops.

Number of Seeds Per Fruit : (Table 27 and 40)

Table of GCA showed that out of 10 parents GCA was significant for 5, 5, 5, 5 and 7 in E_1, E_2, E_3, E_4 and pooled analysis, respectively. NBPGR/TCR-72 (P_2), Coimbatore long (P_4), NBPGR/TCR-36 (P_5), B.G.-14 (P_6) depicted significant negative GCA effects in all as well as over the environments, revealed good general combining ability for less number of seeds per fruit.

Results of SCA revealed that out of 45 hybrids 19 in E_1; 19 in E_2; 20 in E_3, E_4 and pooled each exhibited significant SCA effects in desired direction. The highest SCA effects was observed in cross P_2xP_{10} (-14.31), P_2xP_{10} (-14.43), P_2xP_{10} (-14.02), P_3xP_5 (-13.91) and P_2xP_{10} (-6.21) under E_1, E_2, E_3, E_4 and pooled analysis, respectively. Crosses P_1xP_7, P_1xP_9, P_1xP_{10}, P_2xP_7, P_3xP_5, P_3xP_7, P_3xP_8, P_4xP_7, P_5xP_8 and P_5xP_9 showed significant SCA effects in all as well as over the environments for less

Table 39. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for fruit yield per vine (g) in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	-510.93**	-535.03**	-682.21**	-621.03**	-408.33**
P_1xP_3	-249.42**	-6.65	571.90**	163.43*	-538.20**
P_1xP_4	-464.41**	-489.86**	-558.76**	-440.01**	-402.48**
P_1xP_5	-303.30**	-59.81	-119.97**	-0.13	-176.66**
P_1xP_6	1961.14**	1805.13**	1808.19**	2467.64**	237.25**
P_1xP_7	-354.69**	-337.64**	-646.01**	331.92**	393.01**
P_1xP_8	1607.82**	1518.77**	1433.37**	1411.58**	858.03**
P_1xP_9	57.89	360.87**	791.17**	-614.94**	921.47**
P_1xP_{10}	447.37**	160.74**	364.56**	-460.53**	753.50**
P_2xP_3	-130.96**	34.28	-455.67**	771.05**	1076.38**
P_2xP_4	-97.02*	-199.04**	-311.08**	-165.29*	-39.93
P_2xP_5	127.11**	364.64**	629.25**	155.67*	-294.94**
P_2xP_6	-428.40**	-502.47**	-885.64**	778.89**	-225.10**
P_2xP_7	84.61*	-55.66	501.91**	-361.47**	-2.98
P_2xP_8	544.88**	800.59**	826.50**	297.12**	-156.63**
P_2xP_9	756.01**	459.91**	565.73**	-523.42**	596.34**
P_2xP_{10}	-113.85**	3.07	-88.10	50.16	127.99**
P_3xP_4	-631.75**	-781.62**	-790.16**	313.62**	216.23**
P_3xP_5	-281.43**	-275.26**	-446.20**	-229.76**	-425.51**
P_3xP_6	598.65**	1546.79**	1971.91**	-593.52**	-260.96**
P_3xP_7	65.24	55.47	-542.87**	-811.41**	354.55**
P_3xP_8	-148.08**	-263.35**	-107.89**	1190.59**	741.94**
P_3xP_9	43.96	-172.65**	-95.40	-245.48**	-295.95**
P_3xP_{10}	298.82**	445.36**	585.87**	436.08**	-117.07**
P_4xP_5	530.91**	-414.23**	-608.03**	1509.90**	628.66**
P_4xP_6	491.10**	338.71**	132.91**	449.92**	-170.93**
P_4xP_7	-102.62*	178.74**	92.11	-391.07**	-89.02**
P_4xP_8	-303.82**	-359.33**	-123.13**	790.23**	445.97**
P_4xP_9	-118.65**	-55.88	-324.95**	21.43**	65.99**
P_4xP_{10}	-324.65**	-239.93**	209.57**	-348.60**	-135.49**
P_5xP_6	-445.89**	-237.82**	-78.43	-248.72**	42.79
P_5xP_7	155.05**	311.48**	847.87**	-485.43**	72.94**
P_5xP_8	-317.97**	-429.45**	-586.33**	-533.25**	-120.35**
P_5xP_9	544.21**	569.80**	665.32**	543.70**	250.99**
P_5xP_{10}	1686.89**	1802.27**	1732.34**	1886.49**	406.97**
P_6xP_7	-314.28**	-515.95**	-827.59**	757.13**	432.23**
P_6xP_8	588.56**	697.33**	1663.46**	-350.83**	372.91**
P_6xP_9	-429.60**	-255.66**	-189.97**	-225.36**	313.85**
P_6xP_{10}	-510.79**	-732.69**	-1022.19**	-426.88**	455.92**
P_7xP_8	415.11**	732.04**	1005.50**	5.17	-14.16
P_7xP_9	22.49	121.04**	379.98**	1560.72**	-143.78**
P_7xP_{10}	314.29**	-148.55**	-208.79**	136.38*	43.91
P_8xP_9	-339.58**	-285.11**	-709.34**	688.29**	-27.78
P_8xP_{10}	-561.00**	-551.18**	-695.46**	-925.13**	-100.36**
P_9xP_{10}	111.68**	80.71*	20.86	176.60*	-205.00**
S.E. ± (S_{ij})	41.5645	34.9457	52.6981	69.2620	25.5428
SED ± $(S_{ij}-S_{ik})$	61.0972	51.3681	77.4629	101.8108	37.5464
SED ± $(S_{ij}-S_{kl})$	58.2539	48.9775	73.8580	97.0728	35.7991

* Significant at 5% level

** Significant at 1% level

Table 40. Estimates of specific combining ability (SCA) effect over the environments in F_1 generation for number of seeds per fruit in Bitter gourd

Crosses	Environments				
	E_1	E_2	E_3	E_4	Pooled
P_1xP_2	7.06**	7.26**	7.23**	7.10**	3.84**
P_1xP_3	9.39**	8.38**	8.23**	7.08**	6.76**
P_1xP_4	-3.30**	-4.26**	-5.60**	-4.65**	0.99**
P_1xP_5	0.82	1.02	0.30	1.80**	-0.15
P_1xP_6	-1.98**	-2.45**	-2.42**	-1.50*	1.71**
P_1xP_7	-2.97**	-2.58**	-4.74**	-4.48**	-5.26**
P_1xP_8	4.62**	3.55**	4.17**	3.94**	-1.99**
P_1xP_9	-8.53**	-8.73**	-6.84**	-6.25**	-4.39**
P_1xP_{10}	-3.40**	-2.51**	-1.98**	-2.01**	-4.80**
P_2xP_3	-1.17	-2.31**	-1.80**	-3.56**	3.88**
P_2xP_4	10.18**	12.57**	12.79**	13.56**	2.92**
P_2xP_5	-3.78**	-3.01**	-3.55**	-2.80**	-0.28**
P_2xP_6	1.60*	0.41	-0.19	0.83	-0.83**
P_2xP_7	-4.54**	-2.67**	-3.53**	-1.76*	-2.29**
P_2xP_8	0.22	0.25	-0.53	1.41*	-4.65**
P_2xP_9	3.27**	2.30**	4.95**	3.51**	-2.33**
P_2xP_{10}	-14.31**	-14.43**	-14.02**	15.36**	-6.21**
P_3xP_4	1.54*	1.60**	1.11	1.76*	1.26**
P_3xP_5	-11.57**	-13.14**	-13.35**	-13.91**	-3.72**
P_3xP_6	-4.56**	-0.71	-1.71**	-0.96	-7.45**
P_3xP_7	-4.68**	-4.39**	-4.17**	-3.44**	-4.31**
P_3xP_8	-1.96**	-1.56**	-2.13**	-3.06**	-5.09**
P_3xP_9	5.69**	6.74**	7.38**	8.03**	0.91**
P_3xP_{10}	-1.03	-1.29*	-1.10	-2.07**	1.09**
P_4xP_5	2.12**	2.48**	3.20**	3.29**	5.22**
P_4xP_6	-8.75**	-10.20**	-7.68**	-10.77**	2.92**
P_4xP_7	-9.69**	-10.39**	-9.48**	-9.74**	-5.81**
P_4xP_8	9.41**	10.10**	10.63**	9.00**	-3.46**
P_4xP_9	3.38**	3.84**	3.64**	2.92**	-3.05**
P_4xP_{10}	0.15	0.44	-0.54	0.83	-0.24
P_5xP_6	1.75**	1.63**	2.05**	1.62*	6.13**
P_5xP_7	14.01**	13.84**	15.63**	16.00**	4.91**
P_5xP_8	-13.37**	-12.82**	-11.61**	-10.86**	-1.31**
P_5xP_9	-10.49**	-10.04**	-11.63**	-10.46**	-4.14**
P_5xP_{10}	5.61**	5.65**	4.99**	4.24**	-2.74**
P_6xP_7	-0.99	-1.07	-0.17	-3.74**	-1.66*
P_6xP_8	-0.33	-0.39	0.94	2.73**	0.06
P_6xP_9	-1.88**	-2.29**	-3.44**	-3.02**	-0.24
P_6xP_{10}	14.99**	15.40**	15.08**	14.88**	0.76*
P_7xP_8	-4.63**	3.10**	-3.55**	-5.74**	6.27**
P_7xP_9	13.17**	11.92**	11.55**	10.23**	7.75**
P_7xP_{10}	1.91**	2.25**	2.80**	4.33**	4.95**
P_8xP_9	6.46**	7.46**	9.94**	8.88**	5.44**
P_8xP_{10}	10.19**	9.31**	10.87**	11.65**	10.34**
P_9xP_{10}	-6.03**	-6.23**	-7.71**	-6.10*	6.72**
S.E. ± (S_{ij})	0.6638	0.5755	0.6059	0.6809	0.3170
SED ± (S_{ij}-S_{ik})	0.9758	0.8458	0.8907	1.0009	0.4660
SED ± (S_{ij}-S_{kl})	0.9303	0.8064	0.8492	0.9543	0.4444

* Significant at 5% level

** Significant at 1% level

number of seeds per fruit. It was observed that atleast one good general combiner was involved in all the hybrids possessing high SCA effect.

Similar findings were reported by Sirohi and Chaudhary (1979).

An over all appraisal of table 41, indicated that parental lines P_2, P_6, P_8 and P_{10} were good general combiner for most of the traits. Parents P_6 and P_{10} had high GCA effects for number of female flower per plant and number of fruits per vine. P_1 and P_{10} for node number at which first female flower appear; P_8 and P_9 for percentage fruit set; P_6 and P_8 for fruit yield per vine; P_2, P_4, P_5 and P_6 for number of seeds per fruit. Besides, these parent P_8 was good general combiner for days taken to the appearance of first female flower; while P_2 for length of main shoot, number of male flower per plant, girth of fruit and weight of fruit. Parent P_7 for number of lateral branches per plant and P_4 for length of the fruit had high GCA effect.

The SCA effects were significant for all of the traits in desired direction. Hybrids (P_1xP_9), (P_1xP_{10}), (P_2xP_9), (P_6xP_8) and (P_9xP_{10}) were superior for percentage fruit set; (P_1xP_8), (P_3xP_{10}), (P_5xP_9) and (P_5xP_{10}) for number of fruits per vine, (P_1xP_6), (P_1xP_8), (P_5xP_9) and (P_5xP_{10}) for fruit yield per vine; (P_1xP_7), (P_1xP_9), (P_1xP_{10}), (P_2xP_7), (P_3xP_5), (P_3xP_7), (P_3xP_8), (P_4xP_7), (P_5xP_8) and (P_5xP_9) for number of seeds per fruit, (P_1xP_8), (P_2xP_3) and (P_5xP_{10}) for number of female flower per plant. Besides these (P_5xP_{10}), (P_6xP_9) and (P_1xP_3), (P_2xP_{10}) and (P_1xP_2), (P_1xP_5) were also superior for length of main shoot and number of lateral branches per plant and number of male flower per plant, respectively. Hybrid (P_5xP_7) for days taken to the appearance of first female flower; (P_2xP_5) for node number at which firs female flower appear; (P_5xP_{10}) for length of fruit; (P_4xP_{10}) for girth of the fruit and (P_1xP_6) for weight of the fruit was observed superior. Hybrids (P_5xP_{10}) was observed superior in most of the traits. It was observed, that, in general at least one parent with good general combining ability was involved in superior hybrids.

4.4 STABILITY PARAMETERS

The study of genotype x environment interactions led to successful evaluation of stable genotypes, which could be used in future breeding programmes. Earlier, Finaly and Wilkinson (1963) considered linear regression slopes as a measure of stability. Eberhart and Russell (1966) emphasized the need of considering both the

Table 41. Parents and hybrids possessing good general combining ability, and specific combining ability respectively for thirteen traits in Bitter Gourd

Character	Parents	Hybrids
Days taken to the appearance of first female flower	(P_8)	(P_5xP_7)
Node number at which first female flower appear	(P_1), (P_{10})	(P_2xP_5)
Length of main shoot (cm)	(P_2)	(P_5xP_{10}), (P_6xP_9)
Number of lateral branches per plant	(P_7)	(P_1xP_3), (P_2xP_{10})
Number of male flower per plant	(P_2)	(P_1xP_2), (P_1xP_5)
Number female flower per plant	(P_6), (P_{10})	(P_1xP_8), (P_2xP_3), (P_5xP_{10})
Percentage fruit set	(P_8), (P_9)	(P_1xP_9), (P_1xP_{10}), (P_2xP_9), (P_6xP_8), (P_9xP_{10})
Number of fruits per vine	(P_6), (P_{10})	(P_1xP_8), (P_3xP_{10}), (P_5xP_9), (P_5xP_{10})
Length of fruit (cm)	(P_4)	(P_5xP_{10})
Girth of fruit (cm)	(P_2)	(P_4xP_{10})
Weight of fruit (g)	(P_2)	(P_1xP_6)
Fruit yield per vine (g)	(P_6), (P_8)	(P_1xP_6), (P_1xP_8), (P_5xP_9), (P_5xP_{10})
Number of seeds per fruit	(P_2), (P_4), (P_5), (P_6)	(P_1xP_7), (P_1xP_9), (P_1xP_{10}), (P_2xP_7), (P_3xP_5), (P_3xP_7), (P_3xP_8), (P_4xP_7), (P_5xP_8), (P_5XP_9)

linear (b_i) and non-linear (S^2di) components of genotype x environment interaction in judging the phenotypic stability of a genotype.

In the present investigation, model proposed by Eberhart and Russel (1966) was being used for analysis of G x E interactions. It considered both linear (b_i) and non-linear (S^2di) components of G x E interactions for the prediction of performance of the individual variety. According to this model, an ideal stable genotype will be that, which possessed unit regression coefficient ($b_i = 1$) and deviation from regression not significant by deviate from zero ($S^2di = 0$) with higher mean performance over population mean. In this model, regression co-efficient (b_i) is considered as a parameter of response and deviation from regression (S^2di) as a parameter of stability. The value of $b_i \approx 1$ indicated that the genotype is less responsive to the environmental changes and therefore, is more adaptive. If, however, b_i is less than unity, the genotype will perform well under poor environmental condition, while b_i value more than unity revealed better performance under favourable environments. Significant deviation from regression (S^2di) will invalidate for the linear prediction, whereas non significant S^2di revealed that the performance of a genotype in a given set of environmental conditions may be predicted.

In the present study, suitable inbred lines/strains and hybrids of Bitter gourd were identified by raising 55 genotypes (10 parents and 45 F_1 hybrids) under 4 environments for 13 traits. Singh *et al.* (1985), Bacusmo (1987), Sidhu *et al.* (1988), El-Beheidi (1989), Gill and Kumar (1989) and Prasad and Singh (1990) also screemed suitable genotypes of different vegetable crops.

Pooled Analysis of Variance (Table 42)

Analysis of variance over the environment revealed that environmental and genotypic mean square was significant for all the characters except node number at which first female flower appear, number of male flower per plant and percentage fruit set, where mean square due to environment was non-significant. Interaction of genotypes with environments was also significant for all the characters except node number at which first female flower appear, percentage fruit set, weight of fruit and number of seeds per fruit. Deviation from regression (E linear) and individual genotype mean (G x E linear) was significant for all the characters except percentage

Table 42. Pooled analysis of variance for stability parameters of 13 quantitative and quality characters over the environments in Bitter gourd (Eberhart and Russel, 1966)

Source	d.f.	Days taken to the appearance of first female flower	Node no. at which first female flower appear	Length of main shoot (cm)	No. of lateral branches per plant	No. of male flower per plant	No. of female flower per plant	Percentage fruit set	No. of fruits per vine	Length of fruit (cm)	Girth of fruit (cm)	Weight of fruit (g)	Fruit yield per vine (g)	No. of seeds per fruit
Genotype (G)	54	31.96^{**}	43.08^{**}	179.00^{**}	59.84^{**}	807.00^{**}	330.13^{**}	19.76^{**}	291.47^{**}	15.29^{**}	9.75^{**}	686.90^{**}	176.00^{**}	325.57^{**}
Environment (E)	3	103.48^{**}	4.99	558.00^{**}	104.59^{**}	326.00	770.28^{**}	4.13	668.98^{**}	84.12^{**}	74.32^{**}	183.00^{**}	579.00^{**}	8.52^{**}
G x E	162	$6.26^{\square\square}$	3.08	$817.37^{\square\square}$	$10.19^{\square\square}$	$180.00^{\square\square}$	$46.00^{\square\square}$	5.50	$40.74^{\square\square}$	$3.30^{\square\square}$	$3.69^{\square\square}$	261.75	$214.00^{\square\square}$	1.07
E + (GxE)	165	8.03^{++}	3.12^{++}	181.00	11.90^{++}	181.00	59.17^{++}	5.48	52.16^{++}	4.77^{++}	4.98^{++}	290.25	315.00^{++}	1.20^{++}
E (Linear)	1	310.68^{++}	14.96^{+}	167.00^{++}	313.76^{++}	979.00^{+}	231.00^{++}	12.38	201.00^{++}	252.38^{++}	222.96^{++}	549.00^{++}	174.00^{++}	25.51^{++}
GxE (Linear)	54	13.63^{++}	3.96^{++}	167.00^{++}	15.32^{++}	118.00	69.83^{++}	1.03	60.23^{++}	5.64^{++}	3.78	193.67	138.00	1.70^{++}
Pooled deviation	110	$2.53^{\square\square}$	$2.60^{\square\square}$	$378.46^{\square\square}$	$7.48^{\square\square}$	$204.00^{\square\square}$	$33.48^{\square\square}$	$7.60^{\square\square}$	$30.43^{\square\square}$	$2.09^{\square\square}$	$3.58^{\square\square}$	$290.42^{\square\square}$	$247.00^{\square\square}$	$0.74^{\square\square}$
Pooled error	432	2.84	7.29	551.73	2.85	2074.88	3.18	11.12	6.64	1.09	0.72	265.47	9301.70	1.42

**,* Significant at 1% and 5%, respectively, when tested against GxE

++,+ Significant at 1% and 5%, respectively, when tested against pooled deviation

□□,□ Significant at 1% and 5%, respectively, when tested against pooled error fruit set where E linear and G x E linear was non significant and number of male flower per plant, percentage fruit set, girth of fruit, weight of fruit and fruit yield per vine where G x E was non significant against pooled deviation. This indicate that G x E was significant due to linear as well as non linear components in most of the characters and due to non linear components in girth of fruit, weight of fruit and fruit yield per vine.

Characters exhibited significant difference between genotypes for regressions i.e. G x E linear was as follows :

Days Taken to the Appearance of First Female Flower : (Table 43)

Mean values for days to the appearance of first female flower ranged from 31.79 days(P_7)to 44.95 days (P_4xP_5) with the population mean of 39.569 days. Out of ten only four parents were showed less mean value than population mean and non significant pooled deviation, hence predictable for their mean performance. Out of these, only two parent P_1 (35.62) and P_7 (31.79) indicated higher regression coefficient than average (b>1), therefore these two genotypes were delayed flowering under favourable environments. Only two parent P_3 (34.73) and P_8 (39.26) were observed stable under variable environments as they had nearly unit regression coefficient ($b_i \approx 1$) and non-significant pooled deviation (S^2di). Out of 45 hybrids, only 20 recorded less mean value than population mean and non-significant non linear component (S^2di). Out of these five hybrids depicted higher than unit (b_i>1) regression coefficient and only one hybrid showed value less than unity regression coefficient. Only fourteen hybrids had regression value around unity ($b_i \approx 1$), less mean value than population mean and non-significant pooled deviation stand stable under variable environments.

Gill and Kumar (1989) had also recorded linear and non-linear components and identified stable genotypes for this trait in watermelon.

Length of Main Shoot (cm) : (Table 44)

The mean values for length of main shoot varied from 196.31 cm (P_1xP_9) to 480.81(P_4) with population mean of 332.483 cm. Only six parent surpassed the population mean, had non significant non-linear component (S^2di), so these were predictable for their performance. Out of these three parents P_2 (412.05), P_5 (357.05)

Table 43. Estimates of stability parameters for days taken to the appearance of first female flower in Bitter gourd

Varieties/ strains	Days taken to the appearance of first female flower			Varieties/ strains	Days taken to the appearance of first female flower		
	μi	bi	S^2di		μi	bi	S^2di
P_1	35.62	4.75^{**}	-0.10	P_3xP_4	38.10	-0.82	1.88
P_2	43.93	-0.44^{**}	-0.35	P_3xP_5	39.51	2.60	3.00
P_3	34.73	1.19	1.16	P_3xP_6	37.18	1.84	0.27
P_4	41.32	1.26	0.51	P_3xP_7	41.53	3.44	5.18
P_5	40.38	-0.56^{*}	0.35	P_3xP_8	43.55	3.08^{*}	1.66
P_6	40.71	0.41	0.62	P_3xP_9	42.19	1.30	0.33
P_7	31.79	4.09^{**}	-0.46	P_3xP_{10}	39.64	0.54	0.46
P_8	39.26	0.07	2.30	P_4xP_5	44.95	-0.08	6.71^{*}
P_9	42.65	1.33	0.30	P_4xP_6	40.66	0.93	2.16
P_{10}	42.19	0.01	-0.09	P_4xP_7	42.43	0.38	1.98
P_1xP_2	37.06	0.56	-0.51	P_4xP_8	39.11	0.40	6.54^{*}
P_1xP_3	43.00	1.04	0.27	P_4xP_9	39.45	2.38^{**}	0.30
P_1xP_4	38.69	-1.08	3.22	P_4xP_{10}	39.57	1.61	0.84
P_1xP_5	38.05	2.26^{**}	-0.60	P_5xP_6	40.78	1.68	0.13
P_1xP_6	38.68	2.54	5.27	P_5xP_7	35.71	0.92	-0.41
P_1xP_7	41.68	0.69	0.15	P_5xP_8	33.16	2.39^{**}	-0.48
P_1xP_8	39.68	0.74	0.43	P_5xP_9	38.59	0.74	-0.23
P_1xP_9	44.20	1.06^{**}	-0.58	P_5xP_{10}	41.27	0.10	0.18
P_1xP_{10}	41.05	-0.24	1.72	P_6xP_7	39.64	1.92	2.27
P_2xP_3	38.90	0.62	-0.60	P_6xP_8	36.16	2.40	2.00
P_2xP_4	39.81	0.27^{*}	-0.67	P_6xP_9	40.00	2.61	14.37^{**}
P_2xP_5	37.63	0.56	4.04	P_6xP_{10}	41.88	-2.34^{*}	4.32
P_2xP_6	40.87	-0.05	0.87	P_7xP_8	35.33	2.24^{*}	-0.04
P_2xP_7	42.18	-0.79	4.17	P_7xP_9	40.24	-0.31	5.49^{*}
P_2xP_8	36.49	0.14	2.54	P_7xP_{10}	42.05	0.92	0.68
P_2xP_9	37.08	2.07	1.04	P_8xP_9	38.80	-4.68^{**}	-0.66
P_2xP_{10}	34.21	3.31^{*}	2.50	P_8xP_{10}	40.96	1.51	-0.74
				P_9xP_{10}	42.03	1.46	1.43
PM (x)	39.569						
SE (bi)		0.669					

* Significant at 5% level

** Significant at 1% level

Table 44. Estimates of stability parameters for length of main shoot (cm) in Bitter gourd

Varieties/ strains	Length of main shoot (cm)			Varieties/ strains	Length of main shoot (cm)		
	μi	bi	S^2di		μi	bi	S^2di
P_1	344.74	1.19**	-155.65	P_3xP_4	232.42	0.42**	-49.71
P_2	412.05	0.90	-156.39	P_3xP_5	250.22	1.42**	-164.96
P_3	296.05	0.72**	-157.84	P_3xP_6	276.38	0.88	-42.24
P_4	480.81	1.45	58.49	P_3xP_7	244.30	0.99	-166.20
P_5	357.05	0.97	124.89	P_3xP_8	360.33	0.89**	-180.21
P_6	436.94	1.45**	-129.23	P_3xP_9	279.38	0.25**	-164.86
P_7	327.83	1.32	81.59	P_3xP_{10}	250.01	1.12**	-183.69
P_8	419.52	0.29	563.80	P_4xP_5	448.81	2.74**	1832.15*
P_9	289.66	0.75**	-178.30	P_4xP_6	220.12	0.73**	-174.10
P_{10}	308.99	3.38	4899.21**	P_4xP_7	239.53	0.54**	-158.98
P_1xP_2	265.39	2.79**	665.64	P_4xP_8	411.75	1.35**	-176.06
P_1xP_3	281.98	0.26**	-54.69	P_4xP_9	378.54	0.01**	-128.12
P_1xP_4	322.71	0.65**	-181.19	P_4xP_{10}	309.14	2.91**	649.58
P_1xP_5	274.49	0.30**	-14.68	P_5xP_6	259.95	1.86	498.82
P_1xP_6	253.49	2.09*	616.96	P_5xP_7	349.31	0.89	148.27
P_1xP_7	371.09	0.90	187.63	P_5xP_8	357.58	1.25	530.06
P_1xP_8	287.96	2.04**	401.65	P_5xP_9	345.82	0.89	-155.74
P_1xP_9	196.31	0.84	-94.86	P_5xP_{10}	449.45	1.14	275.73
P_1xP_{10}	291.16	0.69	-40.78	P_6xP_7	303.13	0.98	-31.62
P_2xP_3	334.96	0.12**	163.92	P_6xP_8	411.72	0.04	905.90
P_2xP_4	430.00	0.26**	-54.35	P_6xP_9	391.31	0.25**	-166.92
P_2xP_5	344.24	1.00	-163.88	P_6xP_{10}	242.27	0.63**	-138.42
P_2xP_6	360.15	0.43**	-152.77	P_7xP_8	309.79	1.36	529.09
P_2xP_7	310.35	0.35**	-176.76	P_7xP_9	411.95	0.87	1684.33*
P_2xP_8	372.26	-0.37**	96.67	P_7xP_{10}	319.08	1.24**	-155.75
P_2xP_9	411.86	0.91	207.13	P_8xP_9	367.30	0.72**	-152.47
P_2xP_{10}	346.67	1.22	14.88	P_8xP_{10}	397.01	0.73**	-181.28
				P_9xP_{10}	323.25	1.00	153.33
PM (x)	332.483						
SE (bi)		0.353					

* Significant at 5% level

** Significant at 1% level

and P_8 (419.52) showed averaged regression coefficient (bi=1) response and observed stable. While three parents P_1 (344.74), P_4 (480.81) and P_6 (436.94) had regression value higher than unity (b>1) revealed that these three genotypes were perform. better under favourable environments.

Among 45 hybrids, only 19 hybrids showed higher mean values than population mean and non-significant (S^2di). Out of these 9 hybrids were identified as stable in varied environment as they depicted around unity (bi=1) regression coefficient. Only Nine F_1s had regression value less than average (bi<1) and only one F_1s had depicted higher than unity (bi>1) regression coefficient, revealed that these genotypes perform better under poor and favourable environmental condition, respectively.

Number of Lateral Branches Per Plant : (Table 45)

The mean value for number of lateral branches per plant varied from 6.41 (P_6xP_9) to 24.72 (P_7xP_{10}) with population mean of 12.121. Out of ten, only 3 parent P_4 (16.37), P_5 (13.79) and P_{10} (13.37) exceed the population mean and had non significant pooled deviation. Parent P_5 and P_{10} observed stable with around unity (bi=1) regression coefficient and parent P_4 showed regression value higher than average revealed that this genotype perform better under favourable environment. Out of 45 hybrids, only 11 hybrids recorded higher mean value than population mean and non-significant non-linear component (S^2di). Out of these 10 hybrids were depicted stable with regression values around unity (bi=1) and only two hybrid (P_1xP_3) and (P_1xP_7) showed higher regression coefficient value than unity (bi>1) indicated that this genotype produce more lateral branches per plant in favourable environment.

Peter and Rai (1976) had also identified primary and stable genotypes for this character in tomato.

Number of Female Flower Per Plant : (Table 46)

The range of mean value observed for number of female flower per plant was from 16.99 (P_9) to 62.95 (P_1xP_6) with population mean of 32.058. Out of 10 parents none found acceptable for stability parameters due to lack of either higher mean value than population mean or non-significant pooled deviation. Out of 45 hybrids, only 4

Table 45. Estimates of stability parameters for number of lateral branches per plant in Bitter gourd

Varieties/ strains	Number of lateral branches per plant			Varieties/ strains	Number of lateral branches per plant		
	μi	bi	S^2di		μi	bi	S^2di
P_1	11.06	1.83	1.06	P_3xP_4	11.17	-0.32**	-0.48
P_2	10.21	1.73*	-0.22	P_3xP_5	7.15	1.23	4.76
P_3	13.05	-1.60*	8.43*	P_3xP_6	14.76	0.58	-0.44
P_4	16.37	2.12**	-0.43	P_3xP_7	9.74	0.93	-0.76
P_5	13.79	-1.12	3.60	P_3xP_8	12.32	1.01	-0.68
P_6	11.13	-1.49*	7.67*	P_3xP_9	9.84	0.61	0.11
P_7	9.84	3.69	29.16**	P_3xP_{10}	8.11	0.48	0.84
P_8	7.85	0.61	-0.10	P_4xP_5	17.54	3.91	35.65**
P_9	10.91	1.29	0.01	P_4xP_6	7.52	0.90	-0.84
P_{10}	13.37	1.44	-0.54	P_4xP_7	14.82	1.60	0.04
P_1xP_2	14.61	0.77	-0.11	P_4xP_8	9.50	0.10**	-0.73
P_1xP_3	15.15	1.46*	-0.68	P_4xP_9	19.04	-2.19*	13.61**
P_1xP_4	9.40	1.25*	-0.86	P_4xP_{10}	8.85	0.79	2.42
P_1xP_5	13.67	0.93	0.56	P_5xP_6	9.09	2.30	7.60*
P_1xP_6	8.95	1.06	-0.27	P_5xP_7	18.23	0.72	3.61
P_1xP_7	12.58	1.82**	-0.79	P_5xP_8	8.30	2.51*	1.93
P_1xP_8	13.07	1.15	-0.18	P_5xP_9	12.15	-2.03*	12.65**
P_1xP_9	10.88	2.58**	-0.12	P_5xP_{10}	9.91	3.66	22.76**
P_1xP_{10}	11.80	-0.22	27.06**	P_6xP_7	14.84	6.21	44.51**
P_2xP_3	9.59	0.41	1.08	P_6xP_8	8.21	0.64	0.24
P_2xP_4	10.65	0.67	-0.46	P_6xP_9	6.41	1.12	-0.85
P_2xP_5	18.07	1.43	18.17**	P_6xP_{10}	11.77	-0.73	6.00*
P_2xP_6	9.54	2.38*	1.90	P_7xP_8	6.82	2.04	0.85
P_2xP_7	10.94	0.48**	-0.89	P_7xP_9	19.87	1.29	-0.67
P_2xP_8	8.75	2.39	3.29	P_7xP_{10}	24.72	-2.57	47.30**
P_2xP_9	18.15	-2.91	46.39**	P_8xP_9	11.15	3.04	10.01*
P_2xP_{10}	19.91	1.37	0.19	P_8xP_{10}	10.84	1.63	1.28
				P_9xP_{10}	10.68	0.07	1.65
PM (x)	12.121						
SE (bi)		1.145					

* Significant at 5% level

** Significant at 1% level

Table 46. Estimates of stability parameters for number of female flower per plant in Bitter gourd

Varieties/ strains	Number of female flower per plant			Varieties/ strains	Number of female flower per plant		
	μi	bi	S^2di		μi	bi	S^2di
P_1	19.22	2.60	35.52**	P_3xP_4	18.04	0.55**	0.52
P_2	18.62	1.10**	-1.03	P_3xP_5	30.71	0.68	18.34**
P_3	24.28	-0.13**	-0.88	P_3xP_6	35.10	-0.80	88.67**
P_4	30.56	-0.15**	2.31	P_3xP_7	29.81	-2.53**	22.08**
P_5	19.37	1.07	10.51*	P_3xP_8	32.94	3.06**	23.98**
P_6	33.71	-0.95	44.26**	P_3xP_9	29.98	0.31	13.73**
P_7	23.69	1.37	37.50**	P_3xP_{10}	35.98	0.31	9.69*
P_8	22.12	1.90*	6.65*	P_4xP_5	41.40	2.54	143.75**
P_9	16.99	1.64	7.77*	P_4xP_6	35.05	-0.98	50.33**
P_{10}	26.46	0.84**	-0.97	P_4xP_7	29.14	0.09**	-0.87
P_1xP_2	20.20	1.60**	-0.02	P_4xP_8	24.35	1.36	2.95
P_1xP_3	24.46	0.85	55.77**	P_4xP_9	26.73	0.56**	-0.61
P_1xP_4	29.73	2.03**	-1.04	P_4xP_{10}	33.26	0.35	29.71**
P_1xP_5	35.25	3.73	100.32**	P_5xP_6	36.76	1.92	32.13**
P_1xP_6	62.95	0.79	4.18	P_5xP_7	32.88	0.57	53.71**
P_1xP_7	31.82	2.50	47.09**	P_5xP_8	32.09	2.37	44.37**
P_1xP_8	60.58	1.32	1.02	P_5xP_9	43.23	1.44	5.81
P_1xP_9	37.51	0.81	11.35*	P_5xP_{10}	53.85	0.50**	-0.26
P_1xP_{10}	35.89	-0.39	22.82**	P_6xP_7	35.62	2.06	49.74**
P_2xP_3	35.60	1.87	38.30**	P_6xP_8	38.74	1.01	69.70**
P_2xP_4	26.18	1.08	13.28**	P_6xP_9	34.87	0.17	38.64**
P_2xP_5	36.84	0.56	66.02**	P_6xP_{10}	27.28	-0.41**	6.72*
P_2xP_6	27.09	3.15	143.68**	P_7xP_8	32.52	0.33	8.67*
P_2xP_7	26.80	2.59*	12.64**	P_7xP_9	33.92	3.76*	52.97**
P_2xP_8	37.36	0.60	11.74**	P_7xP_{10}	41.38	-0.67	178.95**
P_2xP_9	31.70	-0.22	96.28**	P_8xP_9	30.10	2.45**	-0.91
P_2xP_{10}	25.44	2.62	29.19**	P_8xP_{10}	32.72	-0.96*	25.94**
				P_9xP_{10}	34.30	0.17	20.22**
PM (x)	32.058						
SE (bi)		0.893					

* Significant at 5% level
** Significant at 1% level

hybrids observed acceptable for prediction of stability parameters, because these genotypes had depicted higher mean value than population mean and non-significant non-linear component (S^2di). Out of these three hybrids i.e. P_1xP_6, P_1xP_8 and P_5xP_9 showed regression value around unity ($b_i \approx 1$) were found stable under different environments. Only one hybrid P_5xP_{10} showed below average ($b_i<1$) regression coefficient revealed that this genotype perform better in poor environment.

Number of Fruits Per Vine : (Table 47)

The mean value for number of fruit per vine varied from 14.38 (P_9) to 57.24 (P_1xP_6) with population mean of 28.198. None of the 10 parents found acceptable for stability parameters due to lack of either higher mean value than population mean or non-significant pooled deviation. Out of 45 hybrids, only 9 hybrids recorded higher mean value than population mean and non-significant pooled deviation. Out of these only six hybrids were identified as stable under variable environments as these showed regression value around unity ($b_i \approx 1$). Only two hybrids i.e. (P_1xP_8) and (P_3xP_8) showed regression coefficient above average ($b_i>1$) and only one hybrids P_5xP_{10} exhibited below average ($b_i<1$) regression coefficient, revealed that these hybrids perform better under favourable and poor environmental condition, respectively.

Gill and Kumar (1993) and Ghanti *et al.* (1991) also identified stable genotypes for this trait, respectively in watermelon and bhindi.

Length of Fruit (cm) : (Table 48)

The range of mean observed for length of fruit varied from 8.11 cm (P_2xP_9) to 16.56 (P_4) with population mean of 11.597 cm. Out of ten, only one parent P_1 (11.87) had higher mean value than population mean and non-significant non linear component (S^2di). This parent showed regression value below average regression coefficient ($bi<1$), revealed that this parent perform better under poor environmental condition. Out of 45 hybrids, only 18 hybrids showed higher mean value than population mean and non- significant pooled deviation. Out of these 8 hybrids showed around unity ($bi=1$) regression coefficient were identified as stable under variable environments. Out of these 4 hybrids and 6 hybrids showed regression value above average ($bi>1$) and

Table 47. Estimates of stability parameters for number of fruits per vine in Bitter gourd

Varieties/ strains	Number of fruits per vine			Varieties/ strains	Number of fruits per vine		
	μi	bi	S^2di		μi	bi	S^2di
P_1	15.83	2.39	34.95**	P_3xP_4	15.13	0.50**	-1.33
P_2	15.34	1.15	-1.97	P_3xP_5	26.88	0.70	13.99*
P_3	21.03	-0.04**	-1.38	P_3xP_6	31.05	-0.82	81.54**
P_4	26.48	-0.16**	2.51	P_3xP_7	24.84	-2.32**	12.00
P_5	16.26	0.88	6.95	P_3xP_8	33.57	3.99**	10.44
P_6	29.44	-0.83	43.99**	P_3xP_9	26.42	0.22	12.00
P_7	19.80	1.30	29.97**	P_3xP_{10}	32.04	0.36	7.14
P_8	18.97	1.78*	2.09	P_4xP_5	35.63	2.80	126.33**
P_9	14.38	1.52	8.03	P_4xP_6	30.96	-0.92	47.48**
P_{10}	23.09	0.78**	-2.10	P_4xP_7	25.70	0.02**	-1.50
P_1xP_2	16.14	1.43	4.82	P_4xP_8	21.12	1.27	0.34
P_1xP_3	21.09	0.84	43.22**	P_4xP_9	23.02	0.46**	-1.66
P_1xP_4	25.99	1.83**	-2.16	P_4xP_{10}	29.41	0.27	29.11**
P_1xP_5	31.00	3.86	111.43**	P_5xP_6	32.64	1.89	28.65**
P_1xP_6	57.24	1.00	-0.05	P_5xP_7	29.22	0.47	46.53**
P_1xP_7	27.95	2.50	51.20**	P_5xP_8	28.03	2.35	44.16**
P_1xP_8	54.49	1.74**	-2.08	P_5xP_9	38.93	1.57	6.91
P_1xP_9	33.28	0.73	9.01	P_5xP_{10}	48.58	0.72**	-2.10
P_1xP_{10}	31.66	-0.34	18.11*	P_6xP_7	31.30	2.04	49.97**
P_2xP_3	30.88	1.84	37.07**	P_6xP_8	35.25	1.02	57.54**
P_2xP_4	22.86	0.99	7.73	P_6xP_9	31.00	0.07	40.27**
P_2xP_5	33.18	0.56	59.22**	P_6xP_{10}	23.76	-0.52**	6.74
P_2xP_6	23.15	3.02	133.97**	P_7xP_8	28.50	0.34	5.01
P_2xP_7	23.19	2.46*	11.92	P_7xP_9	29.20	3.32**	38.32**
P_2xP_8	33.06	0.54	8.13	P_7xP_{10}	35.81	-0.44	133.45**
P_2xP_9	28.23	-0.23	77.42**	P_8xP_9	26.74	2.40**	-1.11
P_2xP_{10}	22.13	2.49	30.92**	P_8xP_{10}	29.02	-1.00*	23.62*
				P_9xP_{10}	30.92	0.16	15.19*
PM (x)	28.198						
SE (bi)		0.913					

* Significant at 5% level

** Significant at 1% level

Table 48. Estimates of stability parameters for length of fruit (cm) in Bitter gourd

Varieties/ strains	Length of fruit (cm)			Varieties/ strains	Length of fruit (cm)		
	μi	bi	S^2di		μi	bi	S^2di
P_1	11.87	-0.31**	-0.19	P_3xP_4	9.44	2.28**	-0.02
P_2	10.74	0.70**	-0.35	P_3xP_5	9.41	2.41**	-0.13
P_3	11.25	0.31**	-0.32	P_3xP_6	12.54	0.51	2.90*
P_4	16.56	2.90	10.56**	P_3xP_7	9.02	-0.49**	-0.17
P_5	11.35	1.20**	-0.35*	P_3xP_8	15.90	-1.02**	1.84
P_6	8.14	1.27	1.50	P_3xP_9	9.81	0.67	2.77*
P_7	10.04	1.69**	-0.32	P_3xP_{10}	11.19	1.15	0.65
P_8	8.71	2.65	4.57**	P_4xP_5	9.25	3.56	9.84**
P_9	9.39	0.13	6.89**	P_4xP_6	13.04	1.16	0.29
P_{10}	9.70	0.81**	-0.01	P_4xP_7	14.24	-0.94**	0.42
P_1xP_2	11.46	-0.05	1.29	P_4xP_8	13.51	1.06	0.89
P_1xP_3	15.54	0.44**	-0.17	P_4xP_9	14.27	0.68	2.95*
P_1xP_4	13.21	0.00	-0.04	P_4xP_{10}	14.43	0.79	-0.12
P_1xP_5	11.05	0.91	-0.25	P_5xP_6	9.43	1.88**	0.11
P_1xP_6	10.32	-0.04**	0.03	P_5xP_7	11.72	2.33**	0.05
P_1xP_7	9.49	1.69	5.20**	P_5xP_8	10.46	-0.26*	1.40
P_1xP_8	13.81	0.48**	-0.30	P_5xP_9	11.79	1.61	0.31
P_1xP_9	13.12	-1.55	12.68**	P_5xP_{10}	14.58	1.06	0.23
P_1xP_{10}	12.38	0.18	1.10	P_6xP_7	11.03	1.11	1.47
P_2xP_3	10.77	1.99*	0.53	P_6xP_8	10.63	1.98	1.07
P_2xP_4	10.18	3.17*	3.05*	P_6xP_9	12.31	0.11*	0.23
P_2xP_5	11.81	1.81**	-0.26	P_6xP_{10}	11.59	0.05	1.99
P_2xP_6	11.94	2.43**	0.12	P_7xP_8	13.18	3.28	8.07**
P_2xP_7	9.95	0.38	2.03	P_7xP_9	13.90	0.82	4.54**
P_2xP_8	11.65	0.35**	-0.32	P_7xP_{10}	11.04	1.46	0.25
P_2xP_9	8.11	0.72	1.32	P_8xP_9	11.30	2.05**	0.88
P_2xP_{10}	12.31 *	0.52	1.22	P_8xP_{10}	11.12	0.88	3.02*
				P_9xP_{10}	12.82	0.01**	-0.02
PM (x)	11.597						
SE (bi)		0.675					

* Significant at 5% level

** Significant at 1% level

below average (gi<1), respectively, indicated that these hybrids perform better under favourable and poor environmental condition, respectively.

Ghanti *et al.* (1991) also identified stable genotypes for this traits.

Girth of Fruit (cm) : (Table 49)

Mean values for girth of fruit ranged from 8.53 cm (P_3xP_7) to 15.96 cm (P_3xP_6) with population mean of 12.227 cm. Out of ten parents, only one parent P_4 (12.64) had depicted higher mean value than population mean and non-significant pooled deviation. This genotype showed regression value around unity (bi=1) and predicted as stable under variable environments. Out of 45 hybrids, only 11 hybrids showed higher mean value than population mean and non-significant non-linear component (S^2di). Out of these only 5 hybrids identified as stable in varied environments as they showed regression value around average ($b_i \approx 1$). Only three hybrids viz. P_1xP_6, P_2xP_9 and P_9xP_{10} showed below average (b_i<1) regression coefficient revealed that these genotypes perform better under poor environment. Another 3 hybrids i.e. P_2xP_8, P_5xP_9 and P_7xP_8 perform better under favourable environment as these genotypes showed regression values above unity (b_i>1) regression coefficient.

Weight of Fruit (g) : (Table 50)

The mean value of weight of fruit ranged from 21 gm (P_6) to 78.40 gm (P_2xP_7) with population mean of 46.915 gm. Out of ten, only 2 parents i.e. P_2 (49.93) and P_4 (74.83) had depicted higher mean value than population mean and non-significant non-linear component (S^2di). Both the genotype showed regression values around unity (bi=1) regression coefficient and identified as stable under variable environments. Among 45 hybrids, only 17 hybrids had observed higher mean value than population mean and non-significant pooled deviation. Out of these only 13 hybrids were identified as stable under variable environments, as these genotypes showed regression values around average ($b_i \approx 1$). Only 3 hybrids showed regression values above average (b_i>1) regression coefficient revealed that these genotypes perform better under favourable environment i.e. higher fertility level. While only one hybrid showed below average (b_i<1) response, suggested better performance under poor environmental condition.

Table 49. Estimates of stability parameters for girth of fruit (cm) in Bitter gourd

Varieties/ strains	Girth of fruit (cm)			Varieties/ strains	Girth of fruit (cm)		
	μi	bi	S^2di		μi	bi	S^2di
P_1	12.77	0.22	1.48*	P_3xP_4	12.08	0.18**	-0.17
P_2	11.81	-0.74**	0.94	P_3xP_5	12.45	1.53	13.10**
P_3	8.93	1.29	0.31	P_3xP_6	15.96	-0.52	3.36**
P_4	12.64	0.56	0.47	P_3xP_7	8.53	1.83**	-0.11
P_5	11.86	-0.35**	-0.15	P_3xP_8	12.61	1.90	3.60**
P_6	9.07	0.19	1.15	P_3xP_9	9.90	1.70*	0.06
P_7	13.09	1.28	3.18**	P_3xP_{10}	13.63	0.19	0.82
P_8	11.56	1.26	3.42**	P_4xP_5	10.74	1.39	10.49**
P_9	12.24	1.50	17.52**	P_4xP_6	13.23	2.38	13.80**
P_{10}	10.70	0.64	1.62*	P_4xP_7	12.29	0.26	3.21**
P_1xP_2	14.42	-0.73*	1.99*	P_4xP_8	12.88	0.72	2.03*
P_1xP_3	12.82	1.56	1.82*	P_4xP_9	14.65	0.89	7.02**
P_1xP_4	11.29	1.67	0.46	P_4xP_{10}	14.12	0.08	0.81
P_1xP_5	13.39	-0.46*	1.78*	P_5xP_6	11.50	1.57	7.92**
P_1xP_6	12.89	-0.37*	0.93	P_5xP_7	10.99	2.05**	0.53
P_1xP_7	11.84	-0.26	2.14*	P_5xP_8	10.81	1.07	1.41
P_1xP_8	13.02	1.02	-0.12	P_5xP_9	12.55	2.54**	0.44
P_1xP_9	13.53	-0.21	8.27**	P_5xP_{10}	13.28	0.72	9.85**
P_1xP_{10}	13.10	0.76	4.16**	P_6xP_7	13.10	-0.32	1.96*
P_2xP_3	12.39	1.64	6.81**	P_6xP_8	13.14	2.10	5.28**
P_2xP_4	12.30	1.10	2.10*	P_6xP_9	13.04	1.08	1.18
P_2xP_5	14.01	2.00	2.76**	P_6xP_{10}	9.57	2.16	11.92**
P_2xP_6	12.69	1.28	1.53*	P_7xP_8	13.98	2.28*	1.36
P_2xP_7	9.78	2.75**	0.80	P_7xP_9	14.07	0.51	1.89
P_2xP_8	12.55	1.96**	0.26	P_7xP_{10}	9.85	1.86	5.51**
P_2xP_9	14.48	-0.79*	1.16	P_8xP_9	11.40	2.80*	1.37
P_2xP_{10}	10.96	1.45	7.31**	P_8xP_{10}	9.94	1.25	1.20
				P_9xP_{10}	12.76	0.59*	-0.11
PM (x)	12.227						
SE (bi)		0.940					

* Significant at 5% level

** Significant at 1% level

Table 50. Estimates of stability parameters for weight of fruit (g) in Bitter gourd

Varieties/ strains	Weight of fruit (g)			Varieties/ strains	Weight of fruit (g)		
	μi	bi	S^2di		μi	bi	S^2di
P_1	38.04	-0.22	113.99	P_3xP_4	40.17	3.49	454.78
P_2	49.93	1.65	54.47	P_3xP_5	35.27	1.20	12.63
P_3	42.92	0.96	-79.51	P_3xP_6	68.47	0.50	917.07*
P_4	74.83	0.86	84.24	P_3xP_7	29.74	0.99	-69.74
P_5	28.05	1.40**	-87.69	P_3xP_8	48.15	2.19	-43.67
P_6	21.00	0.33**	-82.23	P_3xP_9	36.95	1.41	-52.29
P_7	35.25	1.15	-36.08	P_3xP_{10}	50.05	0.79	-67.86
P_8	29.27	1.10	110.57	P_4xP_5	35.64	2.19	276.37
P_9	50.58	1.79	1161.75**	P_4xP_6	67.36	2.41	853.69*
P_{10}	37.63	0.72	-74.19	P_4xP_7	45.32	1.71	-19.55
P_1xP_2	46.77	-0.02	57.89	P_4xP_8	70.30	4.10	1127.94**
P_1xP_3	70.74	2.41	31.14	P_4xP_9	51.28	1.88	-0.94
P_1xP_4	43.24	0.15**	-82.52	P_4xP_{10}	40.77	1.49	-73.60
P_1xP_5	52.00	-0.25	157.62	P_5xP_6	41.25	1.44	12.87
P_1xP_6	65.23	0.52	-79.05	P_5xP_7	47.85	1.30*	-86.30
P_1xP_7	37.80	0.60	-41.45	P_5xP_8	39.04	0.77	-84.19
P_1xP_8	58.88	0.00	-88.11	P_5xP_9	48.65	0.99	-40.41
P_1xP_9	49.74	1.80	1025.22**	P_5xP_{10}	64.88	0.32**	-83.87
P_1xP_{10}	51.49	-0.22	35.66	P_6xP_7	32.50	1.25	154.40
P_2xP_3	35.17	0.45	-50.33	P_6xP_8	65.37	0.49	102.46
P_2xP_4	42.89	0.92	74.54	P_6xP_9	37.55	2.01*	-66.79
P_2xP_5	45.53	1.57	-21.49	P_6xP_{10}	36.33	0.97	64.82
P_2xP_6	44.51	1.07	-81.53	P_7xP_8	64.42	2.07*	-51.81
P_2xP_7	78.40	-6.56	5702.61**	P_7xP_9	50.57	2.20**	-79.18
P_2xP_8	57.36	1.34	-61.58	P_7xP_{10}	30.38	0.59**	-85.87
P_2xP_9	47.19	-0.62	92.85	P_8xP_9	43.67	1.76	178.25
P_2xP_{10}	52.39	-0.94	140.76	P_8xP_{10}	28.65	1.53	-38.73
				P_9xP_{10}	42.91	0.94	-82.15
PM (x)	46.915						
SE (bi)		1.706					

* Significant at 5% level

** Significant at 1% level

Gill and Kumar (1989) and Ghanti *et al* (1991) also suggested similar findings for this trait.

Fruit Yield Per Vine (g) : (Table 51)

Range of mean values for fruit yield per vine varied from 470.17 gm (P_5) to 3756.50 gm (P_1xP_6) with population mean of 1342.962 gm. Out of ten, only one parent P_4 (1995.20) gm had exceed the population mean but due to significant non-linear component (S^2di), this genotype is not acceptable for prediction of stability parameters. Out of 45 hybrids, only 6 hybrids had depicted higher mean value than population mean and non-significant pooled deviation. These hybrids i.e. P_1xP_5,P_1xP_6, P_1xP_8, P_5xP_6, P_5xP_9 and P_5xP_{10} showed regression values around average ($b_i \approx 1$) and identified as stable under variable environments. Out of these P_1xP_6 (3756.50 gm) had depicted highest mean value.

Nandpuri *et al.* (1974), Peter and Rai (1976), Sooch *et al.* (1981), Gill and Kumar (1989), Vadivel and Bapu (1989) and Ghanti *et al.* (1991) reported similar findings for this trait in different vegetable crops.

CLASSIFICATION OF GENOTYPE WITH REGARD TO THEIR ADAPTABILITY UNDER VARYING ENVIRONMENTS : (Table 52)

The genotypes possessing non-significant deviation from regression ($S^2di=0$) and leaving mean performance in desirable direction (i.e. days taken to the appearance first female flower in negative, length of main shoot, number of lateral branches, number of female flower per plant, number of fruits per vine, length of fruit, girth of fruit, weight of fruit and fruit yield per vine in positive were classified for their adaptability under varying environments (high yielding/favourable, over all and low yielding/unfavourable/poor).

The experimental results discussed above revealed that hybrids (P_1xP_6) and (P_5xP_9) were relatively more stable since they both possessed around unit regression coefficient ($b_i \approx 1$) for like days taken to the appearance of first female flower, number of female flower per plant, number of fruits per vine, weight of fruit and fruit yield per vine, besides this hybrid (P_5xP_6) was also stable for length of main shoot and length of fruit. Hybrid (P_5xP_{10}) was found suitable for poor environmental condition,

Table 51. Estimates of stability parameters for fruit yield per vine (g) in Bitter gourd

Varieties/ strains	Fruit yield per vine (g)			Varieties/strains	Fruit yield per vine (g)		
	μi	bi	S^2di		μi	bi	S^2di
P_1	537.19	0.55**	-2120.82	P_3xP_4	632.91	1.25	96762.84**
P_2	782.30	0.94	60075.11**	P_3xP_5	952.35	0.92	18743.89*
P_3	904.90	0.33**	12371.22	P_3xP_6	2273.16	0.16	2616705.25**
P_4	1995.20	0.33	277123.81	P_3xP_7	696.43	-0.34**	10179.67
P_5	470.17	0.63	12032.81	P_3xP_8	1529.50	2.70	434899.76**
P_6	624.38	0.05*	53214.48**	P_3xP_9	994.56	0.78	119108.08**
P_7	741.78	0.93	172511.64**	P_3xP_{10}	1614.50	0.72	71439.28**
P_8	589.33	1.01	91694.95**	P_4xP_5	1761.67	1.81**	2167486.50**
P_9	673.67	0.75	177986.67**	P_4xP_6	1951.88	0.74	48037.59**
P_{10}	875.37	0.60**	1092.46	P_4xP_7	1155.62	0.83	18302.78
P_1xP_2	753.22	0.63	11401.32	P_4xP_8	1569.19	2.72	565569.12**
P_1xP_3	1529.27	1.71	201903.61**	P_4xP_9	1198.95	1.10	25326.67**
P_1xP_4	1127.70	0.94	16074.06	P_4xP_{10}	1203.57	0.99	32026.23*
P_1xP_5	1493.48	1.27	15355.01	P_5xP_6	1344.33	1.34	12434.65
P_1xP_6	3756.50	1.25	9007.04	P_5xP_7	1416.90	1.05	120387.53**
P_1xP_7	1106.98	1.35	328474.12**	P_5xP_8	1099.77	1.21	85615.02**
P_1xP_8	3208.34	1.09	-2469.28	P_5xP_9	1897.55	1.30	12303.26
P_1xP_9	1614.47	0.79	986852.38**	P_5xP_{10}	3154.80	0.90	13975.53
P_1xP_{10}	1654.77	-0.25	330016.84**	P_6xP_7	1116.17	1.66	738886.69**
P_2xP_3	1041.42	1.30	231533.11**	P_6xP_8	2347.83	1.28	1004267.06**
P_2xP_4	1000.15	0.86	43155.38**	P_6xP_9	1173.82	1.26	111624.29**
P_2xP_5	1510.75	1.34	29318.40*	P_6xP_{10}	836.35	0.25**	15207.71
P_2xP_6	1063.87	1.63	423163.75**	P_7xP_8	1850.28	1.40	43734.45**
P_2xP_7	978.24	1.05	94022.78**	P_7xP_9	1582.15	2.83	333578.47**
P_2xP_8	1910.02	1.22	47665.39**	P_7xP_{10}	1077.25	0.09	91163.76**
P_2xP_9	1357.57	-0.07	582528.81**	P_8xP_9	1256.52	2.16	401338.22**
P_2xP_{10}	1066.83	0.59**	1156.75	P_8xP_{10}	795.77	0.53**	-133.20
				P_9xP_{10}	1326.70	0.66	29071.43*
PM (x)	1342.962						
SE (bi)		0.884					

* Significant at 5% level

** Significant at 1% level

Table 52. Classification of genotypes with regard to their adaptability in different types of environment for nine characters in Bitter gourd

Character	Genotype adaptable to different environment		
	Low yielding/ unfavourable/ stress environment ($b_i < 1$)	Overall environments ($b_i = 1$)	High yielding/favourable environment ($b_i > 1$)
Days taken to the appearance of first female flower	(P_8xP_9)	Parents -(P_3), (P_8) and hybrids (P_1xP_2), (P_1xP_4), (P_1xP_6), (P_2xP_3), (P_2xP_5), (P_2xP_8), (P_2xP_9), (P_3xP_4), (P_3xP_5), (P_3xP_6), (P_4xP_{10}), (P_5xP_7), (P_5xP_9), (P_6xP_8)	Parents - (P_1), (P_7) and hybrids (P_1xP_5), (P_2xP_{10}), (P_4xP_9), (P_5xP_8), (P_7xP_8),
Length of main shoot (cm)	(P_2xP_3), (P_2xP_4), (P_2xP_6), (P_2xP_8), (P_3xP_8), (P_4xP_9), (P_6xP_9), (P_8xP_9), (P_8xP_{10})	Parents - (P_2), $P_5)$, (P_8) and hybrids. (P_1xP_7), (P_2xP_5), (P_2xP_9), (P_2xP_{10}), (P_5xP_7), (P_5xP_8), (P_5xP_9), (P_5xP_{10}), (P_6xP_8)	Parents - (P_1), (P_4), (P_6) and hybrids (P_4xP_8),
Number of lateral branches		Parents - (P_5) (P_{10}) and hybrids (P_1xP_2), (P_1xP_5), (P_1xP_8), (P_2xP_{10}), (P_3xP_6), (P_3xP_8), (P_4xP_7), (P_5xP_7), (P_7xP_9)	Parents - (P_4) and hybrid (P_1xP_3), (P_1xP_7),
Number of female flower per plant.	(P_5xP_{10})	(P_1xP_6), (P_1xP_8), (P_5xP_9),	
Number of fruits per vine	(P_5xP_{10})	(P_1xP_6), (P_1xP_9), (P_2xP_8), (P_3xP_{10}), (P_5xP_9), (P_7xP_8),	(P_1xP_8), (P_3xP_8),
Length of fruit (cm)	Parent -(P_1) and hybrids (P_1xP_3), (P_1xP_8), (P_3xP_8), (P_4xP_7), (P_6xP_9), (P_9xP_{10})	(P_1xP_4), (P_1xP_{10}), (P_2xP_{10}), (P_4xP_6), (P_4xP_8), (P_4xP_{10}), (P_5xP_9), (P_5xP_{10}),	(P_2xP_5), (P_2xP_6), (P_2xP_8), (P_5xP_7),
Girth of fruit (cm)	(P_1xP_6), (P_2xP_9), (P_9xP_{10})	Parent - (P_4) and hybrids - (P_1xP_8), (P_3xP_{10}), (P_4xP_{10}), (P_6xP_9), (P_7xP_9),	(P_2xP_8), (P_5xP_9), (P_7xP_8),
Weight of fruit (g)	(P_5xP_{10})	Parents - (P_2), (P_4) and hybrids (P_1xP_3), (P_1xP_5), (P_1xP_6), (P_1xP_8), (P_1xP_{10}), (P_2xP_8), (P_2xP_9), (P_2xP_{10}), (P_3xP_8), (P_3xP_{10}), (P_4xP_9), (P_5xP_9), (P_6xP_8),	(P_5xP_7), (P_7xP_8), (P_7xP_9),
Fruit yield per vine (g)		(P_1xP_5), (P_1xP_6), (P_1xP_8), (P_5xP_6), (P_5xP_9), (P_5xP_{10})	

while (P_7xP_8) for favourable environmental condition. Since they exhibited below average and above average regression coefficient, respectively for most of the traits.

SUGGESTIONS FOR BREEDING METHODOLOGY

The findings obtained from forgoing discussion of results, certain suggestions can be made in respect for future Bitter gourd improvement programme.

The improvement in yield potential, a complex entity influenced by its componential traits, directly or indirectly and environmental conditions, is the major concern to the plant breeder. Hence, it would be easier to increase, the fruit yield in Bitter gourd by improving component al traits like number of female flower per plant, percentage fruit set, number of fruit per plant, size and weight of fruit and earliness in female flower appearance etc.

The method of breeding employed in exploiting any character depends on gene action involved in its expression. For traits governed by additive gene action, the best method of breeding would be the adoption of various types of selection procedures. The characters controlled by non-additive gene action are likely to be best exploited by utilization of hybridization or building up of synthetic varieties. The values of parents, therefore, can be determined by the study of gene action, which will provide a better guidance to the breeder in the formation of an efficient breeding programme.

In the present investigation, the hybrids (P_1xP_6), (P_5xP_9) and (P_5xP_{10}) were superior for fruit yield and its componental traits, since they exhibited higher estimates of heterobeltiosis and economic heterosis over best check involved in the study. The magnitudes of SCA effects for these hybrids were highly significant under all the environments as well as pooled analysis in desired direction, depending upon the economic importance of the traits. Thus, revealed that, these hybrids shall perform better under varying environmental conditions.

The parental lines P_6, P_8 and P_{10} were identified as good general combiner for fruit yield and its components. They might be utilized in further hybridization programme.

The study revealed that, the fruit yield and its components exhibited both types of gene actions viz. additive and non-additive with prominent role of non-additive gene action, which indicated by significant estimates of GCA and SCA variances (combining ability analysis), alongwith linear and non-linear (i.e. pooled deviation) components of G x E interaction (pooled analysis of variance for stability). Under such circumstances, it is suggested that, improvement through selection may be adopted, Sirohi and Chaudhary (1977) also advocated the similar results.

Summary

The present investigation entitled "Combining ability and stability studies in Bitter gourd (*Momordica charantia* Linn.) was conducted during kharif 1993 at Horticulture Farm, Rajasthan College of Agriculture Udaipur.

The experimental material consisting of 56 entries (10 parents, 45 F_1's and standard check for economic heterosis) was obtained through 10 parental lines crossed in all possible combinations in a diallel system (with out reciprocals). The material was raised in randomized block design, comprising 3 replications, with a single row plot of 6 meter length and a spacing of 150 cm 60 cm in each of the 4 environments (created by various fertilizer application).

The observations were recorded for 13 traits viz. Days taken to the appearance of first female flower, node number at which first female flower appear, length of main shoot (cm), Number of lateral branches per plant, number of male flowers per plant, number of female flowers per plant, percentage fruit set, number of fruits per vine, length of fruit (cm), girth of fruit (cm), weight of fruit (g), fruit yield per vine (g) and number of seeds per fruit. The data were analysed for heterobeltiosis (Fonesca and Patterson, 1968), economic heterosis, combining ability (Griffings (1956, a) experimental method -II, model-I) and stability parameters (Eberhart and Russell, 1966), to identify good general combiner parents and superior hybrids with high heterotic effects and stable performance.

The important findings of the present study are summarized below:

1. The analysis of variance for experimental design revealed the existence of adequate genetic variability in the experimental material for all the traits under study. The environment considerably differed from each other. The influence of environmental fluctuations on the genotypes were observed for all the traits.
2. The heterotic effect for fruit yield and its various componential traits was exhibited by hybrids P_1xP_6, P_1xP_8, P_2xP_5, P_2xP_9, P_3xP_{10} and P_5xP_{10} over better parent as well as standard check under all the environments and pooled analysis, thus revealed superior performance under varying environmental

conditions. Hybrid (P_7xP_9) showed superiority for most of the traits over better parent under varying environmental condition.

3. The analysis of variance for combining ability suggested the existence of both additive and non-additive gene action in the experimental material. Predominance of non-additive-gene action in most of the traits.

4. The GCA effect revealed that parents P_2, P_6, P_8 and P_{10} were good general combiner for most of the traits. Parents P_6 and P_{10} had high GCA effect for number of female flowers per plant and number of fruits per vine, P_1 and P_{10} for node number at which first female flower appear; P_6 and P_8 for fruit yield per vine, P_2, P_4, P_5 and P_6 for number of seeds per fruit. Besides, these P_8 was good general combiner for days taken to the appearance of first female flower, while P_2 for length of main shoot, number of male flower per plant, girth of fruit and weight of fruit.

5. The SCA effects, exhibited superiority of hybrids P_1xP_9, P_1xP_{10}, P_2xP_9, P_6xP_8 and P_9xP_{10} for percentage fruit set; P_1xP_8, P_3xP_{10}, P_5xP_9 and P_5xP_{10} for number of fruits per vine; P_1xP_6, P_1xP_8, P_5xP_9 and P_5xP_{10} for fruit yield per vine; P_1xP_7, P_1xP_9, P_1xP_{10}, P_2xP_7, P_3xP_5, P_3xP_7, P_3xP_8, P_4xP_7, P_5xP_8 and P_5xP_9 for number of seeds per fruit, P_1xP_8, P_2xP_3 and P_5xP_{10} for number of female flowers per plant. Besides these P_5xP_{10}, P_6xP_9 and P_1xP_3, P_2xP_{10} were also superior for length of main shoot and number of lateral branches per plant, respectively. Hybrids P_5xP_7 for days taken to the appearance of first female flower; (P_2xP_5) for node number at which first female flower appear; (P_5xP_{10}) length of the fruit; P_4xP_{10} for girth of the fruit and P_1xP_6 for weight of the fruit were observed superior. Hybrid P_5xP_{10} was observed best hybrid, since it exhibited superiority for most of the traits.

6. The pooled analysis for stability parameters revealed existence of genetic variability in the experimental material and the environments were quite variable for one another. The genotypes interacted considerably with the environmental conditions. Both linear (regression coefficient) and non-linear (pooled deviation) components of G x E interaction were present for most of the traits under investigation.

7. Hybrids P_1xP_6 and P_5xP_9 exhibited their stability for yield and related traits. Hybrid P_5xP_{10} was suitable for poor environments, i.e. low fertilizer application, while P_7xP_8 was good under favourable i.e. high fertilizer application environmental conditions.
8. The overall study revealed that hybrids P_1xP_6, P_5xP_9 and P_5xP_{10} were superior for fruit yield and its various componential traits, since they exhibited higher estimates of heterobeltiosis and economic heterosis alongwith higher SCA effects.
9. On the basis of above findings an appropriate breeding methodology might be suggested to formulate an efficient breeding programme.

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*** Original not seen**

APPENDIX 1

METEROLOGICAL OBSERVATIONS (WEEKLY AVERAGES) DURING COURSE OF INVESTIGATION (FROM JULY 1993 TO OCT. 1993) AT RCA FARM, UDAIPUR

Standard week	Date and month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
		Max.	Min.	0735	1435	
27	2nd July to 8th July	32.7	24.4	92	83	114.4
28	9th July to 15th July	29.7	24.0	89	77	85.8
29	16th July to 22nd July	28.4	23.9	91	83	138.6
30	23rd July to 29th July	32.3	24.6	82	63	0.0
31	30th July to 5th August	32.4	24.7	81	63	3.2
32	6th Aug. to 12th Aug.	24.5	23.9	78	66	4.0
33	13th Aug. to 19th Aug.	32.6	23.3	88	62	41.0
34	20th Aug. to 26th Aug.	31.1	23.4	84	61	0.0
35	27th Aug. to 2nd Sept.	32.2	23.4	82	62	1.0
36	3rd Sept. to 9th Sept.	31.3	23.7	80	61	0.0
37	10th Sept. to 16th Sept.	30.6	22.4	92	71	13.2
38	17th Sept. to 23rd Sept.	33.6	22.1	89	69	1.2
39	24th Sept. to 30th Sept.	32.6	21.8	91	52	21.3
40	1st Oct. to 7th Oct.	34.9	19.9	78	32	0.0
41	8th Oct. to 14th Oct.	34.9	18.1	70	31	0.0
42	15th Oct. to 21st Oct.	34.5	17.8	74	41	1.2
43	22nd Oct. to 28th Oct.	33.5	18.0	80	35	0.0
44	29th Oct. to 4th Nov.	31.3	13.6	77	34	0.0

APPENDIX - II
MEAN VALUES OF PARENTS AND CROSSES FOR DIFFERENT CHARACTERS IN BITTER GOURD

Genotype	Days taken to the appearance of first female flower					Node number at which first female flower appear				
	E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Parents										
P_1	31.72	31.11	34.45	45.22	35.62	12.00	12.33	14.00	9.06	11.85
P_2	45.13	44.00	43.41	43.19	43.93	17.76	21.55	38.79	25.33	25.86
P_3	32.20	35.31	34.37	37.04	34.73	8.23	6.82	6.18	7.30	7.13
P_4	41.13	40.55	39.46	44.12	41.32	10.69	12.05	12.50	13.51	12.19
P_5	40.37	40.15	41.96	39.04	40.38	22.88	21.06	23.33	18.00	21.32
P_6	39.41	40.11	42.01	41.30	40.71	14.00	13.58	13.22	14.00	13.70
P_7	27.29	29.29	30.60	40.00	31.79	10.55	11.08	11.98	11.75	11.34
P_8	39.42	37.41	41.02	39.20	39.26	14.57	15.59	16.76	13.75	15.17
P_9	41.14	40.85	43.44	45.17	42.65	13.23	14.32	15.32	15.50	14.59
P_{10}	41.38	42.14	43.21	42.03	42.19	11.77	11.04	10.66	10.25	10.93
Crosses (F_1)										
P_1xP_2	37.22	36.01	36.76	38.27	37.07	12.44	11.44	12.86	7.25	10.99
P_1xP_3	43.00	42.29	41.39	45.33	43.00	10.00	10.07	11.00	12.00	10.77
P_1xP_4	38.16	39.03	41.48	36.10	38.69	13.27	12.21	13.03	13.46	12.99
P_1xP_5	35.62	36.16	37.88	42.53	38.05	16.50	16.32	14.04	19.00	16.47
P_1xP_6	38.44	37.01	34.92	44.33	38.68	14.45	16.00	15.37	14.50	15.08
P_1xP_7	41.37	40.05	42.32	43.00	41.69	12.03	12.53	12.05	12.00	12.15
P_1xP_8	40.10	39.03	38.18	41.40	39.68	12.16	11.22	11.21	11.50	11.52
P_1xP_9	43.18	44.00	43.18	46.43	44.20	13.09	14.00	13.50	16.01	14.15
P_1xP_{10}	40.17	40.70	43.08	40.23	41.05	12.52	11.25	11.01	10.51	14.32
P_2xP_3	38.03	39.12	38.29	40.19	38.90	10.07	10.44	11.66	19.03	12.80
P_2xP_4	39.12	40.21	39.58	40.34	39.81	17.40	16.56	18.01	15.35	16.83
P_2xP_5	39.18	37.07	35.07	39.20	37.63	9.73	10.05	10.53	11.50	10.45
P_2xP_6	42.15	40.83	39.46	41.03	40.87	14.08	13.18	13.00	14.50	13.69
P_2xP_7	41.29	42.14	45.14	40.13	42.18	18.16	18.66	18.12	17.33	13.07
P_2xP_8	38.00	36.41	34.40	37.16	36.49	12.85	13.25	13.75	14.50	13.59
P_2xP_9	34.05	35.38	37.89	41.00	37.08	14.22	14.31	15.00	11.00	13.62
P_2xP_{10}	33.19	30.31	32.18	41.17	34.21	11.41	12.57	12.11	13.26	12.34
P_3xP_4	37.22	40.43	38.45	36.32	38.10	8.75	9.35	10.00	8.00	09.03
P_3xP_5	39.29	36.11	37.57	45.06	39.51	14.64	15.00	15.33	15.66	15.16
P_3xP_6	35.07	37.04	35.59	41.00	37.18	10.61	10.74	12.33	9.50	10.80
P_3xP_7	40.44	39.23	37.44	49.00	41.53	12.42	10.57	10.33	11.00	11.08
P_3xP_8	42.48	40.01	41.71	50.00	43.55	17.00	16.75	17.50	18.00	17.31
P_3xP_9	41.18	42.15	40.41	45.00	42.19	22.11	20.01	18.33	23.00	20.86
P_3xP_{10}	40.29	39.03	38.25	40.97	39.64	9.32	9.85	10.23	10.24	9.91
P_4xP_5	42.25	45.69	47.60	44.27	44.95	18.08	18.23	18.76	19.49	18.64
P_4xP_6	38.22	41.88	40.06	42.47	40.66	12.70	12.45	13.25	15.00	13.35
P_4xP_7	41.22	44.08	41.12	43.30	42.43	13.07	12.03	12.50	13.33	12.73
P_4xP_8	36.06	39.32	41.65	39.40	39.11	16.75	17.47	17.33	16.00	16.89
P_4xP_9	38.43	36.66	38.33	44.38	39.45	10.92	11.55	11.33	14.08	11.97
P_4xP_{10}	39.56	37.51	38.17	43.03	39.57	12.53	13.45	14.40	12.34	13.18
P_5xP_6	38.67	39.08	41.39	44.00	40.78	11.43	12.33	11.14	13.33	12.06
P_5xP_7	34.31	34.89	36.21	37.43	35.71	15.49	16.02	16.50	15.50	15.88
P_5xP_8	30.39	32.16	32.09	38.00	33.16	12.15	12.59	13.00	13.66	12.85
P_5xP_9	38.09	37.18	39.11	40.00	38.59	9.50	9.75	8.50	10.11	9.47
P_5xP_{10}	41.10	42.22	40.15	41.60	41.27	11.43	12.30	11.33	14.21	12.32
P_6xP_7	36.28	38.24	40.84	43.20	39.64	13.43	14.09	12.34	17.00	14.22
P_6xP_8	34.21	35.83	33.32	41.30	36.16	10.15	10.45	18.66	12.40	10.92
P_6xP_9	40.61	39.54	34.32	46.07	40.00	10.59	10.99	11.50	8.93	10.50
P_6xP_{10}	42.11	43.39	45.35	36.67	41.88	13.18	13.35	14.33	12.64	13.32
P_7xP_8	34.30	32.92	34.08	40.00	35.33	15.31	15.35	16.18	14.50	15.34
P_7xP_9	38.42	40.23	43.21	39.12	40.24	16.71	17.28	15.50	19.51	17.25
P_7xP_{10}	42.36	41.33	40.34	44.17	42.05	11.56	12.65	10.65	14.66	12.38
P_8xP_9	43.10	42.73	40.00	29.37	38.80	12.06	10.56	11.34	11.00	11.24
P_8xP_{10}	40.04	39.42	40.30	44.07	40.96	14.59	15.32	15.16	16.33	15.35
P_9xP_{10}	39.28	41.03	43.10	44.70	42.03	15.14	15.41	14.41	13.60	14.64
Check	41.00	41.24	42.11	47.26	48.90	19.88	17.36	18.50	20.00	18.93

Continue Appendix - II

Genotype	Length of main shoot (cm)					Number of lateral branches per plant				
	E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Parents										
P_1	312.30	320.15	350.33	396.18	344.74	8.91	9.33	11.00	15.00	11.06
P_2	381.93	400.69	415.33	450.24	412.05	8.21	8.39	10.75	13.51	10.21
P_3	270.35	288.33	299.30	326.22	296.05	14.11	15.00	15.00	8.09	13.05
P_4	430.09	451.00	511.98	530.17	480.81	13.75	14.24	17.35	20.14	16.37
P_5	315.81	358.50	354.88	399.00	357.05	14.35	15.19	16.02	9.66	13.79
P_6	395.34	402.58	455.66	494.17	436.94	12.00	13.07	13.00	6.45	11.13
P_7	294.39	304.51	320.19	392.22	327.83	6.19	6.37	6.81	20.00	9.84
P_8	394.13	417.51	452.33	414.12	419.52	6.90	7.12	9.39	8.00	7.85
P_9	268.56	247.33	294.33	321.43	289.66	9.31	9.79	10.87	13.67	10.91
P_{10}	238.21	250.33	255.02	492.41	308.99	11.80	11.68	14.00	16.00	13.37
Crosses (F_1)										
P_1xP_2	184.62	190.29	320.33	366.33	265.39	13.58	14.13	14.21	16.50	14.61
P_1xP_3	265.77	280.82	295.67	285.67	281.98	12.76	14.31	16.03	17.50	15.15
P_1xP_4	302.19	310.11	330.35	348.20	322.71	7.82	8.12	10.13	11.52	9.40
P_1xP_5	256.26	283.39	270.17	288.13	274.49	12.25	13.34	13.08	16.01	13.67
P_1xP_6	184.67	201.59	305.35	322.33	253.49	7.91	7.67	9.02	11.21	8.95
P_1xP_7	345.08	340.77	400.33	398.19	371.09	10.11	10.70	14.50	15.00	12.58
P_1xP_8	240.93	244.45	280.17	386.30	287.96	11.51	12.25	13.03	15.50	13.07
P_1xP_9	161.38	189.54	207.00	227.33	196.31	7.68	8.30	12.03	15.51	10.88
P_1xP_{10}	278.66	274.21	285.33	326.44	291.16	11.00	11.67	17.51	7.00	11.30
P_2xP_3	321.10	333.26	357.33	328.13	334.96	8.67	9.20	11.50	9.00	9.59
P_2xP_4	415.82	425.35	445.33	433.54	430.00	9.50	10.50	10.50	12.11	10.65
P_2xP_5	317.32	322.38	350.14	387.17	344.24	15.00	16.67	24.08	16.52	18.07
P_2xP_6	343.63	352.36	370.27	374.33	360.15	6.93	7.00	9.71	14.51	9.54
P_2xP_7	297.23	305.67	315.33	323.15	310.35	10.09	10.68	11.50	11.50	10.94
P_2xP_8	371.05	385.67	385.12	347.20	372.26	6.20	6.24	8.50	14.05	8.75
P_2xP_9	365.59	411.33	430.33	440.17	411.86	21.04	20.07	23.47	8.01	18.15
P_2xP_{10}	314.05	327.10	340.33	405.20	346.67	17.93	18.39	22.23	21.08	19.91
P_3xP_4	220.66	230.37	222.33	256.33	232.42	10.99	12.18	11.00	10.50	11.17
P_3xP_5	210.20	220.39	260.15	310.14	250.22	6.31	5.69	5.60	11.00	7.15
P_3xP_6	240.12	265.12	295.21	305.07	276.38	13.72	14.28	16.00	15.02	14.76
P_3xP_7	210.44	230.67	251.00	285.08	244.30	8.53	8.91	10.01	11.50	9.74
P_3xP_8	331.55	344.33	370.11	395.33	360.33	10.67	11.81	12.69	14.10	12.32
P_3xP_9	290.47	294.32	294.33	310.39	279.38	9.70	8.67	9.50	11.50	9.84
P_3xP_{10}	215.47	238.96	260.30	295.34	250.01	7.25	7.48	10.00	7.71	8.11
P_4xP_5	385.36	400.38	420.17	589.34	448.81	13.88	13.67	14.11	28.50	17.54
P_4xP_6	197.20	204.90	230.17	248.13	220.12	6.51	6.47	8.00	9.09	7.52
P_4xP_7	221.13	228.49	250.18	258.34	239.53	12.70	13.52	15.02	18.05	14.82
P_4xP_8	369.61	389.00	420.33	468.05	411.75	9.27	9.65	9.09	10.00	9.50
P_4xP_9	372.46	381.33	385.34	374.42	378.54	20.84	21.38	21.39	12.54	19.04
P_4xP_{10}	240.08	245.44	305.72	445.33	309.14	7.55	7.77	11.56	8.50	8.85
P_5xP_6	213.62	228.50	245.20	352.50	259.95	6.87	6.67	7.81	15.00	9.09
P_5xP_7	325.17	340.41	335.17	396.50	349.31	16.67	17.56	21.17	17.50	18.23
P_5xP_8	315.62	321.15	400.17	393.37	357.58	5.33	5.88	8.50	13.50	8.30
P_5xP_9	320.86	329.66	347.31	385.44	345.82	13.79	14.31	14.50	6.00	12.15
P_5xP_{10}	408.85	420.60	485.17	483.18	449.45	6.02	6.61	7.51	19.50	9.91
P_6xP_7	277.49	287.45	296.83	350.73	303.13	8.23	8.76	12.54	29.83	14.84
P_6xP_8	400.86	401.00	451.83	390.20	411.72	7.38	7.89	7.51	10.07	8.21
P_6xP_9	379.66	390.40	395.16	400.02	391.31	5.13	5.06	7.23	8.21	6.41
P_6xP_{10}	222.15	235.40	240.20	271.33	242.27	12.13	12.41	14.09	8.45	11.77
P_7xP_8	279.33	287.48	290.06	382.30	309.79	4.30	4.98	7.00	11.01	6.82
P_7xP_9	370.42	385.51	471.36	420.50	411.95	18.33	18.25	21.42	21.50	19.87
P_7xP_{10}	285.35	290.33	330.27	370.34	319.08	26.35	27.27	30.25	15.00	24.72
P_8xP_9	343.11	352.35	380.33	393.42	367.30	7.80	8.22	10.00	18.50	11.15
P_8xP_{10}	374.35	382.40	405.26	426.03	397.01	8.69	9.67	10.50	14.51	10.84
P_9xP_{10}	293.98	306.40	325.23	367.40	323.25	10.12	10.67	12.50	9.42	10.68
Check	-429.95	457.30	465.16	462.27	453.67	12.82	13.37	15.00	14.00	13.80

Continue Appendix - II

Genotype	Number of male flower per plant					Number of female flower per plant				
	E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Parents										
P_1	303.86	305.54	416.09	758.81	446.07	11.82	12.37	17.56	35.13	19.22
P_2	398.89	394.43	509.96	541.87	461.29	14.62	15.73	20.90	23.22	18.62
P_3	695.49	658.00	619.28	584.07	639.21	24.71	24.51	24.51	23.41	24.28
P_4	730.54	702.98	679.52	586.09	674.78	30.20	31.31	32.22	28.51	30.56
P_5	425.56	396.02	395.86	580.93	449.59	16.53	16.71	17.63	26.63	19.37
P_6	924.70	885.75	909.48	538.02	814.49	35.16	35.93	39.44	24.29	33.71
P_7	485.13	427.16	385.92	654.12	488.08	20.60	20.27	19.39	34.50	23.69
P_8	398.04	364.39	610.87	574.25	486.88	15.60	15.71	29.02	28.16	22.12
P_9	316.86	312.83	383.79	583.94	399.36	11.86	12.86	16.87	26.36	16.99
P_{10}	609.94	576.12	597.56	633.71	604.33	23.55	24.20	27.79	30.31	26.46
Crosses (F_1)										
P_1xP_2	365.89	386.01	507.44	611.58	467.73	14.50	16.25	22.25	27.79	20.20
P_1xP_3	513.58	562.70	829.14	522.80	607.05	18.72	22.49	34.53	22.11	24.46
P_1xP_4	516.45	516.74	683.38	752.70	617.32	22.52	24.20	33.93	38.27	29.73
P_1xP_5	365.84	374.89	408.77	710.47	464.99	24.37	26.29	31.18	59.16	35.25
P_1xP_6	875.29	838.98	858.10	771.99	836.09	58.63	61.83	66.62	64.71	62.95
P_1xP_7	476.84	460.45	490.16	784.21	552.91	25.24	25.07	28.99	47.99	31.82
P_1xP_8	795.72	763.64	773.20	759.53	773.02	56.76	55.70	64.38	65.48	60.58
P_1xP_9	561.33	582.16	524.03	622.02	572.39	34.54	36.68	35.17	43.65	37.51
P_1xP_{10}	909.61	800.75	889.75	653.22	813.22	37.20	35.26	40.65	30.45	35.89
P_2xP_3	505.05	453.13	451.02	644.92	513.53	31.09	30.47	32.28	48.56	35.60
P_2xP_4	558.00	532.07	733.21	609.92	608.30	21.86	22.40	32.66	27.79	26.18
P_2xP_5	799.74	784.47	1001.32	669.09	813.66	32.51	34.94	47.21	32.69	36.84
P_2xP_6	361.69	327.28	295.24	719.17	425.85	18.95	19.63	19.67	50.12	27.09
P_2xP_7	402.43	429.24	542.12	764.31	534.52	18.07	20.64	27.73	40.76	26.80
P_2xP_8	815.53	742.71	850.66	704.74	778.41	34.48	35.25	42.64	37.07	37.36
P_2xP_9	865.58	797.68	1065.87	558.91	822.01	31.07	30.23	42.55	22.95	31.70
P_2xP_{10}	373.60	367.41	448.89	735.25	481.29	17.72	18.60	24.42	41.01	25.44
P_3xP_4	492.96	452.67	558.31	516.64	504.65	16.20	15.97	20.54	19.47	18.04
P_3xP_5	658.46	696.96	758.66	619.65	683.44	25.43	30.70	36.21	30.48	30.71
P_3xP_6	889.56	919.78	714.47	512.78	759.15	33.23	39.22	43.55	24.41	35.10
P_3xP_7	1109.36	1014.98	483.30	549.98	789.41	38.32	38.90	19.41	22.59	29.81
P_3xP_8	443.71	417.35	502.59	715.23	519.72	23.24	25.26	33.31	49.95	32.94
P_3xP_9	655.82	652.76	729.06	569.64	651.82	27.36	29.46	34.83	28.27	29.98
P_3xP_{10}	761.66	739.21	766.27	642.85	727.50	33.55	35.42	40.20	34.73	35.98
P_4xP_5	646.81	514.19	424.52	763.19	587.18	33.51	35.52	32.76	61.80	41.40
P_4xP_6	912.27	872.70	902.06	537.77	806.20	36.36	37.50	41.19	25.15	35.05
P_4xP_7	688.11	665.33	635.59	626.25	653.82	28.49	29.13	29.69	29.24	29.14
P_4xP_8	502.83	453.39	638.59	602.70	549.38	19.76	19.67	29.28	28.69	24.35
P_4xP_9	598.94	577.80	601.75	589.21	591.93	24.42	25.32	28.56	28.62	26.73
P_4xP_{10}	729.18	671.82	814.19	587.57	700.69	30.78	31.63	40.29	30.35	33.26
P_5xP_6	663.38	710.79	650.23	912.96	734.34	29.51	34.14	34.19	49.22	36.76
P_5xP_7	747.22	714.18	934.26	627.09	755.69	29.12	30.56	42.45	29.41	32.88
P_5xP_8	605.85	554.76	581.74	910.01	663.09	25.56	26.07	29.16	47.57	32.09
P_5xP_9	889.37	781.58	817.69	922.85	854.37	39.44	38.75	43.32	51.40	43.23
P_5xP_{10}	1086.08	1047.21	1019.50	971.51	1031.03	51.49	52.88	55.68	55.36	53.85
P_6xP_7	606.62	572.30	533.41	808.05	630.09	29.21	31.71	31.56	50.00	35.62
P_6xP_8	799.87	747.59	1010.11	704.01	815.40	33.58	34.63	50.38	36.38	38.74
P_6xP_9	776.08	742.62	864.09	604.47	746.82	32.50	34.10	42.34	30.56	34.87
P_6xP_{10}	792.02	755.59	742.66	567.23	714.38	27.80	28.40	29.60	23.32	27.28
P_7xP_8	776.31	692.24	771.76	647.80	722.03	31.24	30.60	36.73	31.52	32.52
P_7xP_9	474.80	472.74	566.46	884.76	599.69	22.51	24.34	33.03	55.79	33.92
P_7xP_{10}	1319.84	728.43	638.65	892.52	894.86	55.27	33.25	31.31	45.68	41.38
P_8xP_9	517.46	501.25	710.55	783.51	628.19	21.84	22.99	34.92	40.66	30.10
P_8xP_{10}	921.98	908.39	865.35	568.16	815.97	33.64	36.26	36.37	24.61	32.72
P_9xP_{10}	802.26	797.82	872.23	663.55	783.97	31.66	34.46	39.65	31.43	34.30
Check	721.46	704.71	679.33	565.41	667.72	24.61	25.95	27.17	23.39	25.28

Continue Appendix - II

Genotype	Percentage fruit set					Number of fruits per vine				
	E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Parents										
P_1	79.56	79.35	80.12	85.49	81.13	9.41	9.81	14.06	30.05	15.83
P_2	79.59	80.17	82.23	86.66	82.16	11.61	12.45	17.19	20.13	15.34
P_3	85.78	85.09	85.56	85.99	85.61	21.20	20.84	21.96	20.14	21.03
P_4	86.72	86.81	88.37	84.47	86.59	26.18	27.19	28.47	24.07	26.48
P_5	84.42	84.15	83.35	83.27	83.80	13.97	14.23	14.70	22.13	16.26
P_6	87.49	86.52	89.52	84.72	87.06	30.77	31.09	35.31	20.59	29.44
P_7	81.29	82.59	83.45	86.51	83.21	16.76	16.76	16.19	29.51	19.80
P_8	85.89	85.78	85.58	85.95	85.80	13.37	13.46	24.85	24.21	18.97
P_9	84.05	83.32	82.97	86.75	84.27	9.97	10.70	13.99	22.88	14.38
P_{10}	87.00	87.45	87.46	86.89	87.20	20.48	21.14	24.32	26.34	23.09
Crosses (F_1)										
P_1xP_2	80.23	80.12	81.35	85.56	81.82	11.63	13.03	16.11	23.77	16.14
P_1xP_3	85.99	86.53	87.43	84.31	86.06	16.09	19.47	30.19	18.63	21.09
P_1xP_4	87.15	88.05	87.15	86.53	87.22	19.63	21.65	29.58	33.10	25.99
P_1xP_5	83.18	83.43	87.01	92.38	86.50	20.28	21.94	27.12	54.65	31.00
P_1xP_6	90.05	89.87	90.91	92.75	90.90	52.80	55.58	60.56	60.02	57.24
P_1xP_7	83.85	84.57	86.23	90.88	86.38	21.15	22.06	25.00	43.61	27.95
P_1xP_8	85.21	90.25	90.81	92.93	89.80	48.37	50.27	58.47	60.83	54.49
P_1xP_9	89.55	88.02	88.21	88.94	88.68	30.94	32.91	31.03	38.82	33.28
P_1xP_{10}	88.24	88.18	88.57	87.73	88.18	32.81	31.10	36.00	26.73	31.66
P_2xP_3	85.18	85.52	86.21	88.89	86.45	26.49	26.06	27.82	43.15	30.88
P_2xP_4	87.88	88.23	87.14	86.39	87.41	19.22	19.76	28.45	24.01	22.86
P_2xP_5	90.24	90.45	91.21	87.88	89.95	29.35	31.59	43.05	28.73	33.18
P_2xP_6	82.02	82.52	83.45	88.74	84.18	15.53	16.20	16.42	44.47	23.15
P_2xP_7	85.25	85.32	86.81	87.59	86.24	15.39	17.61	24.06	35.69	23.18
P_2xP_8	88.08	88.88	88.65	87.45	88.49	30.70	31.35	37.79	32.43	33.06
P_2xP_9	89.28	89.02	88.83	86.63	88.44	27.69	27.57	37.77	19.90	28.23
P_2xP_{10}	85.52	85.71	85.68	88.87	86.45	15.16	15.97	20.92	36.46	22.13
P_3xP_4	84.45	83.89	83.42	83.98	83.91	13.67	13.38	17.14	16.34	15.15
P_3xP_5	87.08	87.22	88.78	86.81	87.47	22.14	26.79	32.15	26.45	26.88
P_3xP_6	89.63	89.55	89.27	83.72	88.04	29.79	35.12	38.88	20.43	31.05
P_3xP_7	82.79	82.67	83.18	82.76	82.82	31.70	32.83	16.15	18.69	24.84
P_3xP_8	88.00	87.45	87.22	92.14	88.70	20.45	22.09	15.71	46.02	33.57
P_3xP_9	89.05	89.16	88.87	85.24	88.08	24.36	26.26	30.95	24.10	26.42
P_3xP_{10}	89.17	88.25	89.91	88.78	89.03	29.90	31.25	36.15	36.85	32.04
P_4xP_5	88.15	87.85	87.76	89.83	88.40	26.18	32.09	28.74	55.49	35.63
P_4xP_6	88.09	89.25	89.33	85.57	88.06	32.04	33.43	36.81	21.54	30.96
P_4xP_7	88.88	88.49	87.52	85.75	87.66	25.30	25.78	26.63	25.07	25.70
P_4xP_8	87.00	86.69	86.86	86.49	86.76	17.18	17.05	25.43	24.82	21.12
P_4xP_9	87.01	87.18	86.98	84.58	86.44	21.24	22.07	24.83	24.21	23.02
P_4xP_{10}	88.99	89.39	89.97	84.82	88.29	27.40	28.28	36.23	25.74	29.41
P_5xP_6	87.64	87.99	88.93	89.96	88.63	25.87	30.03	30.41	44.26	32.64
P_5xP_7	90.23	90.84	89.57	85.53	89.04	26.26	27.42	38.01	25.17	29.22
P_5xP_8	85.31	85.45	87.64	89.74	87.03	21.81	22.26	25.35	42.69	28.03
P_5xP_9	88.43	88.76	89.78	92.19	89.79	34.88	34.40	59.03	47.40	38.93
P_5xP_{10}	89.00	89.17	89.84	67.74	83.94	45.83	47.16	50.02	51.33	48.58
P_6xP_7	26.73	86.29	86.86	90.17	87.51	25.34	27.36	27.41	45.10	31.30
P_6xP_8	90.77	90.99	91.37	89.81	90.74	30.46	31.85	46.04	32.67	35.25
P_6xP_9	88.95	89.58	90.56	84.46	88.39	28.95	30.90	38.35	25.81	31.00
P_6xP_{10}	89.10	88.02	87.85	88.68	86.91	24.76	25.00	26.01	19.28	23.76
P_7xP_8	86.18	89.06	87.73	87.39	87.59	26.93	27.26	32.23	27.56	28.50
P_7xP_9	86.87	86.33	87.93	88.99	87.78	19.56	21.00	29.04	47.20	29.20
P_7xP_{10}	84.52	84.95	86.81	90.05	86.58	46.68	28.23	27.19	41.13	35.81
P_8xP_9	87.21	87.95	87.72	89.91	88.20	19.06	20.54	30.62	36.73	26.74
P_8xP_{10}	89.92	89.69	88.73	85.50	88.44	30.23	32.50	32.28	21.04	29.02
P_9xP_{10}	90.52	89.98	89.89	89.35	89.94	28.65	31.32	35.64	28.08	30.92
Check	86.05	86.36	86.97	86.15	86.38	21.16	22.39	23.63	20.16	21.83

Continue Appendix - II

Genotype	Length of fruit (cm) E₁	E₂	E₃	E₄	Pooled	Girth of fruit (cm) E₁	E₂	E₃	E₄	Pooled
Parents										
P_1	11.98	12.33	12.05	11.13	11.87	12.11	12.81	14.31	11.86	12.77
P_2	10.03	10.00	11.17	11.75	10.74	12.57	12.66	10.00	12.00	11.81
P_3	10.79	11.00	11.70	11.50	11.25	7.00	8.23	10.00	10.50	8.93
P_4	13.97	14.00	15.02	23.26	16.56	11.88	12.17	14.00	12.50	12.64
P_5	9.87	10.33	12.21	13.00	11.35	12.00	12.44	11.30	11.70	11.86
P_6	7.00	7.00	7.56	11.00	8.14	10.09	7.75	9.43	9.00	9.07
P_7	8.09	8.39	11.54	12.16	10.04	11.79	12.00	12.30	16.25	13.09
P_8	6.19	6.30	8.20	14.16	8.71	10.22	10.55	10.70	14.76	11.56
P_9	9.08	8.63	12.50	7.34	9.39	10.15	10.80	18.00	10.00	12.24
P_{10}	9.14	8.41	10.75	10.50	9.70	10.28	9.72	12.67	10.13	10.70
Crosses (F_1)										
P_1xP_2	11.44	11.20	12.87	10.34	11.46	15.15	15.00	15.33	12.20	14.42
P_1xP_3	15.20	15.07	15.40	16.50	15.54	11.21	11.43	12.73	15.90	12.82
P_1xP_4	13.25	13.00	13.83	12.75	13.21	9.00	10.21	12.46	13.50	11.29
P_1xP_5	9.98	10.12	12.10	12.00	11.05	12.99	14.50	14.30	11.75	13.39
P_1xP_6	10.25	10.30	11.00	9.75	10.32	14.22	12.33	13.00	12.00	12.89
P_1xP_7	8.01	8.10	8.10	13.75	9.49	12.00	12.37	10.00	13.00	11.84
P_1xP_8	13.23	13.31	14.46	14.25	13.81	11.95	12.00	14.27	13.86	13.02
P_1xP_9	14.05	14.43	16.00	8.00	13.12	13.11	14.00	16.46	10.60	13.53
P_1xP_{10}	11.56	12.53	13.75	11.66	12.38	13.91	10.15	18.25	12.50	13.10
P_2xP_3	8.75	8.87	11.20	14.25	10.77	13.34	8.26	14.96	13.00	12.39
P_2xP_4	7.14	7.06	10.50	16.00	10.18	10.45	12.00	12.00	14.75	12.30
P_2xP_5	9.58	10.17	13.50	14.00	11.81	11.43	12.34	17.50	14.75	14.01
P_2xP_6	9.00	10.00	13.00	15.75	11.94	12.72	10.27	13.00	14.75	12.69
P_2xP_7	9.73	8.90	11.90	9.25	9.95	6.27	7.72	12.00	13.12	9.78
P_2xP_8	11.37	11.14	12.10	12.00	11.65	10.08	11.00	14.60	14.50	12.55
P_2xP_9	7.03	7.30	10.10	8.00	8.11	15.04	15.36	15.03	12.50	14.48
P_2xP_{10}	11.12	12.11	14.00	12.00	12.31	9.88	8.87	15.10	10.00	10.96
P_3xP_4	7.05	7.21	10.50	13.00	9.44	11.77	12.03	12.01	12.50	12.08
P_3xP_5	6.23	7.50	11.50	12.42	9.41	10.87	11.33	10.00	17.59	12.45
P_3xP_6	11.23	12.32	14.85	11.75	12.54	16.33	16.41	17.50	13.60	15.96
P_3xP_7	10.00	9.07	8.50	8.50	9.02	6.52	6.83	10.30	10.47	8.53
P_3xP_8	17.05	16.46	16.80	13.30	15.90	10.19	10.96	16.30	13.00	12.61
P_3xP_9	8.88	8.83	12.30	9.25	9.81	7.99	8.40	11.00	.12.20	9.90
P_3xP_{10}	9.25	10.52	13.00	12.00	11.19	12.93	13.80	14.80	13.00	13.63
P_4xP_5	6.53	5.30	8.50	16.66	9.25	11.88	7.30	9.30	14.50	10.74
P_4xP_6	11.22	12.27	14.67	14.00	13.04	7.53	14.00	14.00	17.40	13.23
P_4xP_7	14.65	15.67	14.25	12.40	14.24	13.89	10.28	13.00	12.00	12.29
P_4xP_8	12.00	12.50	15.54	14.00	13.51	12.82	11.71	12.00	15.00	12.88
P_4xP_9	12.38	14.38	16.50	13.83	14.27	11.54	15.58	17.30	14.18	14.65
P_4xP_{10}	13.07	14.21	14.96	15.50	14.43	15.00	13.23	13.60	14.65	14.12
P_5xP_6	7.53	7.20	11.50	11.50	9.43	13.06	7.06	12.80	13.06	11.50
P_5xP_7	9.39	9.00	14.00	14.50	11.72	8.28	9.50	13.20	13.00	10.99
P_5xP_8	10.44	10.64	11.75	9.00	10.46	10.03	9.61	10.41	13.20	10.81
P_5xP_9	10.13	10.31	12.07	14.65	11.79	9.50	10.40	15.30	15.00	12.55
P_5xP_{10}	13.46	13.71	14.50	16.67	14.58	9.40	15.48	13.40	14.83	13.28
P_6xP_7	9.99	10.12	10.33	13.67	11.03	14.84	12.21	12.10	13.25	13.10
P_6xP_8	8.37	8.40	13.43	12.33	10.63	11.88	10.00	17.32	13.34	13.14
P_6xP_9	12.66	11.87	11.67	13.04	12.31	13.00	10.92	14.73	13.50	13.04
P_6xP_{10}	11.21	12.33	10.00	12.82	11.59	10.00	5.31	8.50	14.45	9.57
P_7xP_8	9.55	10.80	12.35	20.00	12.18	11.02	11.10	14.02	17.00	13.98
P_7xP_9	13.37	13.34	12.03	16.87	13.90	13.51	13.76	13.00	16.00	14.07
P_7xP_{10}	9.33	9.47	13.00	12.37	11.04	8.00	8.21	9.00	14.17	9.85
P_8xP_9	9.06	9.56	11.56	15.00	11.30	9.75	7.63	12.80	15.40	11.40
P_8xP_{10}	10.71	10.17	9.75	13.83	11.12	8.22	9.23	10.00	12.33	9.94
P_9xP_{10}	13.12	12.65	12.23	13.30	12.82	12.05	12.30	12.96	13.73	12.76
Check	8.68	8.57	12.56	17.00	11.70	10.33	10.64	11.18	10.00	10.53

Appendix - II

	Weight of fruit (g)					Fruit yield per vine				
	E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
	34.76	45.52	48.88	23.01	38.04	327.80	446.01	687.41	687.55	537.19
	42.12	42.81	70.32	44.46	49.93	488.77	539.11	1208.33	892.99	782.30
	[illegible]0.15	36.24	50.21	45.08	42.92	852.47	755.68	1105.71	905.76	904.90
	64.71	28.25	90.05	66.30	74.83	1692.74	2126.54	2566.25	1595.29	1995.20
	21.06	21.02	35.16	34.97	28.05	243.59	295.11	518.22	773.76	470.17
6	20.36	18.54	25.05	20.07	21.00	625.87	576.12	882.37	413.16	624.38
P_7	30.46	27.57	35.21	47.74	35.25	508.32	463.40	571.33	1424.07	741.78
P_8	25.29	20.47	22.56	48.76	29.27	339.81	278.78	558.52	1180.29	589.33
P_9	45.38	42.22	93.63	21.09	50.58	448.52	453.20	1309.04	483.93	673.67
P_{10}	30.19	38.17	41.81	40.36	37.63	618.85	808.02	1014.69	1059.91	875.37
Crosses (F_1)										
P_1xP_2	43.31	52.12	57.01	43.63	46.77	503.09	654.24	1031.39	824.15	753.22
P_1xP_3	48.43	69.05	78.91	86.58	70.74	779.84	1343.92	2381.89	1611.41	1529.27
P_1xP_4	42.66	42.00	41.84	46.46	43.24	838.51	894.93	1238.25	1539.11	1127.70
P_1xP_5	48.34	60.34	63.88	35.43	52.00	979.16	1322.79	1732.36	1939.63	1493.48
P_1xP_6	63.67	61.16	65.67	70.44	65.23	3363.47	3456.17	3976.80	4229.55	3756.50
P_1xP_7	32.32	36.63	34.95	47.31	37.80	682.54	806.43	874.45	2064.51	1106.98
P_1xP_8	59.11	58.67	59.44	58.30	58.88	2860.97	2950.38	3473.56	3548.43	3208.34
P_1xP_9	37.42	48.51	90.48	22.55	49.74	1156.02	1620.37	2805.81	875.67	1614.47
P_1xP_{10}	55.06	51.34	60.60	38.95	51.49	1805.75	1596.84	2180.84	1035.64	1654.77
P_2xP_3	30.04	35.31	32.30	43.02	35.17	488.77	919.85	899.39	1857.68	1041.42
P_2xP_4	38.46	36.47	36.23	60.39	42.89	796.38	720.75	1031.00	1452.99	1000.15
P_2xP_5	33.99	40.64	47.05	60.43	45.53	1000.04	1282.23	2026.64	1734.08	1510.75
P_2xP_6	36.29	42.23	50.53	49.00	44.51	564.41	683.57	828.04	2179.44	1063.87
P_2xP_7	184.85	35.34	65.11	28.32	78.40	712.32	623.41	1567.44	1009.77	978.24
P_2xP_8	45.28	56.32	63.81	64.03	57.36	1388.51	1767.20	2411.77	2072.61	1910.02
P_2xP_9	52.15	49.97	56.34	30.32	47.19	1444.61	1254.40	2125.44	605.83	1357.57
P_2xP_{10}	55.10	61.07	60.83	32.57	52.39	835.02	974.16	1273.25	1184.97	1066.83
P_3xP_4	20.32	22.41	43.90	80.03	40.17	276.88	299.48	648.31	1306.96	632.91
P_3xP_5	27.43	30.01	32.59	51.07	35.27	606.74	803.64	1047.59	1351.95	952.35
P_3xP_6	53.98	82.40	97.31	40.18	68.47	1606.70	2894.13	3781.98	809.84	2273.16
P_3xP_7	22.38	27.84	38.56	30.20	29.74	708.19	895.85	619.06	562.63	696.43
P_3xP_8	34.64	39.16	54.25	64.53	48.15	710.79	864.55	1573.77	2968.89	1529.50
P_3xP_9	30.71	29.83	50.44	36.83	36.95	747.81	783.14	1560.70	886.58	994.56
P_3xP_{10}	42.25	50.52	56.52	50.91	50.05	1262.92	1577.75	2043.61	1573.70	1614.50
P_4xP_5	25.17	21.81	30.28	65.32	35.64	1692.74	698.90	872.77	3622.26	1761.67
P_4xP_6	55.42	51.39	52.36	110.27	67.36	1772.81	1720.28	1930.00	2384.93	1951.88
P_4xP_7	3212	40.87	47.85	60.44	45.32	813.98	1053.34	1241.05	1514.12	1155.62
P_4xP_8	48.23	47.16	60.73	125.06	70.30	828.71	802.80	1545.55	3099.68	1569.19
P_4xP_9	40.42	42.28	53.06	69.37	51.28	858.86	934.14	1318.17	1684.64	1198.95
P_4xP_{10}	33.37	32.80	45.61	51.31	40.77	913.11	926.69	1654.33	1320.17	1203.57
P_5xP_6	31.56	37.99	58.25	37.21	41.25	815.36	1141.55	1773.97	1646.42	1344.33
P_5xP_7	40.04	42.65	53.99	54.74	47.85	1051.20	1183.89	2052.13	1380.39	1416.90
P_5xP_8	36.29	34.28	44.92	40.66	39.04	794.10	730.49	1137.66	1736.83	1099.77
P_5xP_9	42.99	45.32	60.61	45.68	48.65	1501.25	1557.62	2363.76	2167.54	1897.55
P_5xP_{10}	63.39	62.93	64.68	68.52	64.88	2904.20	2966.69	3232.41	3515.89	3154.80
P_6xP_7	27.66	22.85	25.26	54.24	32.50	701.75	624.90	692.95	2445.10	1116.17
P_6xP_8	60.22	67.48	80.50	53.28	65.37	1820.57	2125.71	3703.73	1741.39	2347.83
P_6xP_9	22.45	32.78	47.68	47.30	37.55	647.32	1000.61	1824.74	1220.62	1173.82
P_6xP_{10}	33.32	28.00	30.63	53.36	36.33	826.39	700.18	794.16	1024.67	836.35
P_7xP_8	47.72	60.67	74.26	75.02	64.42	1281.96	1653.46	2397.62	2068.09	1850.28
P_7xP_9	37.63	41.39	60.17	63.07	50.57	734.31	870.34	1746.55	2977.39	1582.15
P_7xP_{10}	27.54	27.52	35.21	31.27	30.38	1286.37	777.35	959.41	1285.86	1077.25
P_8xP_9	30.80	37.24	38.35	68.31	43.67	588.16	751.72	1176.96	2509.22	1256.52
P_8xP_{10}	20.77	20.43	30.65	42.75	28.65	627.00	662.26	992.49	901.36	795.77
P_9xP_{10}	40.00	36.15	47.15	48.34	42.91	1144.65	1122.03	1683.25	1356.85	1326.70
Check	31.49	23.16	31.48	62.75	37.22	647.46	518.94	744.25	1263.63	793.57

Continue Appendix - II

Genotype	Number of seeds per fruit				
	E_1	E_2	E_3	E_4	Pooled
Parents					
P_1	26.51	27.00	27.30	28.00	27.20
P_2	21.28	20.08	19.20	18.20	19.69
P_3	30.05	30.75	31.24	32.00	13.01
P_4	14.01	19.21	18.77	20.10	19.27
P_5	28.15	28.77	28.32	27.75	28.25
P_6	20.35	21.00	19.43	23.00	20.94
P_7	15.06	14.63	13.50	15.60	14.70
P_8	30.73	29.66	26.51	26.55	28.36
P_9	41.46	41.15	40.32	41.13	41.02
P_{10}	26.03	26.53	27.00	26.00	26.39
Crosses (F_1)					
P_1xP_2	31.02	30.82	30.40	31.20	30.86
P_1xP_3	36.01	35.50	35.20	34.80	35.38
P_1xP_4	21.15	20.31	19.03	21.21	20.43
P_1xP_5	24.85	25.23	24.20	27.17	25.36
P_1xP_6	21.84	21.56	21.15	24.28	22.21
P_1xP_7	18.64	19.11	16.33	18.00	18.02
P_1xP_8	36.32	35.00	35.35	35.95	35.65
P_1xP_9	27.15	26.51	28.57	30.51	28.17
P_1xP_{10}	25.32	26.32	26.85	27.85	26.58
P_2xP_3	22.04	21.53	21.87	19.75	21.30
P_2xP_4	31.22	33.85	34.12	35.00	33.55
P_2xP_5	16.84	17.91	17.05	18.15	17.49
P_2xP_6	22.00	21.13	20.07	22.19	21.35
P_2xP_7	13.66	15.73	14.24	16.30	14.98
P_2xP_8	28.51	28.41	27.34	29.00	28.32
P_2xP_9	35.53	34.25	37.00	35.85	35.66
P_2xP_{10}	11.00	11.12	11.51	10.08	10.93
P_3xP_4	25.24	26.45	26.24	26.83	26.19
P_3xP_5	11.72	11.35	11.05	10.67	11.20
P_3xP_6	18.52	23.58	22.35	24.03	22.12
P_3xP_7	16.19	17.58	17.40	18.25	17.35
P_3xP_8	29.00	30.17	29.54	28.16	29.22
P_3xP_9	40.62	42.26	43.23	44.00	42.53
P_3xP_{10}	26.95	27.82	28.23	27.00	27.50
P_4xP_5	23.24	24.42	25.26	26.00	24.73
P_4xP_6	12.15	11.54	14.05	12.35	12.52
P_4xP_7	9.00	9.03	9.75	10.08	9.46
P_4xP_8	38.19	39.28	39.97	38.35	38.95
P_4xP_9	36.14	36.81	37.15	37.02	36.78
P_4xP_{10}	25.95	27.00	26.45	28.03	26.86
P_5xP_6	22.23	23.00	23.05	24.25	23.13
P_5xP_7	32.29	32.89	34.13	35.33	33.66
P_5xP_8	15.00	16.00	17.00	18.00	16.50
P_5xP_9	21.85	22.57	21.15	23.15	22.18
P_5xP_{10}	31.00	31.85	31.25	30.95	31.26
P_6xP_7	17.07	17.78	18.00	16.00	17.21
P_6xP_8	27.82	28.22	29.21	32.00	29.31
P_6xP_9	30.25	30.11	29.01	31.00	30.09
P_6xP_{10}	40.16	41.40	41.00	42.00	41.14
P_7xP_8	21.32	23.19	22.23	20.23	21.74
P_7xP_9	43.09	42.00	41.50	40.95	41.89
P_7xP_{10}	24.88	25.92	26.23	28.15	26.30
P_8xP_9	46.47	47.31	50.00	49.13	48.23
P_8xP_{10}	43.25	42.75	44.40	45.00	43.85
P_9xP_{10}	31.00	31.00	30.00	32.00	31.00
Check	31.18	32.00	32.15	32.62	31.99