HETEROSIS IN SNAKEGOURD
(*Trichosanthes anguina* L.)

By
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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Heterosis in snakegourd (*Trichosanthes anguina* L.)" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

PHILIP VARGHESE

Vellanikkara,
26-3-'91

CERTIFICATE

Certified that this thesis entitled "Heterosis in snakegourd (Trichosanthes anguina L.)" is a record of research work done independently by Sri. Philip Varghese, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Introduction

INTRODUCTION

The cucurbitaceae family has become an important source of food and utensils since the dawn of civilization. Snakegourd (*Trichosanthes anguina* L.) occpies a pride of place among the cucurbitaceous vegetables particularly in South India, where it is commonly grown throughout the year. It grows wild in India. Indian Archipelago is considered its place of origin. It is considered as a good source of minerals, fibre and other nutrients to make the food wholesome and healthy. The percentage of edible portion is 98.0. Every 100 g of edible portion contains 94.6 g of moisture, 0.5 g of protein, 0.3 g of fat, 0.5 g of minerals, 0.8 g of fibre and 3.3 g of carbohydrate, with a calorific value of 18.0. It is moderately rich in vitamin A, which is 160.0 IU and is three times that of ridgegourd (Gopalan *et al*., 1982). The medicinal values of snakegourd has been recognised lately.

In spite of its economic importance as a common vegetable consumed by many people in the country, especially in South India, no serious attempt has so far been made to upgrade the productivity and acceptability of this crop. The types that are under cultivation at present are non descript ones. This necessitates a need based crop improvement programme for developing high yielding varieties with superior quality fruits. And there is an imperative need for developing varieties suited to different agro-climatic conditions. Exploitation of heterosis is a known technique of boosting up production and productivity of crop plants. Snakegourd being a cross pollinated crop, considerable scope exists for commerical exploitation of heterosis. And there exists considerable level of diversity among the snakegourd types in South India. Identification of specific combination(s) with heterotic effects for economic characters augur well in this context.

The preliminary step in all crop improvement programmes is the selection of desirable gentoypes. For effective selection, information on the extent of variability in a population for different characters is inevitable. In selecting a plant or a type, one should be reasonably sure that there is good chance of desirable characters being inherited by the progenies. This can be ascertained by partitioning the total variability into heritable and non-heritable components with the aid of suitable genetic parameters such as genotypic coefficient of variation, heritability and genetic advance. Locating ideal parental combinations and their combining ability for desirable characters and extent of heterosis are stepping stones for hybrid seed production.

Review of Literature

REVIEW OF LITERATURE

The information on various aspects of the research topic 'Heterosis in snakegourd' are reviewed under the following heads.

A. Genetic variability

Variability available on a population could be partitioned into heritable and non-heritable components with the aid of genetic parameters such as genotypic and phenotypic coefficients of variations (gcv and pcv), heritability (h^2) and genetic advance (GA) which serves as a basis for selection (Johnson et al., 1955).

Tyagi (1972) in bottlegourd used 25 inbreds comprising of genetically diverse germplasm for divergence study. Significant differences were noticed among the strains in respect of all the characters. The ranges for various traits were, fruits/plant (13.1-21.9), fruit length (12.0-87.3 cm), fruit girth (32.5-61.6 cm), shoot length (348.3-711.4 cm), branches/plant (6.2-10.1), seeds/fruit (187.0-525.8) and 100 seed weight (17.2-21.94 g). Fruits/plant had the highest gcv (48.26) followed by seed breadth (31.96), fruit length (26.64) and fruit girth (23.28).

Thakur and Nandpuri (1974) observed in watermelon variability for vine length (2.64-4.84 m), branches/plant (5.34-7.65), sex ratio (15.7:1 - 2.5:1), days to fruit picking (81.5-99.2 days), fruits/vine (0.64-1.85), average fruit weight (2.29-5.95 kg), yield/vine (2.43-6.6 kg), seeds/kg of fruit (53.2-260.3), 100 seed weight (4.92-13.85 g) and TSS (6.17-8.74%). The pcv was maximum for seeds/kg of fruit (41.31) and minimum for days to fruit picking (6.46). The gcv values also showed the same trend.

Kalyanasundaram (1976) evaluated three muskmelon (*Cucumis melo* L.) varieties: Annamalai, Hara Madhu and Arka Rajhans and observed significant differences among the three varieties for economic characters. Kubiaki and Walezak (1976) reported larger differences within and between varieties with respect of β carotene content in 19 varieties belonging to *Cucurbita pepo*, *Cucurbita maxima* and *Cucurbita moschata*. The variety Golden Delicious (*Cucurbita maxima*) recorded the highest carotene content.

Srivastava and Srivastava (1976) studied variability in 10 lines of bittergourd and observed significant differences for all the characters except for male flowers/plant. The highest gcv was for fruits/plant (37.45) followed by yield/plant (32.13) and fruit weight (30.02). Male flowers/plant had the lowest gcv (11.47). Singh *et al.* (1977) evaluated 25 diverse varieties of bittergourd and obtained maximum value of gcv for fruits/plant (30.0) followed by fruit yield/plant (30.0). Days to flower had the lowest gcv.

In snakegourd, Joseph (1978) recorded the following observations on variability among 25 lines. Days to first male flower anthesis (36.22-45.00 days), days to first female flower opening (45.33-51.33 days), node at which first female flower formed (15.11-23.44), female flowers/plant (16.66-53.33), main vine length (4.01-6.17 m), fruits/plant (8.11-18.99), yield/plant (3.02-8.92 kg), fruit length (45.08-89.55 cm), fruit girth (13.08-24.14 cm), fruit weight (267.7-858.03 g), flesh thickness (4.4-6.57 mm), seeds/fruit (29.4-64.80), 100 seed weight (27.31-34.46 g) and vitamin C content (8.75-19.39 mg/100 g fruit). The highest gcv was for fruit weight (28.29) followed by female flowers/plant (25.8) and fruit length (19.23).

Evaluating 25 diverse lines of bittergourd, Ramachandran (1978) observed considerable variability for several vegetative and productive characters. The primary branches/ plant among different bittergourd geno types ranged from 18.00 to 35.89 with a general mean of 27.12. The estimated phenotypic, genotypic and environmental variance (Vp = 21.64, Vg = 20.81, Ve = 0.83) showed a predominant influence of genetic component in relation to the environmental effects on this character.

Gopalakrishnan (1979) studied variability for 25 quantitative characters among 18 genotypes of <u>Cucurbita moschata</u> Poir, and found significant differences for all the characters. The yield/plant ranged from 5.45 kg (CM-18) to 16.0 kg (CM-17). Carotene content ranged from 0.132-0.527%. This study identified lines CM-17 and CM-14 (Ambili) as high yielders (16.10 kg and 15.38 kg/plant respectively). The maximum value of genotypic coefficient of variation was for male flowers/plant (56.23) followed by fruits/plant (50.32).

Ramachandran and Gopalakrishnan (1979) carried out detailed variability studies in 25 diverse lines of bitter-gourd and observed significant variability for primary branches/plant, main vine length, node to first female flower, days to first female flower opening, female flowers/plant, days to fruit picking maturity, yield/plant, number, weight, length and girth of fruits and 100 seed weight. They observed the highest pcv (39.88) and gcv (37.82) for yield/plant. The lowest gcv was recorded for seeds/plant.

Ramachandran and Gopalakrishnan (1980) observed significant variability with respect to certain chemical constituents in bittergourd. The variance components and genotypic coefficient of variation were calculated for TSS, vitamin C, protein, potassium and iron contents in all the genotypes. The range of variation was wide and the differences between genotypes were highly significant.

Solanki and Seth (1980) observed a wide range of variation for 24 characters in cucumber. The pcv varied from 10.43 for fruits/plant to 71.80 for plant height. The gcv was the lowest for fruits/plant (5.996) and the highest for plant height (69.026), whereas the environmental coefficient of variation ranged from 6.896 to days to fruit maturity to 71.202 for yield/plant.

Arora *et al*. (1983) found that the varietal differences were significant for the characters in spongegourd. Genotype HS-4 was the poorest yielder (0.021 kg/plant) followed by HS-12 (1.368 kg/plant) and HS-13 (1.392 kg/plant). The genotype HS-3 with maximum vine length (275.1 cm) was early (68.3 days to flowering) having low sex ratio (8.6) and the node setting first female flower (8.2), second highest number of fruits/plant (10.5) and the longest fruits (25.7 cm), maximum diameter (5.2 cm) at edible stage and fruit yield/ plant (3.106 kg). Maximum range of variation and high genotypic and phenotypic coefficients of variation were for yield/plant and were closely followed by fruits/plant and sex ratio, indicating scope for selection for these characters.

Doijode (1983) reported high variability for TSS and carotene among seven inbred lines to pumpkin. The TSS content ranged from 4.7 to 8.1 per cent and carotene from 1.7 to 8.65 mg/100 g fruit.

Reddy and Rao (1984) found that in ridgegourd (_Luffa acutangula_ Roxb.), pcv ranged from 14.38 to 162.62 and gcv from 13.56 to 112.03 for days to first marketable fruit formation and yield/plant respectively. The pcv and gcv for yield/plant were the highest. The lowest values of pcv and gcv were realised for days to fruit picking and fruit diameter.

Singh _et al_. (1985) found significant differences for all the characters studied in 18 types of pointed gourd. FP 3 gave the highest yield.

Doijode and Sulladmath (1986) found that fruit weight and B carotene showed the highest pcv and gcv as compared to other characters in pumpkin. In general pcv was higher than gcv.

Rana _et al_. (1986) in their studies on yield/plant and 11 yield related quality and development traits from 19 genotypes of pumpkin in two seasons, found highly significant differences for all traits except dry matter and carotenoid content. Phenotypic and genotypic coefficients of variation were high for vine length, fruit set per cent, branches / plant and fruit weight in both the seasons.

Chaudhary (1987) in bittergourd observed significant variability in respect of various vegetative and yield characters. The highest pcv and gcv were observed for yield/plant, vine length and fruit weight. For fruit length and diamter, seeds/fruit and seed weight/fruit, the gcv and pcv were of average order. The estimates of gcv and pcv were low for early female flower formation and early harvest.

Rajendran (1989) observed in 30 genotypes of water-melon that vine length ranged from 1.13 to 3.53 m and the pcv and gcv were 35.45 and 21.86 respectively. Days to first female flower opening ranged from 37.17 to 61.72 and the pcv and gcv were 19.10 and 19.91 respectively. The sex ratio ranged from 12.83 to 131.47 with moderately high value of pcv (86.72) and gcv (6.60), fruits/vine ranged from 0.64 to 3.17 and pcv and gcv were 58.29 and 39.8 respectively. Fruit yield/vine ranged from 0.38 to 9.54 kg and pcv and gcv for yield were 88.34 and 67.60 respectively. Seeds/fruit had a wide range of 20.50 to 539.83 and pcv and gcv were 58.76 and 44.64 respectively.

Sureshbabu (1989) in 50 genotypes of pumpkin observed following variability. Days to first male flower anthesis (41.0-73.0 days), days to first female flower opening (41.0-84.5 days), female flowers/plant (2.25-5.0), male flowers/plant (32.5-92.5), node at which first female flower is retained (24.0-78.5), vine length (6.78-13.98 m), average fruit weight (0.0-6.7 kg), flesh thickness (1.45-4.65 cm), seeds/fruit (62.5-717.0), yield/plant (0.9-13.4 kg) and carotene content (4.46-215 g/100 g). The highest gcv was observed for seeds/fruit (37.37) and the lowest for node at which first female flower is formed (12.77). The highest and the lowest pcv were observed for yield/plant (58.0) and days to first male flower anthesis (13.08) respectively.

Vahab (1989) found significant differences among 50 genotypes of bittergourd for all the 18 characters studied. The highest pcv was observed for fruit weight (48.77) followed by yield/plant (39.91) and fruits/plant (31.83). It was moderate for fruit length (29.56), percentage of female flowers (28.56) and female flowers/plant (27.33). The pcv was low for node to first female flower formation (8.18) and days to first female flower opening (3.38).

B. **Heritability and genetic advance**

Heritability and genetic advance are two important criteria for selection of plants. The degree to which the variability for a quantitative character is transmitted to the progeny is called 'heritability'. It can be defined as that proportion of total variation in a progeny which is the result of genetic factors and may be transmitted. Hanson et al. (1956) proposed the mathematical relationship of various estimates on computation of heritability which is usually expressed as a percentage. In the 'broad sense' it refers to the relative proportion of the genotypic variance to the phenotypic variance. In the 'narrow sense' it is the proportion of additive genetic variance to phenotypic variance. Coefficient of variation is used to compare the relative variables, when different metric traits are measured in different units. Dividing the standard deviation of the trait by mean, renders the coefficient of variation independent of the unit of measurement. Estimates of heritability along with genetic advance are more useful in the choice of selection method rather than heritability or genetic advance alone.

Thakur and Nandpuri (1974) reported a heritability estimate of 92.2 per cent for seed weight and 84.97 per cent for seeds/kg of fruit in watermelon. The minimum heritability estimate of 25.95 per cent was observed for branches/plant. The maximum genetic advance was observed for seeds/kg of fruit (83.75%). The lowest estimate of genetic advance was observed for days to first picking (5.78%).

Miller and Quiscenberry (1976) observed moderately high heritability for days to first female flower opening in cucumber.

Srivastava and Srivastava (1976) reported that fruits/plant had the highest estimates of genetic advance (71.75%) resulting from the highest estimate of variability (gcv = 37.45) and heritability (99.31%) in bittergourd. Male flowers/plant recorded the lowest estimate of genetic gain (16.78%) and heritability (49.98%). High heritability associated with moderate variability resulting in high genetic gain was observed for fruit weight, yield/plant and fruit length.

Panwar *et al*. (1977) found in 40 varieties of sponge-gourd that estimates of broad sense heritability and genetic advance were high for fruit length and days to flowering.

Brar and Nandpuri (1978) conducted genetic analysis of yield and fruit number in watermelon. The h^2 (b) was moderate (48.92%) and h^2 (n) low (23.64%) for yield/plant. The h^2 (b) was higher (72.29%) and h_2 (n) was moderate (66.9%) for fruit number.

Joseph (1978) studied heritability and expected genetic advance for 21 characters in 25 varieties of snakegourd. Fruit length had the highest heritability of 99.19%, followed by fruit girth (98.60%) and vitamin C content (97.59%). Yield/plant had a comparatively low estimate of heritability (45.90%). The lowest heritability estimate was recorded for fruits/plant (21.20%).

Ramachandran (1978) reported that heritability in broad sense was quite high for all the 21 characters studied in bittergourd, except for seeds/fruit. Fruits/plant had the highest heritability estimate of 99.8 per cent which was closely followed by yield/plant (99.74%) and vitamin C content (99.63%). The lowest heritability was for seeds/fruit (43.37%). Genetic gain was the highest for yield/plant (81.93%) followed by vitamin C content (70.72%) and fruits/plant (64.3%).

Chonkar *et al*. (1979) reported that the values of heritability and genetic advance showed effectiveness in selection for pulp thickness, fruit weight and percentage of TSS in muskmelon.

Gopalakrishnan (1979) reported the highest heritability estimate of 99.14% for male flowers/plant followed by percentage of female flowers and female flowers/plant in *Cucurbita moschata*. The lowest heritability estimate of 76.96 per cent was observed for fruit set percentage. He also found that male flowers/plant had the highest value of genetic gain (52.32%).

Solanki and Seth (1980) reported association of high heritability with genetic advance for vine length, leaves/plant, male flowers/plant, female flowers/plant, internodal length, days to maturity and fruit yield in *Cucumis sativus*.

Mangal *et al*. (1981) noted high heritability values for leaf length, vine length, average fruit weight, branches/plant, fruits/plant, yield/plant and seeds/fruit in bittergourd.

In spongegourd, Arora _et_ _al_. (1983) found high heritability estimates for all characters, except vine and internodal length and fruit diameter which showed moderate values. The genetic gain was also the highest for yield/plant followed by sex ratio and fruits/plant.

Prasad _et_ _al_. (1984) in _Luffa_ _cylindrica_ L. found that yield/plant and four other traits gave heritability estimates of 100.0 per cent during 1982-'83. High values for both heritability and genetic advance were obtained for five traits, including fruit length and diameter.

Reddy and Rao (1984) found maximum genetic gain for fruit yield/plant (157.14%) followed by average fruit weight (130.00%), leaf area (108.71%) and number of fruits in ridgegourd. The highest heritability was for average fruit weight and the lowest for days to first harvest.

Doijode and Sulladmath (1986) in pumpkin reported that out of six quantitative fruit characters studied, all characters except TSS showed high narrow sense heritability.

Gill and Kumar (1986) reported high heritability for fruit shape index, TSS, total sugars and vitamin C content in watermelon. According to them though TSS showed high heritability (82.76%) the expected genetic advance was very low (10.42%). The genetic gain was high for vitamin C content of fruits.

Chaudhary (1987) in bittergourd reported that the genetic advance was very high for yield/plant (114.39) and vine length (151.53). Singh et al. (1987) also observed high estimates of heritability and expected genetic advance for fruit yield, fruits/plant and fruit length in bittergourd.

Vijay (1987) noticed high heritability and high genetic advance for fruits/vine, TSS, flesh thickness, yield/vine, fruit weight and days to flower in muskmelon.

Krishnaprasad and Singh (1989) in ridgegourd noticed high heritability and low genetic advance for number of nodes (12.06% and 1.67), node on which first female flower appeared (15.38% and 1.28), fruit length (57.23% and 5.06) and fruit diameter (12.5% and 0.53). These are attributable to the non-additive effects. High heritability coupled with high genetic advance for yield in q/ha (74.0% and 240.3), yield/plant (73.0% and 9.39), number of fruits (42.0% and 18.87) indicated that selection would be effective for genetic improvement. Low heritability was recorded for vine length (5.0%) followed by fruit diameter (12.5%), number of nodes (12.06%) and node on which first female flower appeared (15.35%).

Rajendran (1989) studied heritability and genetic advance in watermelon and reported that heritability and genetic gain were 38.0 per cent and 27.76 per cent respectively, for vine length. He also reported low heritability (25.0%) and moderate genetic advance (47.40%) for leaves/vine, moderate heritability (49.0%) and comparatively high genetic gain (87.46%) for sex ratio, moderate heritability (4.0%) and genetic gain (56.60%) for fruits/vine, low heritability (4.0%) and genetic gain (6.97%) for crop duration and medium heritability (58.0%) and genetic gain (69.87%) for seeds/fruit.

Sureshbabu (1989) in a study involving 50 pumpkin genotypes reported the highest heritability [h^2 (b)] for node at which first fruit retained (93.0%) and the lowest for yield/plant (23.0%). He also found that the genetic gain was the highest for seeds/fruit (73.05%) and the lowest for internodal length (19.1%).

Vahab (1989) in bittergourd reported high heritability along with genetic gain for fruit weight, yield/plant and fruits/plant. Though heritability was high for primary branches/plant and days to first female flower opening, the genetic gain was of low magnitude.

C. Grouping of genotypes

Importance of genetic divergence in selection of parents for hybridization was stressed by many workers. According to Singh and Gupta (1968), the more diverse the parents, within a reasonable range, the more would be the chance of improving the character in question. Usually in most of the conventional heterosis breeding programmes, geographic diversity at times and phenotypic diversity in many times are taken as the criteria for choosing genetically divergent populations for isolation of inbred lines. Phenotypic divergence in a population has also been considered as an index and criterion of genetic diversity (Rai, 1979).

Generally geographic diversity has been considered as an index of genetic variability in crop plants. However, this may not be true for every case, as many workers postulated that geographic diversity need not necessarily be related to genetic diversity. Varieties from widely separated localities are usually included in hybridization programmes presuming genetic divergence and greater likelihood of yielding better segregants. Validity of the above presumption depends upon the association between geographic diversity and genetic diversity (Singh and Bain, 1968).

Ramachandran <u>et al</u>. (1981) grouped 25 types of bitter-gourd into 10 clusters based on their D^2 values. The intercluster distance value observed was maximum between clusters VI and VIII (8569.31) and the minimum was between clusters II and III (393.62). The coefficients of variation estimated for different characters among the 10 clusters showed greater role for yield/plant (38.84), fruits/plant (25.65), female flowers/plant (19.82) and fruit length (19.05) in determining the intercluster distance. It was further observed that the characters yield/plant, fruits/plant, female flowers/plant and fruit length contributed predominantly to divergence.

A study involving 45 diverse lines of Cucumis melo (Kalloo et al., 1982) revealed high diversity as indicated by the range of D^2 values from 2.52 to 210.14 among the lines. Depending on the genetic divergence, the 45 strains were grouped into 14 clusters. The maximum distance at inter-cluster level was 14.50 followed by 13.29. The intracluster divergence ranged rom 9.36 to 19.86. They also found that the genotypes usually did not cluster according to the geographical distribution. However, in some cases, geographical origin influenced clustering.

Sukhija et al. (1982) while analysing 46 lines of watermelon found that the D^2 values ranged from 3.84 to 308.43 showing high divergence among different lines. They concluded that the lines New Dragon, RSX 10-6-5, HW-Bangalore, R-2216, Sugar Baby and H-23 were substantially divergent from each other as well as from other lines. The 46 lines were grouped into 12 clusters depending on their genetic divergence. The intracluster distance ranged from 0.0-19.40. Lines usually did not cluster according to their strict geographical distribution.

Kadam and Kale (1985) observed highly significant differences between cultivars suggesting considerable divergence among 30 ridgegourd cultivars. The 30 cultivars were grouped into 20 clusters based on their D^2 values. Cluster A having two cultivars had the lowest intracluster D^2 value (8.22) while cluster I which has two cultivars had the highest intracluster value of 18.59. The highest intercluster distance was observed between clusters E and M (387.11) and it was minimum between clusters D and G (19.79).

While studying seven diverse watermelon varieties and their hybrids, Sidhu and Brar (1985) found that the clustering pattern of hybrids was not influenced by the parentage and their geographical origin. They observed highly significant differences among the genotypes. The average fruit weight contributed maximum towards genetic divergence (28.04%) followed by fruits/plant (23.28%) which together constituted 51.32% of the divergence. The 28 genotypes (including hybrids) were grouped into seven clusters. The intercluster values ranged from 12.88 to 39.99. The low intracluster and high intercluster values suggested that the population grouped were homogenous within and heterogenous between clusters. The results did not show any consistent relationship between divergence and heterosis for yield in watermelon.

Mathew *et al*. (1986) studied the genetic distance among five botanical varieties of *Cucumis melo*, viz., *Cucumis* melo var. Conomon (oriental pickling melon), Cucumis melo var. inodorus (muskmelon), Cucumis melo var. flexuosus (snakemelon), Cucumis melo var. utilissimus (longmelon), and Cucumis melo var. momordica (snapmelon). The genetic distance was calculated considering four quantitative characters, node to first female flower, fruit weight, seeds/fruit, and fruits/plant. Maximum genetic distance of 12.49 was observed between muskmelon and snakemelon. Longmelon and snapmelon were the closest (D^2 = 0.38). Muskmelon and longmelon were also placed distantly (D^2 = 9.16) followed by muskmelon and snapmelon (D^2 = 8.79). Fruits/plant contributed maximum to total divergence (80.0%). Seeds/fruit did not contribute to total divergence. They found that selection of botanical varieties based on fruits/plant would be logical in selection of divergent parents.

D. Combining ability

In heterosis breeding programme, the concept of combining ability is very important. Combining ability is the ability to produce superior hybrids in combination with other inbreds. General combining ability is the average performance of a strain in a series of crosses. Specific combining ability is the deviation from performance predicted on the basis of general combining ability.

Brar and Sukhija (1977) in a line x tester analysis in watermelon with 10 male parents and two female parents, involving four characters, viz. yield/plant, fruit number, fruit weight and TSS. The variance due to general combining ability was higher than that due to specific combining ability of males and females for all characters. The crosses exhibiting high specific combining ability for yield also had high or average combining ability for yield components. The crosses showing high specific combining ability involved at least one high general combining parents and in no case low x low combiners was at the top. The crosses exhibiting high specific combining ability for yield also had high or average combining ability for one out of two yield components.

Sirohi and Chaudhary (1977) undertook a detailed investigation in a group of eight genetically diverse lines of bittergourd and found significant general combining ability effects in four for vine length and seed weight, five for fruit length, fruit weight and total yield/plant, three for fruit diameter flesh thickness and fruits/plant, and two for seeds/fruit. The parent Pusa Do Mousmi had the highest gca effects for total yield/plant and high gca effects for weight, length and diameter of fruits, vine length, seeds/fruit and seed weight/fruit. Among the 28 hybrids, 14 for vine length, seven for fruit weight, 12 for fruit diameter, 13 for flesh thickness, 16 for fruits/plant, 10 for fruit weight, nine for seeds/fruit, six for seed weight/fruit and 18 for total yield/ plant showed significant sca effects. It was observed that

The present investigation was therefore formulated with the following objectives.

a. To study the extent of genetic divergence in snakegourd.

b. To find out the combining ability of the selected snakegourd genotypes.

c. To work out the extent of heterosis in snakegourd.

when either 1 or 2 of these parental lines having high gca effects for yield and its component characters were involved in the crosses, the F_1 hybrids gave the best performance.

Bhagchandani et al. (1980) made combining ability studies in a 5 x 5 diallel cross in summer squash for vine length, branches, fruits and yield/plant. Additive gene effect was responsible for vine length, whereas non-additive for yield. However, additive and non-additive effects were prevalent for branches as well as fruits/plant. Vegetable marrow x Early Yellow Prolific was the best combiner followed by Vegetable marrow x Si-Pl-8. Fruits per plant was found to be the major component of yield.

Nandpuri et al. (1983) in a combining ability study involving three female and 10 male parents of muskmelon found that Arka Rajhans and Hara Madhu were the best combiners for weight/fruit. Pusa Sharbati was the best combiner for transmitting earliness to the F_1 hybrids. Hara Madhu was the best combiner for transmitting high TSS to the F_1 hybrids. As regards the gca effects of the female parents, functional male sterile line, FM S_{1-2} was the best combiner for fruit weight. The male sterile line, MS_1 was the best combiner for sweetness (TSS) of fruits. With regard to the sca effects, the combination FM S_{1-2} x Edisto had the highest combining ability effect for fruit yield/vine. Taking into consideration the overall performance, it was found that the cross combination FM S_{1-2} x Sarada was the best. MS_1 x Hara Madhu was the best F_1 hybrid for yield and TSS, while MS_1 x Pusa Sharbati for TSS and earliness.

Pal et al. (1983) in a Line x Tester analysis with five lines and two testers in bittergourd, observed that the parents showed relatively higher gca for days to female flower formation and fruits/plant Higher variances and sca were exhibited by node to first female flower, days to maturity, fruit yield, fruit size, fruit weight and fruit cavity size. The phenotypically superior parent Monsoon Miracle was the best general combiner for fruit yield, fruit weight, fruit size and fruit cavity size. In a few combinations like Monsoon Miracle x Holly Green, The Largest x Indian Prime and China x Indian Prime the absolute value of sca effets were negative indicating that the hybrids can be exploited for earliness. In spite of high sca effects some of the hybrids were not heterotic, whereas heterosis was exhibited by three other hybrids having no marked sca effects.

Chaudhary (1987) studied a 11 parental diallel in bittergourd and observed that the gca and sca variances were significant for all the 13 characters studied. The variances due to gca were consistently greater than the sca variances for all the characters The parents Coimbatore Long Hissar

Selection and Khandesh Mali were the best combiner since they made significant contributions towards yield contributing characters as evidenced by their high gca effects.

Lawande and Patil (1989) in a cross involving 11 inbreds of bittergourd found that the crosses Green Long x Co-2 White long, Co_1 Green x Hissar Selection, Hissar Selection x Green Long, Co_1 Green x Green Long and Green Long x Delhi Local which were heterotic also produced higher yield than that of better parent, Green Long. When the observations on heterosis and sca effects of hybrids were considered it revealed general that the crosses with high heterosis displayed high sca effects. It was also observed that the cross combinations which were having high mean values were derived from parents having high sca. Nearly 80.0% crosses which were having better F_1 mean, involved at least one parent with high gca.

Vahab (1989) in a 10 x 10 diallel in bittergourd found that the gca and sca variances were highly significant for days to first female flower opening during the three seasons. MC-49 and MC-34 had the highest negative gca effect during first and third seasons indicating earlier flowering. MC-79 had the highest gca effect for female flowers/plant for three seasons. Priya ranked first in gca effect in yield/plant, followed by MC-66 and MC-78. The crosses, Arka Harit x MC-49, Arka Harit x MC-79, MC-78 x NC-79 and MC-34 had higher values of sca effects in the first season. Arka Harit x MC-79, MC-82 x MC-79 and Priya x MC-49 in the second and MC-82 x MC-79, MC-78 x MC-66, MC-49 x MC-34, Arka Harit x MC-34 and Priya x MC-78 in the third season had higher values of sca effect. For fruits/plant MC-79 had the highest and consistent values of gca effects followed by MC-82 and MC-66. The cross Arka Harit x MC-79 had highest sca effect in the first season. Other crosses with high sca effects were MC-49 x MC-34, MC-78 x MC-66, MC-78 x MC-49, in the first, MC-78 x MC-79, Arka Harit x MC-79, Arka Harit x MC-69 and MC-49 x MC-34 in the second and MC-82 x MC-79 and Arka Harit x MC-34 in the third season.

E. Heterosis

The term heterosis refers to the phenomenon in which the F_1, obtained by crossing of the two genetically dissimilar gametes or individuals, shows increased or decreased vigour over the better parent or over the mid-parental value. Heterosis was first noted in cucurbits by Hayes and Jones (1916) in cucumber. Several workers reported heterosis for different traits in cucurbits.

Pal Singh (1946) in a study involving five diverse lines of bittergourd observed heterobeltiosis for male and female flowers, main vine length, fruit size and total yield/ plant. Higher increase in fruits/plant was observed in hybrids between small fruited varieties than hybrids between long fruited varieties. In a few crosses there were negative heterosis. In the case of yield, all except a few showed striking increase over the better parent. In a cross between Dlehi Local x Panipat Local, the percentage increase over better parent was as high as 191.3. In the two seasons tested, the performance of the hybrid in the hot season was significantly better than in rainy season. The hybrid between Panipat Local x Ambala Local gave consistently higher yield as compared to other hybrids. There was distinct differences in the reciprocal crosses for all the characters studied.

Aiyadurai (1951) observed heterosis in bettergourd for earliness, fruits/plant, fruit size, fruit flesh thickness and total yield. The F_1's were intermediate for vine length. Aggarwal et al. (1957) crossed wild types of bittergourd with cultivated varieties and observed intermediate performance for earliness, vine length, female flowers, fruits and yield/plant.

Srivastava (1970) in his attempt to exploit heterosis in bittergourd found that as much as 45 out of 90 F_1 hybrids produced female flowers significantly earlier than the better parents and concluded that days to female flower formation could be reduced to 16.7% from that of the parents. He also observed 64.0% heterobeltiosis for yield. Significant increase was also observed in hybrids for fruit length, fruit girth, fruit weight and fruits/plant.

Kohle (1972) examined hybrid vigour for yield in six hybrids selected from various cross combinations of six parents - MP-14, Bihar-15, Coimbatore-16, Jamner-21, Mulshi-26 and a Local of bittergourd. None of these hybrids possessed standard heterosis. However the cross B-15 x Jamner-21 showed a heterobeltiosis of 2.4% and 29.71% (over mid-parent).

Tyagi (1973) in bottlegourd found that all crosses showed significant heterosis for number of female flowers over mean of parents. The maximum heterosis of 84.52% and 69.06% was exhibited by the cross 5414 x 6106 over the mean of the parents and superior parents respectively. For number of fruits, the crosses 5309 x Type I, Type x 6022, 5717 x Type 1, 5604 x 5728, 5713 x 5604, 5902 x 5716 and 5927 x 5902 showed positive heterosis for number of fruits over superior parent but the maximum significant increase of 33.33% was exhibited by the cross Type I x 6022 over mean of the parents. In case of weight of fruits, the percentage increase in F_1 over superior parent varied between 3.04-13.64. Cross Type I x 6022 showed significant heterosis for weight of fruits over better parents. The maximum heterosis of 38.29 and 13.64% for weight of fruits was manifested by cross Type I x 6022 over mean of parents as well as superior parent. The number of seeds in F_1 over superior parent ranged from 1.10-2.10%.

Lal <u>et al</u>. (1976) in bittergourd isolated two hybrids, Green Local x White Local and Green Local x Bundelkhand Local which were heterotic for vegetative growth, floral characters and fruit yield. They observed heterosis for internodal length, petiole length, leaf length, leaf width, branches/ plant, shoot length, fruits/plant, length, girth and weight of fruits and total yield. In total yield, Green Local x White Local gave 139.1% increase over better parent whereas it was only 35.2% in the hybrid Green Local x Bundelkhand Local. In the case of days to flower, there was 7.02% negative heterosis in the hybrid, Green Local x Bundelkhand Local.

Sirohi and Chaudhary (1978) developed 28 F_1 hybrids using eight diverse lines of bittergourd and observed that when either one or two of these parental lines having high gca effects for yield and its component characters were involved in the crosses, the F_1 hybrid gave the best performance. Among the 28 hybrids, crosses between Pusa Do Mausmi x S-144, Pusa Do Mausmi x S-63 and Coimbatore Long x S-63 appeared the best performing for total yield/plant and its component characters and they showed 84.10%, 72.00% and 45.46% higher yield respectively than the top parent, Pusa Do Mausmi. Singh and Joshi (1979) studied a five parental diallel cross of bittergourd. Heterobeltiosis ranged from 2.1 to 22.3% for plant height and 7.8 to 37.1% for primary branches/plant. Fruit length registeredl significant heterobeltiosis in BWMI x Coimbatore Long having 29.9% heterobeltiosis. Crosses BWMI x BWLI and BWLI x BSI had significantly more fruits/plant with 13.7 and 34.4% heterobeltiosis respectively.

More and Seshadri (1980) made heterotic study between one monoecious female parent and 20 andro-monoecious male lines in muskmelon. Maximum heterosis was observed in H-7 (8.68%) followed by H-5 (6.82%) for earliness in the 1976 trial. In 1977 trial, H-49 was the topmost hybrid in respect of earliness (9.5%). In the case of number of fruits/plant, maximum heterosis was 29.55% in H-24 followed by H-37 (22.95%) and H-49 (20.7%). The maximum percentage of increased yield over better parent recorded was 109.44 in H-15, 90.96 in H-2 and 89.5 in H-18. In the case of TSS the hybrid H-48 showed heterosis of 52.78% followed by H-49 (52.70%).

Kale and Seshadri (1981) in watermelon observed significant heterosis for percentage early yield, 33.33% for number of marketable fruits, 80.00% for marketable yield, 53.33% for average fruit weight, 26.67% for percentage rind with inedible flesh, 20% for TSS content and 13.33% for weight of seeds.

Doijode and Sulladmath (1982) in pumpkin found that the heterosis for vine ranged from -19.3% (IHR-6 x Arka Chandan) to 59.0% (IHR-83 x CM-12) over their corresponding mid-parental values. Only two crosses, viz. IHR-83 x CM-12 and IHR-9 x CM-12 exhibited significant heterosis over better parent. Node at which first female flower formed recorded -20.3% in IHR-61 x IHR-8 to 11.7% in CM-37/9 x Arka Chandan heterosis over their respective mid-parents. Heterosis for female flowers ranged from -34.2% in CM-37/9 x Arka Chandan to 52.0% in IHR-83 x CM-12 over their mid-parents. The cross, IHR-83 x CM-12 had significant increase for female flowers/ plant.

Solanki et al. (1982) in cucumber, noticed pronounced heterosis in F_1 over better parent for primary branches/plant (25.26%), number of female flowers (50.95%) fruits harvested/ plant (42.12%) average fruit weight (33.33%) and for the fruits (83.8%).

Dixit and Kalloo (1983) in muskmelon noticed the extent of heterosis as 46.70% for yield, 54.30% for number of fruits, 39.70% for weight of fruits, 18.50% for thickness of flesh, -12.30% for length of cavity, -27.90% for width of cavity, 26.10 for TSS and -29.76 for node of first hermaphrodite flower. Crosses Pusa Sharbati x Sarada melon and Pusa Sharbati x Punjab Sunehari were heterotic for yield and Punjab Sunehari x Sel-1 and Arkajeet x Durgapura madhu for number of fruits.

Pal et al. (1983) in line x tester analysis with five lines and two testers examined the performance of hybrid vigour and its feasibility of exploitation in bittergourd. In all these combinations, manifestation of heterosis was very little as a whole. However, in some combinations like Monsoon

Miracle x Holly Green, The Largest x Indian Prime and China x Indian Prime, the absolute values were negative and high indicating the possibility of exploitation for earliness. It was suggested that the limited hybrid vigour in the crosses could be due to limited diversity among the parents. Srivastava and Nath (1983) observed heterosis for various characters in bittergourd. They observed significant reduction in days to opening of first female flower (0.3-16.7%). Out of 90 hybrids heterobeltiosis was observed in 35 for vine length (0.4-27.1%) and 40 for fruits/plant (0.2-47.2%). They also observed as much as 64.0% increased yield in the hybrids.

In bottlegourd, Pal et al. (1984) found heterosis even during seed germination. In the hybrids, the process started from 4-8th day, while in parent, it was from 6-15th dayi. The initial vigour of hybrids was lost during the seedling stage. At the reproductive stage heterosis was marked by earliness of flowering (11 days over better parent). Superiority of hybrids was noted in terms of flesh thickness (17.0-28.0% increase), which iis a useful attribute to this crop as it constitutes better quality fruits. The hybrids gave about 20.0% higher yield. The spread of harvest period in hybrids was more (65.0-71.0 days) as compared to parents.

Chaudhary (1987) in a 11 x 11 diallel analysis in bittergourd observed heterosis for various traits. He observed that the average performance of F_1 hybrids exceeded that of the parents by 26.32% in vine length, 22.00-98.00% for early female flower formation, 19.26% for early harvest and 1.26% for days to fruit set. For fruit characters, the figures exceeded 11.57% for length, 2.88% for diameter, 16.18% for flesh thickness, 2.12% for seeds/fruit, 5.89% for seed weight/fruit, 18.11% for fruits/plant, 25.32% for total yield/plant and 11.87% for TSS. Relative heterosis was maximum for yield/plant (276.43%) followed by fruits/plant (127.44%), fruit weight (121.45%), flesh thickness (118.74%) and fruit diameter (106.53%). Heterobeltiosis also was maximum for yield/plant (235.94%) followed by diameter (93.12%), fruit weight (85.7%) and flesh thickness (74.24%). The hybrids C-96 x Green bittergourd, Khandesh Mali x Green bittergourd, BG-114 x Coimbatore Long and Washin Local x BG-110 which recorded 53.03%, 24.40%, 12.32% and 10.45% heterosis respectively for yield over top parents. Khandesh Mali was the most promising.

Lawande and Patil (1989) in a 11 x 11 diallel in bittergourd fround that significant heterotic crosses were very few for average fruit weight, length and diameter of fruit. Crosses between Co_1 Green x Hissar Selection, Green Long x Co_2 White Long, Co_1 Green x Delhi Local, Co_1 Green x VK_1 Priya White and Hissar Selection x Green Long were very promising for yield, number of fruits, fruit weight and diameter of fruit. No significant heterosis was displayed for length except the cross Co_1 Green x Hissar Selection. Vahab (1989) in a 10 x 10 diallel in bittergourd found significant standard heterosis for earliness in the crosses MC-66 x MC-49 (-11.97%) and MC-49 x MC-34 (-13.28%) in the first and Arka Harit x MC-82 (-11.67%) in the third season. For percentage of female flowers, the standard heterosis was 7.91% in Priya x MC-49 and 7.1% in the cross MC-49 x MC-69. For yield, Arka Harit x MC-79 had high heterobeltiosis in the first and second seasons (117.7% and 43.09%). The crosses, MC-78 x MC-49 (40.76%), MC-49 x MC-34 (17.07%) in the first and MC-49 x MC-69 (37.83%) and Arka Harit x MC-79 (37.6%) in the second season were superior heterobeltiotic F_1 hybrids for fruits/ plant.

Materials and Methods

MATERIALS AND METHODS

The investigation was undertaken during the period from December, 1988 to December 1990 at the research plots of the Department of Olericulture, College of Horticulture, Vellanikkara. The experimental field is located at an altitude of 22.5 m above M.S.L. between 70° 32' N latitude and 76° 16' E longitude. The area enjoys a warm humid tropical climate. The experimental site has a sandy loam soil with a pH of 5.1. The whole experiment consisted of three parts.

A. Assessment of variability and divergence and grouping of genotypes based on D^2 values

B. Assessment of combining ability of parents

C. Crossing and evaluation of hybrid vigour

A. Assessment of variability and divergence and grouping of genotypes based on D^2 values

1. Assessment of genetic variability, heritability and genetic advance

a. Experimental materials

The experimental material consisted of 48 snakegourd genotypes. This included genotypes maintained in the department of Olericulture, College of Horticulture and others collected

Table 1. Morphological description of 48 snakegourd genotypes with source

Accession Number	Number in TA series	Origin	Petiole length	Types of lobes or lamina type	Lamina tip	Fruit colour	Fruit length
1	2	3	4	5	6	7	8
1	69	Piravom	Small	Medium	blunt	White	Medium
2	70	Malappuram	Long	Shallow	pointed	Green with white stripes	Short
3	102	Kasaragod	Medium	Deep	pointed	White	Short
4	39	Karivadi	Medium	Medium	pointed	Pale white	Short
5	44	Thavanur	Medium	Medium	pointed	Green with white stripes	Medium
6	32	Edapally	Medium	Medium	blunt	Pale white	Medium
7	30	Edapally	Medium	Medium	blunt	White	Short
8	20	Edapally	Medium	Medium	pointed	White	Long
9	34	Vandazhi	Small	Medium	blunt	White	Medium
10	71	Malappuram	Long	Medium	pointed	White	Medium
11	72	Wynad	Long	Shallow	pointed	White with pale green stripes at stylar ends	Medium
12	73	Pilicode	Medium	Medium	pointed	Green with white stripes	Long
13	74	Tamilnadu	Medium	Shallow	pointed	Green with white stripes, on the green area white specks	Short
14	75	Pilicode	Medium	Shallow	pointed	White with pale green stripes	Medium
15	56	Malappuram	Small	Medium	pointed	White	Short
16	76	Piravom	Long	Shallow	pointed	White	Long
17	77	Pilicode	Medium	Shallow	pointed	White, pale green colour at stylar end	Long
18	78	Malappuram	Long	Medium	pointed	Green with white stripes	Short
19	79	Tamilnadu	Medium	Deep	pointed	White with ash coloured short stripes	Short
20	80	Wynad	Long	Medium	pointed	White	Medium
21	81	Pilicode	Medium	Shallow	pointed	Green with white stripes	Short
22	82	Wynad	Medium	Shallow	pointed	Green with white stripes	Short
23	83	Pilicode	Long	Shallow	pointed	White with light green stripes	Long
24	37	Palghat	Medium	Medium	pointed	Green with white stripes	Short

Contd.

Table 1 (contd.)

1	2	3	4	5	6	7	8
25	84	Tamilnadu	Long	Medium	pointed	Green with white stripes	Long
26	85	Wynad	Medium	Medium	pointed	Green with white stripes	Medium
27	86	Vellayani	Medium	Medium	pointed	White with non-continuous pale green stripes	Medium
28	41	Kuttippuram	Medium	Deep	pointed	White	Short
29	87	Chenkal	Medium	Medium	pointed	Green with white stripes	Medium
30	88	Kalpetta	Medium	Shallow	pointed	White with ashy spots	Medium
31	89	Pilicode	Medium	Medium	pointed	White with short pale green stripes	Long
32	19	Thrissur	Medium	Shallow	blunt	Green with white stripes	Medium
33	90	Aluva	Small	Shallow	pointed	White	Medium
34	91	Manantody	Medium	Shallow	pointed	Green with white stripes	Medium
35	55	Thrissur	Medium	Medium	pointed	Green with white stripes	Medium
36	92	Kalpetta	Medium	Shallow	pointed	White with short green stripes	Medium
37	93	Pilicode	Long	Medium	pointed	Pale white with irregular pale green stripes	Medium
38	45	Nilambur	Medium	Shallow	pointed	White with pale green stripes	Medium
39	94	Andhra Pradesh	Medium	Deep	pointed	White with ashy spots	Medium
40	95	Pilicode	Small	Medium	pointed	White with pale green lines	Medium
41	43	Thrissur	Medium	Shallow	Pointed	Green with white stripes and specks	Short
42	96	Wynad	Long	Shallow	pointed	White	Very long
43	97	Tamilnadu	Long	Medium	pointed	Green with white stripes	Long
44	98	Malappuram	Medium	Shallow	pointed	Green with white stripes	Long
45	99	Andhra Pradesh	Medium	Shallow	pointed	White with ashy specks	Short
46	32	Edapally	Medium	Shallow	pointed	Dark green with white stripes	Medium
47	100	Balaramapuram	Small	Deep	pointed	White	Long
48	101	Pilicode	Long	Shallow	pointed	Green with white stripes	Very long

from various parts of South India. The source and morphological description of the genotypes are presented in Table 1 and Plate I.

The 48 genotypes were grown in a randomised block design with two replications during December, 1988 to April, 1989. There were three pits/replication and one plant/pit was retained. The spacing adopted was 2.0 x 2.0 m. The cultural practices, plant protection measures and fertilizer applications were adopted according to the package of practices recommendations of Kerala Agricultural University (1986).

b. Observations recorded

The quantitative and qualitative characters observed were as follows. All the plants were considered for observations.

(i) Main vine length (cm)

The plants were pulled out after the last harvest and the length was measured from the collar region to the tip of the main vine.

(ii) Primary branches/plant

The number of branches originating from the main vine were recorded, after the plants were pulled out.

(iii) Days to first male flower anthesis

The number of days were counted from the date of germination to the date when the first male flower opened.

(iv) Days to first female flower opening

The number of days were counted from the date of germination to the date when the first female flower opened.

(v) Node at which first female flower appeared

The nodes were counted from the lowest to the one at which first female flower opened.

(vi) Male flowers/plant

The averages of male flowers of six inflorescences each from the man branch, secondary branches and tertiary branches were taken and multiplied by the total number of inflorescences.

(vii) Female flowers/plant

The number of female flowers opening daily were counted and finally added together.

(viii) Sex ratio

This was calculated as a ratio of the number of male flowers to female flowers/plant.

(ix) Nodes on main vine

The number is counted from the base of the vine to the tip of the vine, after the plants were pulled out.

(x) Fruiting nodes on main vine

This was counted after the plants were pulled out by noting the number of fruit stalks remaining on the main vine.

(xi) Days to fruit maturity

The number of days were counted from the date of opening of the female flower to the date of harvesting of the fruits and from each plant , first six fruits harvested were used for this.

(xii) Days to first fruit picking maturity

Number of days were counted from the date of germination to the date of first harvest of fruits.

(xiii) Yield/plant (g)

The total weight of all the harvested fruits from each plants were recorded.

(xiv) Fruits/plant

The number of fruits in each plant was counted as and when the fruits were harvested and finally added together.

(xv) Fruit length (cm)

The length of first six fruits harvested from each plant was recorded and the average worked out.

(xvi) Fruit girth (cm)

Girth at the middle of first six fruits from each plant was recorded and the average worked out.

(xvii) Flesh thickness (cm)

Observations were taken from the first six fruits harvested from each plant. Each fruit was cut at the middle and the flesh thickness was measured with a common scale.

(xviii) Seeds/fruit

Seeds/fruit were counted from the first six fruits harvested from every plant and the average worked out.

(xix) Seed weight/fruit (g)

The seed weight/fruit was recorded from the last six fruits harvested from every plant and the average was worked out.

(xx) 100 seed weight (g)

Weight of 100 seeds from each plant was recorded.

(xxi) Average fruit weight (g)

The weight of first six fruits harvested from each plant was recorded and the average was worked out.

(xxii) Total crop duration

The number of days were counted from the date of germination to the date of final harvest of fruits.

For estimating the following chemical constituents of fruit, one fruit/plant was taken at the time of second harvesting.

(xxiii) Vitamin C content of fruit (mg/100 g)

Samples were taken from the middle portion of fruits and macerated in pestle and mortar, adding two per cent metaphosphoric acid solution and vitamin C content was estimated by the 2,6-dichlorophenol indophenol visual titration method (A.O.A.C., 1960).

(xxiv) Crude fibre content of fruit (%)

One gram of the dried and powdered flesh of the fruit was extracted with 1.25% H_2SO_4 and then with 1.25% NaOH. The residue was then washed with acetone to estimate the crude fibre content (Chopra and Kanwar, 1976).

(xxv) Crude protein content of fruit (%)

The sample consisted of 0.1 g of the dried and powdered fruit and nitrogen content was estimated by microkjeldahl method. The protein content was calculated by multiplying the value of nitrogen by 6.25 and the resulting value was expressed in gram per 100 g of fruit on dry weight basis (Jackson, 1958).

c. Statistical analysis

(i) Analysis of variance

Analysis of variance for RBD in respect of the various characters was done as per Panse and Sukhatme (1957). The break-up of the total variance is given in the Table 2.

Table 2. Analysis of variance of the design

Source of variation	df	M.S. observed	Expected
Total	95		
Replications	1	M_1	
Genotypes	47	M_2	Error variance + (number of replications x genotypic variance)
Error	47	M_3	Error variance

(ii) Estimation of variability, heritability and genetic advance

Variability existed in the population for various characters were estimated by the method suggested by Burton (1952).

The formulae used were;

Genotypic coefficient of variation (gcv)

$$= \frac{\text{Genotypic standard deviation}}{\text{Mean of the character under study}} \times 100$$

Phenotypic coefficient of variation (pcv)

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

Environmental coefficient of variation (ecv)

$$= \frac{\text{Environmental standard deviation}}{\text{Mean of the character under study}} \times 100$$

Standard error of mean

$$= \frac{\text{Environmental standard deviation}}{\sqrt{\text{Number of replications}}} \times 100$$

The genotypic, phenotypic and environmental standard deviations were obtained as square root of the respective variances which were determined using the following formulae.

$$\text{Genotypic variance} = \frac{M_2 - M_3}{\text{Number of replications}}$$

Phenotypic variance = Genotypic variance + Error variance

M_3 = Error variance

M_2 = Error variance + Number of replications x Genotypic variance

Heritability $[h^2(b)]$

Heritability in broad sense was estimated by the formula suggested by Burton (1952),

$$h^2(b) = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}}$$

Expected genetic advance

The genetic advance of the genotypes at 5% selection pressure was calculated using the formula suggested by Lush (1949) and Johnson *et al*. (1955).

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

where,

'σp' refers to phenotypic standard deviation and 'i' intensity of selection having a value of 2.06 as given by Allard (1960).

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

2. Assessment of genetic divergence and grouping of genotypes

The genetic distances among 48 snakegourd genotypes were assessed by determining Mahalanobis D^2 (Mahalanobis, 1928) values between every pair using 25 quantitative characters.

The D^2 value between genotypes k and l was determined as follows,

$$D^2 = \sum_{ij=1}^{p} W^{ij} (X_i^k - X_i^l)(X_j^k - X_j^l), \text{ where}$$

W^{ij} is the i, j^{th} element of the inverse of the estimated variance-covariance matrix.

X_i^k is the observation on the i^{th} character of k^{th} genotype, i = 1, 2, ..., 25

k = 1, 2, ..., 48

The square root of D^2 value was calculated to obtain generalised statistical distance between two genotypes.

All the genotypes were grouped into a number of clusters by the computer oriented iterative (check whether) algorithm, proposed by Suresh (1986) as follows.

(i) The two genotypes having maximum D^2 value between them were identified and they were termed nuclei of two clusters.

(ii) Each genotype was considered in turn and allocated to the clusters for which it's D^2 value with the nucleus genotype was minimum.

(iii) To increase the number of clusters by one the maximum D^2 within the above two clusters was found and the genotypes having maximum D^2 value were considered as the nuclei in addition to the nucleus genotype of the remaining clusters. The genotypes were re-assigned as in (ii).

The initial clusters thus obtained were further optimised using the iterative algorithm as described below.

(i) Numbered the genotypes from 1-48 where there are 48 genotypes.

(ii) Took out genotype number 1 from the cluster to which it was allocated and calculated the average D^2 values between the genotypes and each cluster.

(iii) Allocated the genotype to the cluster for which the average D^2 value was minimum. Repeated (ii) for all genotypes numbered from 1-48. With the clustering obtained in step (iii), a second iteration may be started, if necessary.

The iterations were continued till two successive iterations ended up with the same configuration of clusters. The genotypes were grouped into 10 clusters.

B. Assessment of combining ability of parents

This part of the experiment (line x tester analysis) was conducted during September-December, 1990, owing to non-germination of a few F_1's, thus rendering it not being able to estimate the combining ability of parents from the data obtained during the crop grown from February to May, 1990.

1. Experimental materials

For assessment of combining ability of the parents, three testers and eight lines were used. The genotypes used as testers were TA-99 (P_1), TA-70 (P_2) and TA-41 (P_4). The genotypes used as lines were TA-77 (P_5), TA-19 (P_6), TA-30 (P_8), TA-82 (P_9), TA-102 (P_{10}), TA-100 (P_{11}), TA-87 (P_{12}) and TA-89 (P_{13}). The parents along with 24 F_1's were evaluated in a randomised block design with two replications. There were three pits/replication with one plant/pit. The cultural practices, plant protection measures and fertilizer application were same as in part A.

2. Observations recorded

Observations were recorded on main vine length, primary branches/plant, days to first male flower anthesis, days to first female flower opening male flowers/plant, female flowers/plant, sex ratio, nodes on main vine, fruiting nodes on main vine, days to fruit maturity, days to first fruit picking maturity, yield/plant (kg), fruits/plant, fruit length, fruit girth, flesh thickness, seeds/fruit, average fruit weight and total crop duration.

3. Statistical analysis

The method outlined by Kempthorne (1957) for covariance of half sibs and full sibs was used for obtaining estimates of general and specific combining effects and variances.

a. Gca effect of the i^{th} line was estimated by,

$$gi = \frac{Xi..}{tr} - \frac{X...}{ltr}$$

where,

l = number of lines

t = number of testers

r = number of replications

b. Gca effect of the j^{th} tester was estimated by,

$$gj = \frac{X.j.}{lr} - \frac{X...}{ltr}$$

c. Sca effect of i^{th} line and j^{th} tester was estimated by,

$$Sij = \frac{Xij}{r} - \frac{Xi..}{tr} - \frac{X.j.}{lr} + \frac{X...}{ltr}$$

C. Crossing and evaluation of hybrid vigour

1. Experimental materials

From the original germplasm, 13 parents were selected based on genetic variability and overall performance (Plates II-XIV). The selected parents were TA-99 (P_1), TA-70 (P_2), TA-55 (P_3), TA-41 (P_4), TA-77 (P_5), TA-19 (P_6), TA-84 (P_7), TA-30 (P_8), TA-82 (P_9), TA-102 (P_{10}), TA-100 (P_{11}), TA-87 (P_{12}) and TA-89 (P_{13}). These parents were selfed for one generation. The selfed parents were crossed in a 13 x 13 diallel excluding reciprocals during September, 1989-January, 1990. These parents along with their F_1's were evaluated during February-May, 1990. The design used was same as that for part A. All field operations were also the same.

2. Observations recorded

Observations were recorded as in Part B.

3. Statistical analysis

Magnitude of heterosis was calculated in terms of three parameters. Heterosis over mid-parent (Relative heterosis), better parent (Heterobeltiosis) and standard variety (Standard heterosis) were worked as suggested by Briggle (1963) and Hayes et al. (1965).

Plate I Variability in snakegourd genotypes

Plate II P_1 (TA-99)

Plate I

Plate II

Plate III P_2 (TA-70)

Plate IV P_3 (TA-55)

Plate III

Plate IV

Plate V P_4 (TA-41)

Plate VI P_5 (TA-77)

Plate V

Plate VI

Plate VII P_6 (TA-19)

Plate VIII P_7 (TA-84)

Plate VII

Plate VIII

Plate VII

Plate VIII

Plate IX P_8 (TA-30)

Plate X P_9 (TA-82)

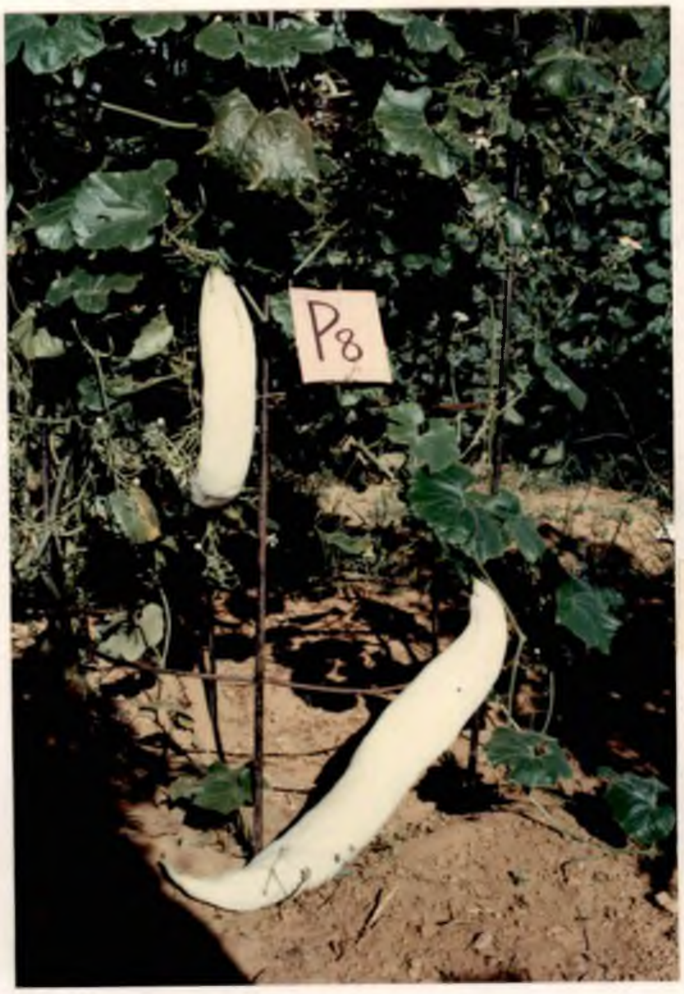


Plate IX

Plate X

Plate XI P_{10} (TA-102)

Plate XII P_{11} (TA-100)

Plate XI

Plate XII

Plate XIII P_{12} (TA-87)

Plate XIV P_{13} (TA-89)

Plate XIII

Plate XIV

a. Relative heterosis $= \frac{F_1 - MP}{MP} \times 100$, where F_1 and MP are the average performance of the F_1 and mid-parental value respectively.

b. Heterobeltiosis $= \frac{F_1 - BP}{BP} \times 100$, where BP = average performance of better parent

c. Standard heterosis $= \frac{F - \text{Check variety}}{\text{Check variety}} \times 100$

Check variety denotes the average performance of the check variety, TA-19.

For testing heterosis over mid parents,

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

$$CD = SE \times t$$

and over better parent and top parent

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

$$CD = SE \times t$$

Ve = Error mean square in RBD

r = Number of replications

CD = Critical difference

Results

RESULTS

The results of the experiments are presented under the following heads.

A. Assessment of variability and divergence and grouping of genotypes based on D^2 values

1. Assessment of genetic variability, heritability and genetic advance

The analysis of variance with respect to 25 quantitative characters in 48 snakegourd genotypes indicated that the genotypic variances were significant for all characters studied (Appendix - I). Variability and magnitude of various biometric characters and genetic parameters are presented in Tables 3 and 4 respectively. The mean performance of genotypes are presented in Tables 5a-5c.

a. Main vine length

Main vine length ranged from 303.5 cm to 785.0 cm. The genotype TA-99 had the shortest and TA-70 the longest vines. The genotypic and phenotypic coefficients of variation were 19.52 and 19.85 respectively. The broad sense heritability was 97.0%. The genetic gain was moderate (39.55%).

Table 3. Variability for different characters among 48 snakegourd genotypes

Characters	Range				Mean
	Minimum	Accession No. (TA series)	Maximum	Accession No. (TA series)	
1. Main vine length (cm)	303.50	99	785.00	70	511.39 ± 12.92
2. Primary branches/plant	7.50	87	17.50	19	10.89 ± 0.52
3. Days to first male flower anthesis	27.50	19, 82	45.00	71	33.94 ± 0.91
4. Days to first female flower opening	33.50	82	65.00	84	41.52 ± 1.64
5. Node at which first female flower appeared	11.70	102	26.00	70	18.45 ± 0.55
6. Male flowers/plant	2440.00	41	15000.00	80	5624.23 ± 91.27
7. Female flowers/plant	63.00	45	130.00	94	85.53 ± 8.17
8. Sex ratio	30.00	83	150.00	80	67.29 ± 0.96
9. Nodes on main vine	31.00	83, 99	66.00	70	40.82 ± 2.07
10. Fruiting nodes on main vine	0.00	43, 70, 91, 97, 101	4.00	41	1.45 ± 0.314
11. Days to fruit maturity	10.00	70, 73, 82, 91, 95, 102	16.00	55, 100	12.79 ± 0.28
12. Days to first fruit picking maturity	43.50	82	81.00	84	55.08 ± 1.61
13. Yield/plant (g)	7330.00	96	20230.00	94	10884.16 ±680.67
14. Fruits/plant	11.00	71	57.50	94	24.43 ± 0.37
15. Fruit length (cm)	30.10	56	116.00	96	61.10 ± 2.22
16. Fruit girth (cm)	12.00	97	29.35	70	19.07 ± 0.85
17. Flesh thickness (cm)	0.60	32	1.00	71	0.76 ± 0.24
18. Seeds/fruit	30.00	55	72.50	19	46.88 ± 3.23
19. Seed weight/fruit (g)	7.50	82	18.86	82	14.12 ± 1.06
20. 100 seed weight (g)	20.00	82	41.00	73	30.30 ± 0.48
21. Average fruit weight (g)	300.00	82	900.00	71	537.76 ± 20.07
22. Total crop duration (days)	95.00	77	140.00	32, 71	118.95 ± 0.29
23. Vitamin C content of fruit (mg/100 g)	13.00	69	31.20	79, 102	19.64 ± 0.25
24. Crude fibre content of fruit (%)	25.00	34	71.80	94	40.37 ± 0.52
25. Crude protein content of fruit (%)	8.75	80	48.12	55	26.98 ± 0.28

Table 4. Genotypic, phenotypic and environmental coefficients of variation, heritability, genetic advance and genetic gain

	Characters	gcv	Pcv	ecv	$[h^2(b)]$	ga	gg
1.	Main vine length	19.52	19.85	3.57	0.970	202.290	39.55
2.	Primary branches/plant	20.95	22.01	6.75	0.910	4.470	41.07
3.	Days to first male flower anthesis	9.39	10.13	3.80	0.860	6.090	17.93
4.	Days to first female flower opening	13.93	15.01	5.59	0.860	11.060	26.64
5.	Node at which first female flower appeared	20.41	20.84	4.20	0.960	7.600	41.18
6.	Male flowers/plant	47.49	47.55	2.30	0.990	47.490	97.95
7.	Female flowers/plant	17.12	21.81	13.51	0.620	23.670	27.67
8.	Sex ratio	45.61	45.65	2.03	0.990	63.160	93.86
9.	Nodes on main vine	15.93	17.47	7.18	0.830	12.220	29.95
10.	Fruiting nodes on main vine	62.99	70.05	30.65	0.810	1.690	116.57
11.	Days to fruit maturity	12.09	12.46	3.04	0.940	3.090	24.15
12.	Days to first fruit picking maturity	11.19	11.93	4.14	0.880	11.910	21.62
13.	Yield/plant	30.06	31.33	8.84	0.920	31.330	0.29
14.	Fruits/plant	38.93	39.99	9.11	0.950	19.070	78.08
15.	Fruit length	32.15	32.52	5.14	0.975	39.570	0.84
16.	Fruit girth	20.26	21.23	6.34	0.910	7.600	39.84
17.	Flesh thickness	13.09	13.73	4.14	0.909	0.196	25.71
18.	Seeds/fruit	18.74	21.13	9.74	0.787	16.060	34.26
19.	Seed weight/fruit	27.87	29.81	10.59	0.873	7.580	53.66
20.	100 seed weight	15.25	15.92	2.24	0.978	9.420	31.10
21.	Average fruit weight	24.62	25.05	5.28	0.954	259.160	48.19
22.	Total crop duration	9.24	9.25	0.34	0.998	22.670	19.02
23.	Vitamin C content of fruit	25.56	26.62	1.81	0.995	10.720	54.57
24.	Crude fibre content of fruit	26.25	26.31	1.84	0.995	21.780	53.95
25.	Crude protein content of fruit	33.66	33.69	1.49	0.998	18.690	69.26

Table 5a. Mean performance of 48 snakegourd genotypes for various characters

Accession number (TA-series)	Main vine length (cm)	Primary branches/ plant	Days to first male flower anthesis	Days to first female flower opening	Node at which first female flower appeared	Male flowers/ plant	Female flowers/ plant	Sex ratio
1	2	3	4	5	6	7	8	9
69	415.0	7.75	31.5	39.0	13.8	2575.0	90.0	34.0
70	785.0	16.35	39.0	46.8	26.0	6460.0	90.0	71.0
102	452.5	11.65	35.0	37.5	11.7	6750.0	68.3	57.0
39	422.5	10.00	34.0	36.0	12.0	3600.0	70.0	52.0
44	423.5	13.00	36.0	39.0	14.5	4420.0	80.0	55.0
32	435.0	9.85	32.5	36.5	13.0	3510.0	70.0	51.0
30	424.0	7.75	36.4	38.3	16.5	2711.0	80.0	33.5
20	500.0	9.00	32.0	40.0	18.0	3000.0	70.0	42.0
34	456.0	12.00	34.5	43.5	20.6	2750.0	75.0	36.0
71	745.0	11.00	45.0	46.0	18.0	9460.0	73.0	135.0
72	515.0	9.50	33.0	34.5	19.0	4350.0	65.0	67.0
73	655.0	9.00	32.5	41.5	16.8	3420.0	90.0	38.0
74	543.5	10.50	35.0	39.5	20.0	5228.0	90.0	90.0
75	648.5	13.00	31.5	36.5	18.5	4000.0	80.0	50.0
56	441.0	11.40	35.0	44.5	19.8	6750.0	90.0	75.0
76	540.0	13.50	30.5	41.0	12.0	6975.0	77.0	92.0
77	607.5	10.00	30.8	36.0	20.0	3600.0	75.0	48.0
78	435.0	9.00	41.5	50.0	12.0	9000.0	70.0	128.0
79	545.5	17.50	35.5	47.5	25.3	7800.0	87.0	90.0
80	470.0	9.00	35.0	45.0	15.0	15000.0	100.0	150.0

Contd.

Table 5a (contd.)

1	2	3	4	5	6	7	8	9
81	547.5	12.00	33.5	40.0	19.0	5400.0	100.0	54.0
82	450.0	14.00	27.5	33.5	22.0	3450.0	110.0	31.0
83	477.0	10.00	33.5	39.0	15.0	3000.0	100.0	30.0
37	485.0	12.25	35.0	40.0	23.5	9000.0	120.0	75.0
84	450.0	12.00	34.0	65.0	25.0	12000.0	90.0	130.0
85	470.0	9.00	30.0	38.8	15.0	5256.0	90.0	90.0
86	695.0	7.75	34.0	44.0	21.0	8225.0	90.0	91.0
41	475.0	8.50	34.0	36.0	17.0	2440.0	80.0	30.0
87	745.0	7.50	35.5	50.0	21.8	7787.0	90.0	86.0
88	480.0	9.50	34.0	44.0	17.0	3600.0	75.0	48.0
89	460.0	9.00	30.5	37.5	19.0	7290.0	110.0	65.5
19	585.0	12.00	27.5	40.0	21.0	5000.0	102.5	50.0
90	480.0	8.00	38.0	44.0	17.0	2780.0	80.0	34.0
91	474.5	11.50	39.0	46.0	16.5	6860.0	80.0	85.5
55	585.0	10.00	32.0	37.0	21.0	10500.0	90.0	122.0
92	492.5	8.00	38.0	45.0	14.0	6750.0	90.0	75.0
93	540.0	8.75	33.0	37.0	14.0	2980.0	72.0	41.0
45	455.0	8.50	32.5	37.5	15.0	6300.0	63.0	100.0
94	453.5	10.00	36.5	52.0	22.3	4960.0	130.0	38.0
95	505.0	10.00	29.5	38.0	17.0	3420.0	90.0	38.0
43	303.5	12.00	32.0	39.0	18.0	4830.0	120.0	40.0
96	655.0	12.00	36.0	44.5	22.5	2970.0	50.0	59.0
97	505.0	13.50	36.0	57.0	25.0	5400.0	60.0	90.0
98	555.0	12.50	36.0	40.0	22.0	5940.0	75.0	78.0
99	303.5	12.50	32.0	39.0	20.0	4830.0	120.0	40.0
32	495.0	15.00	30.0	36.5	20.0	8000.0	85.0	94.0
100	490.0	11.75	32.0	36.4	21.5	5015.0	77.5	59.5
101	475.0	14.50	31.5	38.0	21.5	4620.0	75.0	61.0

Table 5b. Mean performance of 48 snakegourd genotypes for yield and related characters

Accession number (TA-series)	Nodes on main vine	Fruiting nodes on main vine	Days to fruit maturity	Days to first fruit picking maturity	Yield/ plant (g)	Fruits/ plant	Fruit length (cm)	Fruit girth (cm)	Flesh thickness (cm)
1	2	3	4	5	6	7	8	9	10
69	42.0	1.50	15.0	55.0	11215.0	24.00	63.4	19.40	0.75
70	66.0	3.25	10.0	57.5	18720.0	29.50	41.0	29.35	0.98
102	50.0	1.50	10.0	53.5	18770.0	44.00	44.1	20.80	0.73
39	41.5	2.25	12.0	49.0	11445.0	24.50	39.0	21.00	0.80
44	36.5	1.00	14.0	55.5	13399.9	23.50	70.0	20.90	0.64
32	42.5	2.00	12.0	49.0	11499.0	19.25	53.2	22.00	0.89
30	45.0	2.50	12.0	54.0	14425.0	28.10	48.7	24.69	0.95
20	38.5	2.50	13.0	54.0	10210.0	25.00	66.5	22.00	0.78
34	33.0	0.50	14.0	55.5	16180.0	22.50	65.2	21.63	0.86
71	56.5	2.50	13.0	60.0	9700.0	11.00	50.0	31.00	1.00
72	33.0	1.00	14.0	55.0	11793.0	19.25	59.5	18.84	0.85
73	41.0	1.00	10.0	48.0	9364.9	23.00	79.2	13.45	0.63
74	43.0	2.50	12.0	50.0	6110.0	24.35	31.6	20.00	0.71
75	53.5	1.00	15.0	51.5	12625.0	33.25	62.8	17.25	0.71
56	41.5	1.00	12.0	61.0	10165.0	22.50	30.1	23.00	0.84
76	40.0	1.50	13.0	54.0	7900.0	13.50	92.5	21.30	0.76
77	33.5	3.00	14.0	52.0	10930.0	23.30	76.0	16.90	0.85
78	38.5	1.00	12.0	63.0	9050.0	11.00	45.0	27.00	0.95
79	35.0	1.00	12.0	60.0	9880.0	25.50	34.3	19.15	0.79
80	40.5	1.25	12.0	58.0	7525.0	12.00	65.0	20.20	0.84
81	43.0	3.50	12.0	51.0	7487.5	20.50	44.0	21.60	0.83
82	37.0	1.00	10.0	43.5	10175.0	42.50	32.5	16.90	0.70
83	31.0	2.00	13.0	55.0	16500.0	35.20	68.6	15.60	0.74

Contd.

Table 5b (contd.)

1	2	3	4	5	6	7	8	9	10
37	41.0	0.50	12.0	52.0	12795.0	37.00	36.5	21.00	0.78
84	36.0	0.00	14.0	81.0	7557.5	16.00	100.8	13.75	0.68
85	39.5	1.25	12.0	51.0	8786.5	20.00	51.9	17.15	0.85
86	52.5	2.50	14.0	58.5	11415.0	22.00	60.9	16.60	0.64
41	38.0	4.00	13.0	49.0	9750.0	34.00	37.1	22.05	0.77
87	54.0	1.50	14.0	63.0	9230.0	16.25	56.3	19.25	0.89
88	36.0	1.75	12.0	58.0	8930.0	22.50	63.5	18.25	0.91
89	33.5	2.00	13.0	53.5	14474.9	39.00	80.7	13.40	0.65
19	46.5	0.50	12.0	52.0	7515.0	15.00	55.3	22.00	0.77
90	40.0	1.00	12.0	58.5	7620.0	13.00	63.5	19.25	0.70
91	36.5	0.00	10.0	56.5	9062.5	21.00	60.2	16.85	0.69
55	43.0	2.00	16.0	53.0	12969.9	24.25	53.5	17.25	0.69
92	38.0	1.00	12.0	48.5	7975.0	15.50	75.0	16.50	0.68
93	37.5	0.50	14.0	50.5	10099.9	24.40	60.8	16.35	0.64
45	41.5	0.50	13.0	50.5	8797.5	20.35	58.1	19.00	0.87
94	37.5	2.50	12.0	65.0	20230.0	57.50	66.1	12.20	0.65
95	42.0	1.00	10.0	48.0	9837.5	27.50	66.2	15.65	0.775
43	39.5	0.00	13.0	52.0	7482.5	21.00	46.0	18.15	0.73
96	43.0	1.00	15.0	61.0	7330.0	16.00	116.0	16.10	0.70
97	41.5	0.00	14.0	71.5	6490.0	14.65	97.9	12.00	0.52
98	39.0	2.00	13.0	53.0	10935.0	25.50	77.3	18.75	0.80
99	31.0	0.50	12.0	55.0	11665.0	44.85	40.3	14.75	0.64
32	40.0	1.50	15.0	52.0	7745.0	17.50	63.5	16.50	0.60
100	34.0	0.00	16.0	53.0	15835.0	25.95	77.7	22.15	0.89
101	36.5	1.75	15.0	53.0	12840.0	24.50	106.0	16.50	0.78

Table 5c. Mean performance of 48 snakegourd genotypes for various characters

Accession number (TA-series)	Seeds/ fruit	Seed weight/ fruit (g)	100 seed weight (g)	Average fruit weight (g)	Total crop duration (days)	Vitamin C content of fruit (mg/100 g)	Crude fibre content of fruit (%)	Crude protein content of fruit (%)
1	2	3	4	5	6	7	8	9
69	47.20	14.76	31.35	602.0	104.0	13.0	43.0	17.50
70	61.75	15.93	26.00	665.0	130.0	20.0	40.0	43.75
102	58.65	15.28	26.10	518.0	125.0	31.2	42.0	17.50
39	50.00	15.75	31.50	425.0	130.0	15.0	35.0	26.25
44	46.30	12.24	26.80	581.9	105.0	15.0	27.0	35.00
32	69.75	18.45	28.50	610.0	127.0	14.8	35.0	26.25
30	56.63	18.67	33.15	608.5	110.0	26.0	51.0	35.00
20	50.00	12.50	25.00	493.5	106.0	23.4	45.0	26.25
34	40.73	13.61	33.65	808.5	118.0	25.0	25.0	8.75
71	35.00	8.58	24.50	900.0	140.0	30.0	37.0	26.25
72	35.50	10.15	28.25	488.5	114.5	15.0	27.0	17.50
73	42.50	17.45	41.00	600.0	125.0	22.0	40.0	35.00
74	51.75	16.06	31.00	395.0	99.0	15.0	29.0	17.50
75	44.75	16.80	35.00	525.0	105.0	20.0	47.0	26.25
56	48.80	15.54	31.85	465.0	113.0	14.9	34.0	21.87
76	45.00	15.30	34.00	580.0	120.0	20.0	35.0	17.50
77	51.00	15.30	30.00	470.5	95.0	16.7	33.0	30.63
78	50.00	14.13	28.25	755.0	122.0	19.7	40.0	35.00
79	40.05	8.41	21.00	440.0	100.0	31.2	45.0	21.87
80	42.50	14.19	33.80	675.0	120.0	22.0	42.0	8.75
81	56.00	18.86	33.65	435.0	98.0	15.0	29.0	35.00
82	37.50	7.50	20.00	300.0	105.0	26.0	45.0	35.00
83	44.45	12.28	28.90	571.0	115.0	26.0	50.0	17.50

Contd.

Table 5c (contd.)

1	2	3	4	5	6	7	8	9
37	62.00	16.12	26.00	438.5	124.0	29.6	60.0	26.25
84	44.65	12.98	28.50	466.5	140.0	23.4	60.0	35.00
85	60.00	18.21	30.35	447.5	120.0	17.0	40.0	35.00
86	44.60	15.16	34.00	702.5	125.0	15.0	31.0	17.50
41	49.00	12.25	25.00	372.5	105.0	23.4	50.0	35.00
87	33.00	9.48	28.65	689.5	125.0	15.0	31.0	17.50
88	56.50	16.13	29.00	475.0	120.0	18.0	37.0	17.50
89	36.00	12.60	35.00	515.0	125.0	15.0	32.0	35.00
19	72.50	14.85	20.50	575.0	130.0	18.5	40.0	35.00
90	45.00	14.85	33.00	630.0	120.0	17.0	47.0	17.50
91	53.50	15.45	28.85	480.5	125.0	18.5	31.0	17.50
55	30.00	12.09	33.60	500.0	126.0	18.5	35.0	48.12
92	40.00	12.00	30.00	465.0	120.0	31.2	42.0	26.25
93	47.65	15.85	33.15	412.5	120.0	15.0	42.0	43.75
45	37.00	11.21	30.25	475.0	115.0	18.0	33.0	17.50
94	37.35	14.78	40.85	495.0	128.0	15.0	71.8	26.25
95	55.00	22.00	40.00	428.5	125.0	18.5	35.0	17.50
43	44.15	14.79	33.50	325.0	130.0	16.7	60.0	26.25
96	37.00	9.92	26.80	600.0	110.0	17.8	40.4	26.23
97	42.65	12.56	29.50	487.5	127.0	19.6	30.0	35.00
98	45.00	13.28	29.50	660.0	120.0	20.0	42.7	35.00
99	31.85	9.56	30.00	380.0	127.0	10.0	70.0	26.25
32	46.25	15.88	34.35	405.0	140.0	15.0	35.0	35.00
100	50.50	13.07	26.00	847.0	123.0	16.7	28.0	35.00
101	43.25	15.15	35.00	627.0	113.0	22.2	38.0	26.25

b. Primary branches/plant

Primary branches/plant varied from 7.50 to 17.50. The genotype TA-87 had the lowest number of primary branches and TA-79 had the highest number of primary branches. The genotypic and phenotypic coefficients of variation were 20.95 and 22.01 respectively. The broad sense heritability [$h^2(b)$] was 91.0%. The extent of genetic gain was 41.07%.

c. Days to first male flower anthesis

The most precocious genotypes were TA-82 and TA-19 (27.5 days) and the latest was TA-71 (45.0 days) and the mean being 33.94 days. The genotypic and phenotypic coefficients of variation for days to first male flower anthesis were 9.39 and 10.13 respectively. The broad sense heritability for this character was 86.0% and genetic gain 17.93%.

d. Days to first female flower opening

Days to first female flower opening ranged from 33.5 to 65.0 days. The genotypes TA-82 and TA-84 took the minimum and maximum days respectively. The average value was 41.52 days. The genotypic and phenotypic coefficients of variation were 13.93 and 15.01 respectively. The broad sense heritability was 86.0% and the genetic gain being 26.64%.

e. Node at which first female flower appeared

This trait varied from 11.7 to 26.0. The genotypes TA-102 and TA-70 had the lowest and highest node respectively. The genotypic and phenotypic coefficients of variation were 20.41 and 20.84 respectively. It recorded a heritability [h^2(b)] of 96.0% and the genetic gain 41.18%.

f. Male flowers/plant

Male flower/plant had a range of 2440.0 to 15000.0. The genotype TA-41 had the lowest number of male flowers and TA-80, the maximum number of male flowers/plant. The average number was 5624.22.

The genotypic and phenotypic coefficients of variation were 47.49 and 47.55 respectively. The heritability [h^2(b)] was 99.0%. The trait exhibited a high percentage of genetic gain, 97.95.

g. Female flowers/plant

Female flowers/plant ranged from 63.0 (TA-45) to 130.0 (TA-94), the mean value being 85.53. The gcv and pcv were 17.12 and 21.8 respectively. The heritability [h^2(b)] and genetic gain were 62.0% and 27.67% respectively.

h. Sex ratio

Sex ratio exhibited a wide range of 30.0-150.0. The maximum was recorded in the accession, TA-80 and minimum in TA-83. The gcv and pcv were 45.61 and 45.65 respectively. It recorded heritability [h^2(b)] of 99.0% and genetic gain of 93.86%.

i. Nodes on main vine

The genotypes TA-83 and TA-99 had the minimum (31.0) and TA-70 had the maximum (66.0) nodes followed by TA-71 (56.5) and TA-87 (54.0). The average for this trait was 40.82. The gcv and pcv were 15.93 and 17.47 respectively. The heritability [h^2(b)] was 83.0%. The genetic gain was 29.95%.

j. Fruiting nodes on main vine

It ranged from 0.0 to 4.0. The genotypes TA-84, 91, 43, 97 and 100 had the least value and TA-41 exhibited the maximum. The mean value was 1.45. The gcv and pcv were 62.99 and 70.05 respectively. The heritability [h^2(b)] and genetic gain were 81.0% and 116.57% respectively. Among 25 traits, genetic gain was the highest for this trait.

k. Days to fruit maturity

Days to fruit maturity varied from 10.0 to 16.0 days. The genotypes TA-70, 102, 73, 82, 91 and 95 took a fewer days while TA-55 and TA-100 took more days to fruit maturity. The average value was 12.79 days. The gcv and pcv were 12.09 and 12.46 respectively. The heritability [h^2(b)] was 94.00% and the genetic gain recorded was 24.15%.

l. Days to first fruit picking maturity

The accession TA-82 was the earliest (43.5 days) and the latest was TA-84 (81.0 days) followed by TA-97 (71.5 days) and TA-94 (65.0 days). The average value was 67.29. The gcv and pcv were 11.19 and 11.93 respectively. The heritability [h^2(b)] was 88.0%. The genetic gain obtained was 21.62%.

m. Yield/plant

The yield/plant varied from 7330.0 to 20230.0 g. TA-96 yielded the minimum and TA-94 the maximum followed by TA-70 with an yield of 18720.0 g. THe gcv and pcv were 30.06 and 31.33 respectively. The heritability [h^2(b)] was 92.0%. However, the genetic gain was the lowest among the 25 quantitative characters studied (0.29%).

n. Fruits/plant

Fruits harvested/plant ranged from 11.0 to 57.5 with a mean of 24.43. The accession TA-71 had the minimum number of fruits and TA-94 had the maximum number of fruits followed by

TA-99 (44.85) and TA-102 (44.10). The gcv and pcv were 38.93 and 39.99 respectively. The heritability [h^2(b)] was 95.0% and the genetic gain obtained was 78.08%.

o. Fruit length

Fruit length ranged from 30.1 cm to 116.0 cm. The genotype TA-56 had the shortest fruit (30.1 cm) and TA-96 had the longest fruit (116.0 cm) followed by TA-101 (106.0 cm) and TA-84 (100.8 cm). The gcv and pcv for the character were 32.15 and 32.56 respectively. This trait had a broad sense heritability (97.5%). The genetic gain being 0.84%.

p. Fruit girth

Fruit girth varied from 12.0-29.35 cm. The genotype TA-97 had the lowest fruit girth and TA-70 had the maximum fruit girth. The average fruit girth was 19.07 cm. The gcv and pcv were 20.26 and 21.23 respectively. The heritability [h^2(b)] was 91.0%. The genetic gain was 39.84%.

q. Flesh thickness

The flesh thickness had a range of 0.52-1.00 cm. The genotype TA-97 had the lowest flesh thickness and TA-71 had the highest flesh thickness. The average being 0.76 cm. The gcv and pcv were 13.09 and 13.73 respectively. The heritability [h^2(b)] and the genetic gain were 91.0% and 25.71% respectively.

r. Seeds/fruit

The seeds/fruit ranged from 30.00-72.50. The genotype TA-55 had the lowest number of seeds and TA-19 had the maximum number followed by TA-32, TA-37 and TA-70 with 69.75, 62.0 and 61.75 seeds/fruit respectively. The mean was 46.90. The gcv and pcv were 18.74 and 21.13 respectively. The heritability [h^2(b)] was 78.7%. The genetic gain was 34.26%.

s. Seed weight/fruit

The seed weight/fruit varied from 7.50 to 18.86 g. The lowest value for seed weight/fruit was in TA-82 and the highest was in TA-81. The average was 14.12 g. The gcv and pcv were 27.87 and 29.81 respectively. The broad sense heritability recorded was 87.30%. The genetic gain was 53.66%.

t. 100 seed weight

This trait ranged from 20.00 to 41.00 g. The minimum value for 100 seed weight was exhibited by TA-82 and the maximum was shown by TA-73 followed by TA-94 (40.85 g). The average was 30.30 g.. The gcv and pcv were 15.25 and 15.92 respectively. The heritability [h^2(b)] was 97.8%. The genetic gain was 31.10%.

u. Average fruit weight

Average fruit weight recorded the highest value, 900.0 g in TA-71 and TA-81 recorded the minimum (300.0 g). The average was 537.76 g. The gcv and pcv were 24.62 and 25.05 respectively. The heritability [h^2(b)] value was 95.4% and the genetic gain being 48.19%.

v. Total crop duration

Total duration of the crop ranged from 95.0 days in TA-77 to 140.0 days in TA-71 and TA-32, average being 118.95 days. Out of 25 traits studied, total duration of the crop showed the least genotypic and phenotypic coefficients of variation (9.24 and 9.25 respectively). The heritability [h^2(b)] was 99.8%. The genetic gain was 19.02%.

w. Vitamin C content of fruit

Vitamin C content of the fruit varied from 13.0-31.2 mg/100 g of fruit. The lowest content of vitamin C was observed in TA-69 and the maximum was in TA-102 and TA-79. The gcv and pcv were 26.56 and 26.62 respectively. The heritability [h^2(b)] was 99.5% and the genetic gain being 54.57%.

x. Crude fibre content of fruit

The crude fibre content of fruit ranged from 25 to 71.8%. The lowest was observed in TA-34 and the maximum was in TA-94. The mean value was 40.37%. The gcv and pcv were 26.35 and 26.31 respectively. The heritability [h^2(b)] was 99.5%. The genetic gain was 53.95%.

y. Crude protein content of fruit

The crude protein content had a range of 8.75-48.12%. The lowest content was observed in TA-80 and the maximum in TA-55. The gcv and pcv were 33.65 and 33.69 respectively. The heritability [h^2(b)] was 99.8%. The genetic gain was 69.26%.

2. Assessment of genetic divergence and grouping of genotypes

The 48 snakegourd genotypes included in the study were grouped into 10 clusters. Cluster I contained the maximum of 13 genotypes. The cluster X consisted of six genotypes, cluster VII had eight genotypes, cluster V consisted of seven genotypes and clusters III and IX consisted of three genotypes each. Clusters IV, VI and VIII comprised of two genotypes each and cluster II had only one genotype (Table 6).

The intracluster distance among 10 clusters ranged from 36.53 (cluster X) to 43.88 (cluster VIII). The remaining

Table 6. Details of snakegourd genotypes constituting different clusters

Cluster number	Genotypes constituted	Total number/ cluster
I	TA-39, 32, 72, 74, 56, 77, 79, 81, 85, 88, 91, 45, 95	13
II	TA-70	1
III	TA-80, 86, 87	3
IV	TA-94, 99	2
V	TA-69, 102, 44, 55, 75, 76, 83	7
VI	TA-71, 78	2
VII	TA-30, 20, 73, 82, 41, 19, 90, 93	8
VIII	TA-37, 92, 43	3
IX	TA-84, 96, 97	3
X	TA-34, 89, 98, 32, 100, 101	6

Table 7. Average intra and infter cluster D^2 values of 10 clusters of snakegourd considering 25 characters

	I	II	III	IV	V	VI	VII	VIII	IX	X
I	37.48									
II	54.68	0.00								
III	45.04	62.22	38.82							
IV	49.77	60.35	53.93	36.64						
V	43.84	61.30	48.00	50.76	39.86					
VI	48.87	60.88	52.90	57.81	51.10	40.48				
VII	42.52	57.98	48.51	51.01	45.36	50.47	39.89			
VIII	47.52	64.45	52.87	54.47	50.63	56.52	47.27	43.80		
IX	46.55	61.60	51.20	54.30	49.17	54.44	47.20	53.02	38.48	
X	41.70	58.64	45.96	49.10	44.84	48.72	44.20	47.23	46.00	36.50

Table 8. Average intra and inter cluster (D) values of 10 clusters of snakegourd considering 25 characters

	I	II	III	IV	V	VI	VII	VIII	IX	X
I	6.12									
II	7.39	0.00								
III	6.71	7.89	6.23							
IV	7.05	7.77	7.34	6.05						
V	6.62	7.83	6.93	7.12	6.31					
VI	6.99	7.80	7.27	7.60	7.15	6.36				
VII	6.52	7.61	6.96	7.14	6.73	7.10	6.32			
VIII	6.89	8.03	7.27	7.39	7.12	7.52	6.88	6.62		
IX	6.82	7.85	7.16	7.37	7.01	7.38	6.87	7.28	6.20	
X	6.46	7.66	6.78	7.01	6.70	6.98	6.65	6.87	6.78	6.04

intracluster (D^2) values were in the order of 36.44, 37.48, 38.48, 38.82, 39.86, 39.89 and 40.48 in clusters IV, I, IX, III, V, VII and VIII respectively (Table 7). The intra and inter cluster D values are presented in Table 8. With the help of average intercluster distance values (D) the cluster diagram showing the intercluster relationship was prepared (Fig.1). The cluster means of various characters are illustrated in metroglyph method as depicted in Fig.2-5.

a. Main vine length

The maximum main vine length (mean) was found in cluster II (785.00 cm) followed by cluster III (636.66 cm), VI (590.00 cm), VII (570.38 cm), IX (536.67 cm), X (502.28 cm) and I (495.53 cm). The shortest length was observed in the cluster IV (378.50 cm) followed by cluster VIII (427.00 cm) and V (492.75 cm).

b. Primary branches/plant

The cluster mean values ranged from 8.08 (cluster III) to 16.35 (cluster II). The values in the ascending order were 9.63, 9.90, 10.00, 10.70, 10.75, 11.25, 12.00 and 12.50 for clusters VII, V, VI, I, VIII, IV, X and IX respectively.

c. Days to first male flower anthesis

The minimum and maximum mean values were recorded in

Fig. 1 Diagramatic representation of clustering of 48 snakegourd genotypes

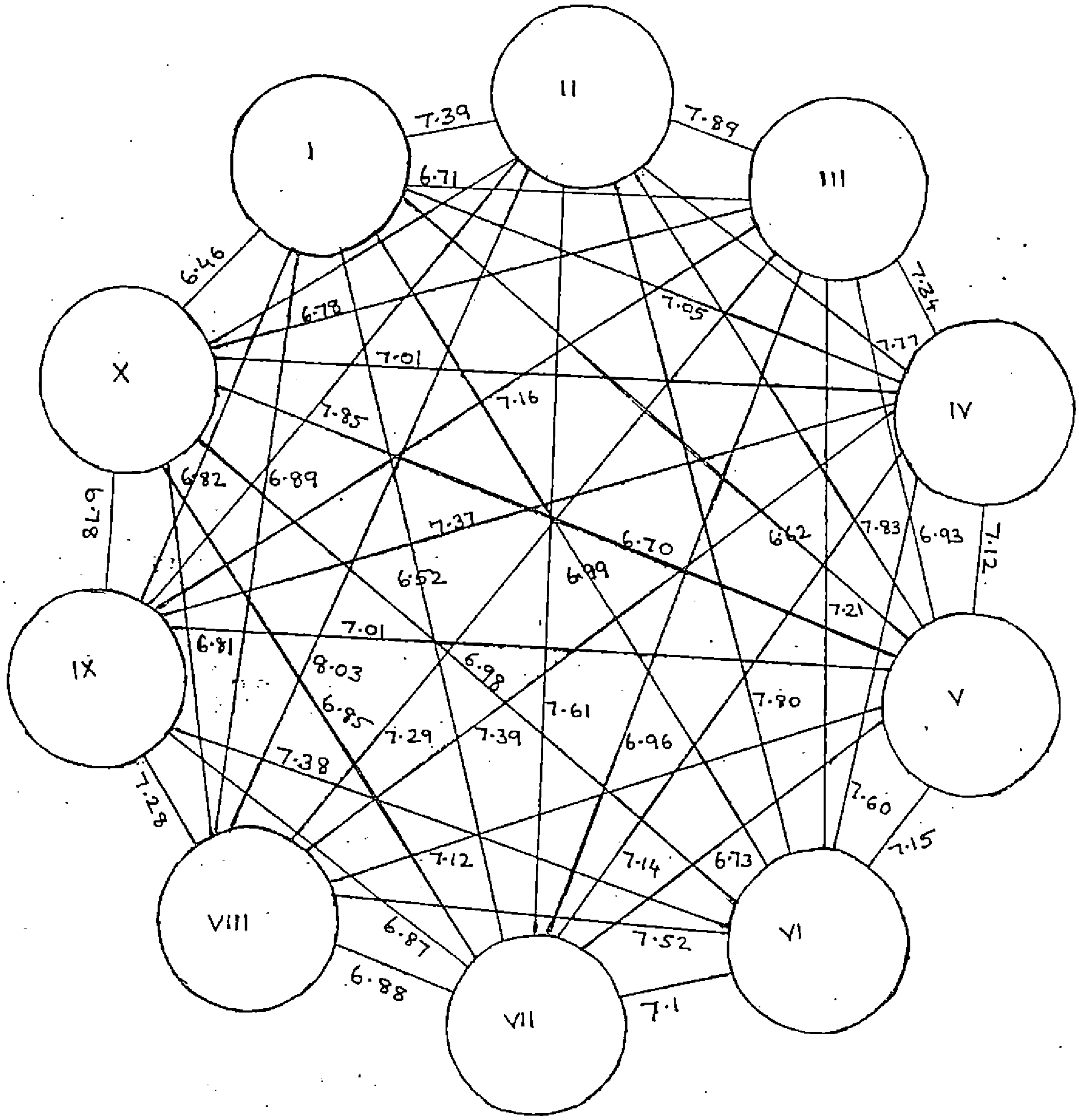


Fig.2 Metroglyph showing vegetative and productive characters in 10 clusters of snakegourd

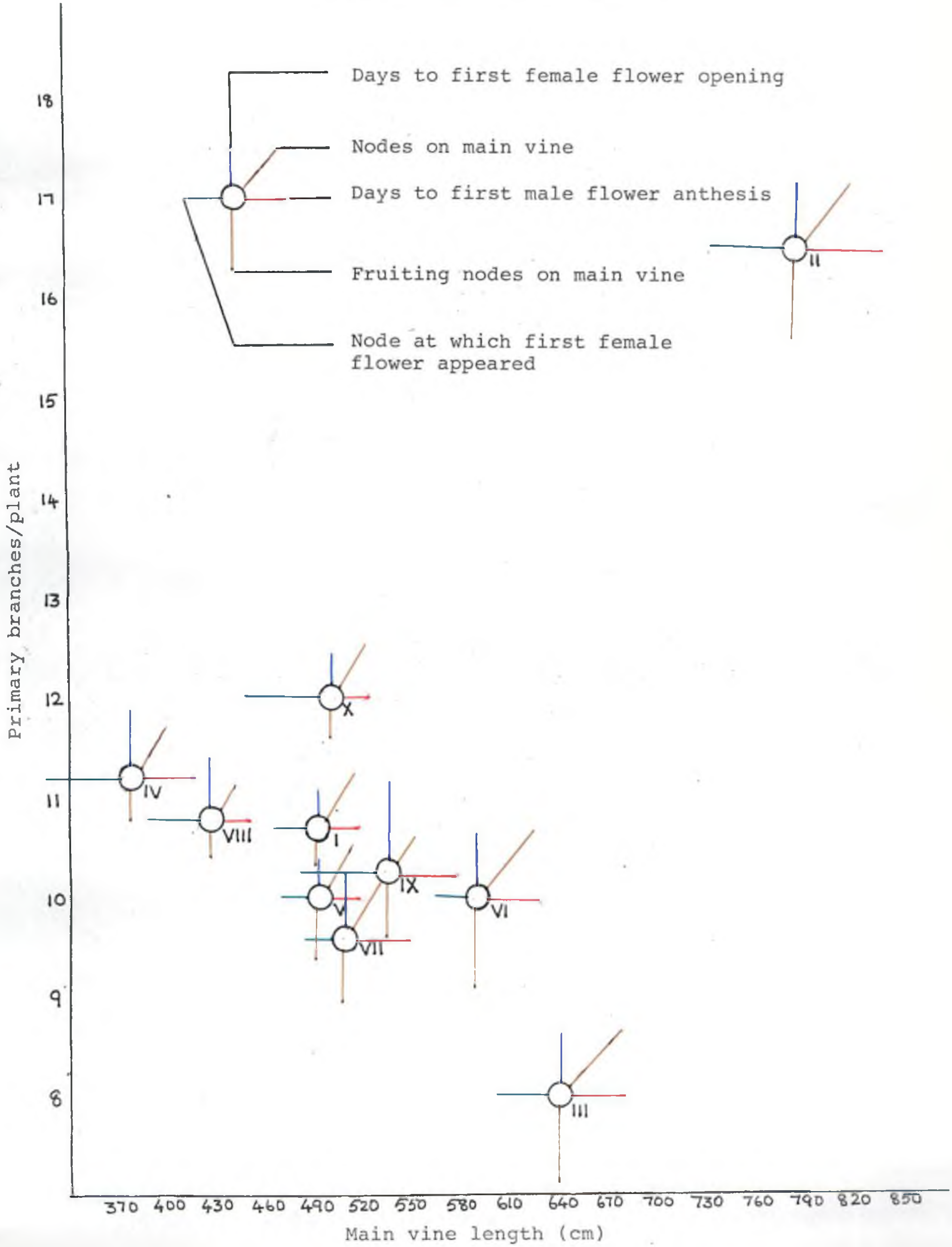


Fig.3 Metroglyph showing sex ratio and crop maturity in 10 clusters of snakegourd

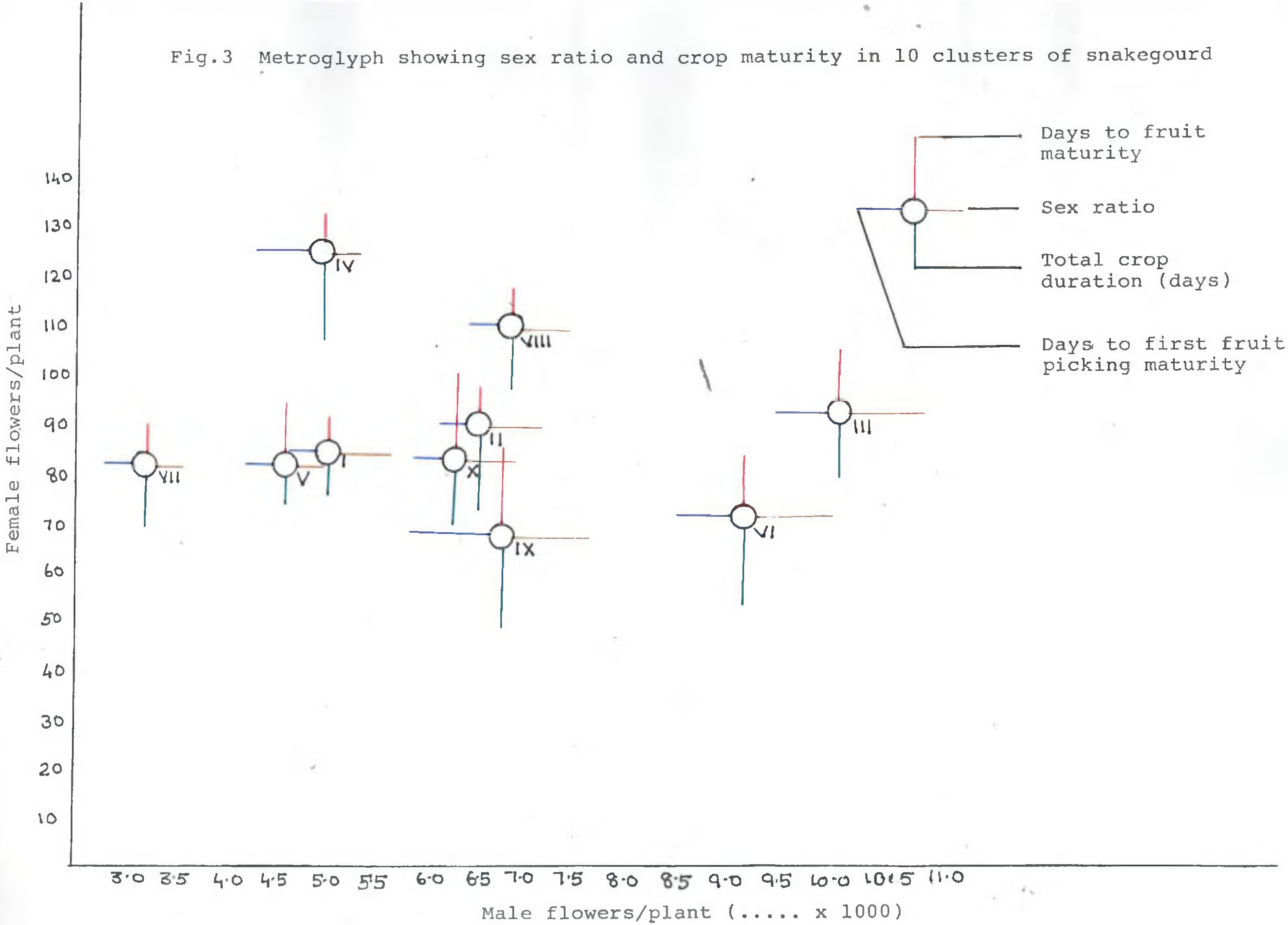


Fig.4 Metroglyph showing yield/plant and associated characters in 10 clusters of snakegourd

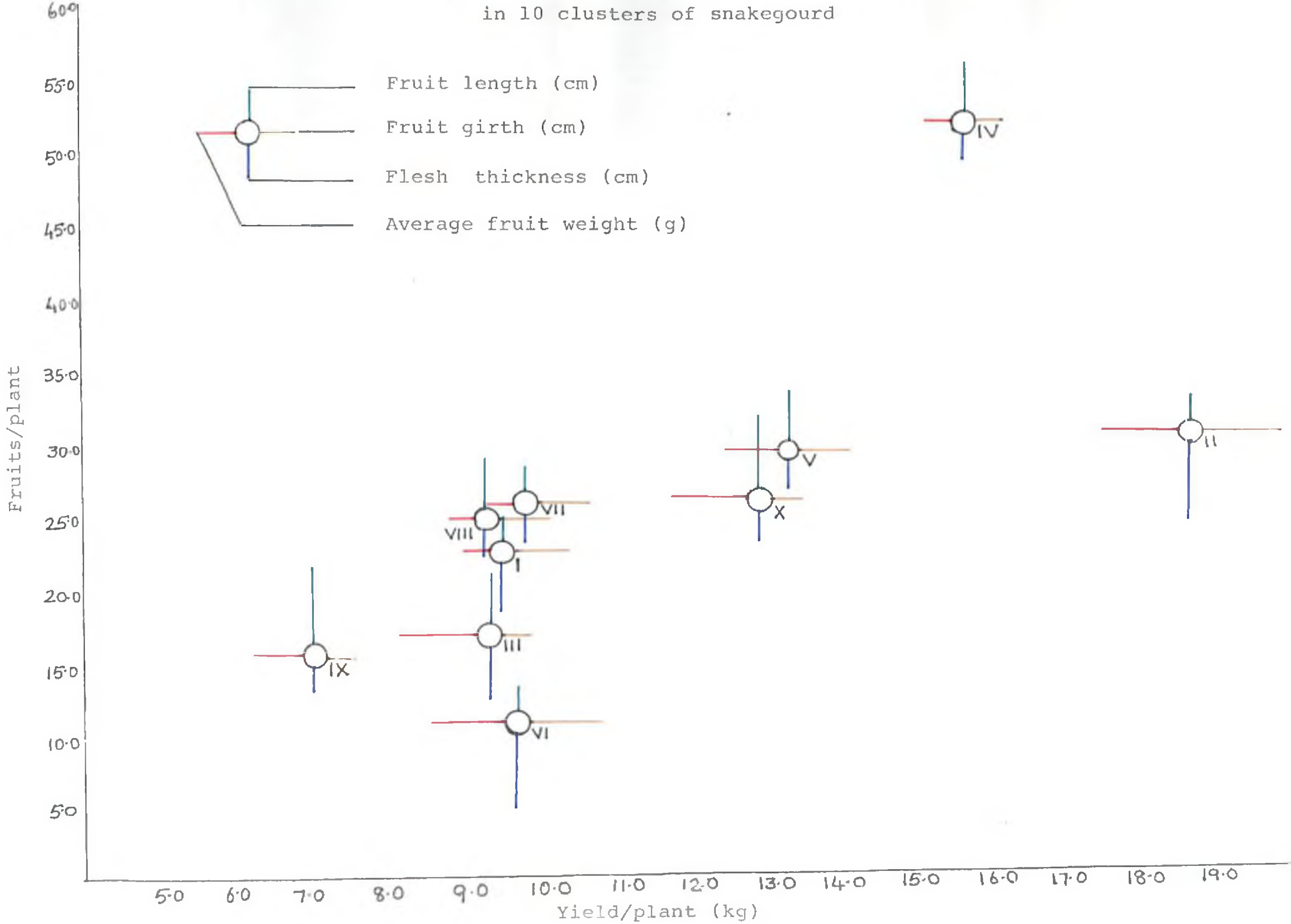
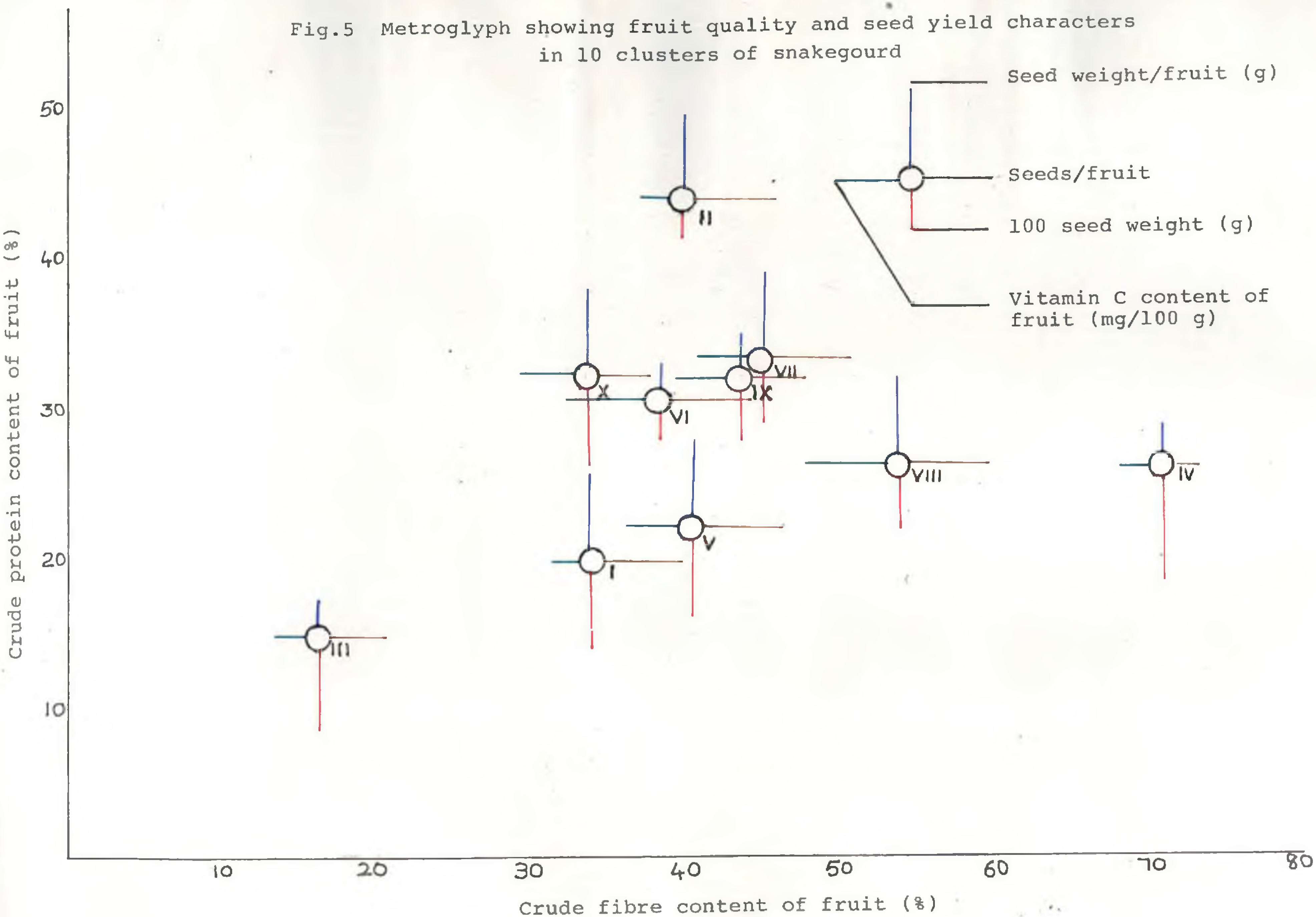


Fig.5 Metroglyph showing fruit quality and seed yield characters in 10 clusters of snakegourd



the clusters X (32.31 days) and VI (43.25 days) respectively. The values for other clusters were 33.00, 33.11, 33.40, 34.25, 34.83, 35.00, 35.33 and 39.00 days for clusters V, VII, I, IV, III, VIII, IX and II respectively.

d. Days to first female flower opening

The minimum and maximum mean values were found in the clusters X (38.41 days) and IX (55.5 days) respectively. The values were 48.00, 46.75, 46.33 and 45.50 days for clusters VI, II, III and IV respectively. The clusters I, V, VII and VIII had values 39.90, 38.66, 38.78 and 41.33 days respectively.

e. Node at which first female flower appeared

The maximum mean value was found in cluster II (26.00) followed by clusters IX, X, IV, III and VIII with values 24.17, 23.94, 21.25, 19.25 and 18.50 respectively. The minimum mean value was observed in cluster V (14.25) followed by clusters VI, VII, and I with values 15.00, 17.78 and 17.94 respectively.

f. Male flowers/plant

The maximum mean value was found in cluster III (10337.5) followed by clusters VI, VIII, IX, II and X with values 9230.0, 6860.0, 6790.0, 6460.0 and 6302.14 respectively. The minimum mean value was found in the cluster VII (3222.68) followed by V, IV and I with values 4620.0, 4895.0 and 5051.84 respectively.

g. Female flowers/plant

This trait had a range from 66.67 (cluster IX) to 125.00 (cluster IV). The other clusters had mean values of 71.50, 80.38, 82.54, 83.93, 85.50, 90.00, 93.33 and 110.00 for clusters VI, I, V, X, VII, II, III and VIII respectively.

h. Sex ratio

This trait had a range from 36.31 to 131.5 in cluster VII and VI respectively. The mean values for clusters IV, V, VIII, I, II, X, IX and III were 39.0, 53.0, 63.67, 68.31, 71.0, 73.11, 93.00 and 103.00 respectively.

i. Nodes on main vine

The minimum and maximum mean values were found in clusters IV (39.25) and II (66.00) respectively. Clusters I and VIII had the same value (39.50). The values were 37.00, 40.17, 40.50, 42.17, 47.50 and 49.00 for clusters X, IX, VII, V, VI and III respectively.

j. Fruiting nodes on main vine

The minimum and maximum mean values were found in clusters IX (0.33) and II (3.25) respectively. The values for clusters VIII, X, V, IV, I and VII were 0.50, 1.39, 1.42, 1.50, 1.60 and 1.63 respectively. Clusters VI and III had the same value (1.75).

k. Days to fruit maturity

The minimum and maximum mean values were exhibited by clusters II and X (10.0 and 14.57 days respectively). The mean values of other clusters were 11.75, 12.00, 12,33, 12.53, 13.00, 13.33, 13.33 and 14.33 days for clusters VII, IV, VIII, I, VI, V, III and IX respectively.

l. Days to first fruit picking maturity

The maximum mean value was found in cluster IX (71.77 days) followed by clusters VI, IV, III, II, V and X with values 61.50, 60.00, 58.83, 57.50, 54.08 and 53.28 days respectively. The lowest mean value was exhibited by the cluster VIII (50.83 days) followed by clusters VII and I with values 51.19 and 53.15 days respectively.

m. Yield/plant

The mean values ranged from 7125.67 g (cluster IX) to 18720.0 g (cluster II) followed by clusters IV, V, X and VII with values 15947.0, 13401.0, 12996.86 and 9893.62 g respectively. The mean values of other clusters were 9594.0, 9417.0, 9390.0 and 9375.0 g for clusters, I, VIII, III and VI respectively.

n. Fruits/plant

The number of fruits/plant (mean) ranged from 11.0 (cluster VI) to 51.18 (cluster IV). The clusters IX, III, I, VIII, X, VII, V and II exhibited mean values of 15.56, 16.75, 22.34, 24.50, 25.60, 25.61, 28.95 and 29.50 respectively.

o. Fruit length

The minimum and maximum mean values of this trait was found in clusters VII and IX with values 38.78 cm and 104.88 cm respectively followed by clusters X, V, III, IV, VIII and I with values 74.80, 66.58, 60.71, 53.28, 52.50 and 51.32 cm respectively. The values for clusters II and VI were 41.00 and 47.50 cm respectively.

p. Fruit girth

The minimum and maximum mean values of fruit girth were found in clusters IV (13.48 cm) and II (29.35 cm). The mean values arranged in ascending order were 13.95, 17.98, 18.03, 18.67, 19.20, 19.64, 19.83 and 29.00 cm for clusters IX, III, X, VIII, V, VII, I and VI respectively.

q. Flesh thickness

The mean values ranged from 0.65 cm (cluster IV) to 0.98 cm (clusters II and VI) followed by 0.82, 0.81, 0.75 and 0.73 cm for clusters I, III, X and VIII respectively. The mean values of other clusters were 0.63, 0.72 and 0.72 cm for clusters IX, V and VII respectively.

r. Seeds/fruit

The number of seeds/fruit (mean) was maximum in the cluster II (61.75) and minimum in the cluster III (40.03). The values of other clusters were 40.03, 41.43, 41.68, 42.50, 48.00, 48.83, 50.09 and 58.45 for clusters III, IX, X, VI, I, VIII, VII and V respectively.

s. Seed weight/fruit

The mean value for this trait ranged from 11.35 g (cluster VI) to 15.93 g (cluster II) followed by 15.5, 14.42, 14.30, 14.24, 13.68 and 12.94 g for clusters I, V, VIII, VII, X and III respectively. For other clusters IX and IV values were 11.82 and 12.17 g respectively.

t. 100 seed weight

The minimum and maximum mean values were found in clusters II and IV respectively (26.00 and 35.43 g respectively).

The other clusters VI, IX, VII, VIII, I, V, III and X had mean values 26.38, 28.27, 28.85, 29.83, 30.31, 30.36, 32.15 and 32.44 g respectively.

u. Average fruit weight

The mean values for average fruit weight ranged from 409.50 (cluster VIII) to 827.50 g (cluster VI) followed by 689.00, 665.00, 623.24, 562.97, 518.00 and 453.23 g in clusters III, II, X, V, IX and I respectively. The clusters IV and VII exhibited values 437.50 and 420.25 g respectively.

v. Total crop duration

The maximum and minimum mean values were 131.00 and 112.30 days recorded in clusters VI and V respectively. The mean values for clusters I, VII, III, X, VIII, IX, IV and II were 113.96, 115.13, 123.33, 124.00, 124.67, 125.67, 127.50 and 130.00 days respectively.

w. Vitamin C content of fruit

The minimum and maximum mean values were found in clusters IV (12.5 mg/100 g) and VIII (25.82 mg/100 g) followed by clusters VI, VII, V, IX and II with values 25.15, 21.37, 20.87, 20.27 and 20.00 mg/100 g respectively. The remaining clusters I, X and III had values 17.50, 19.12 and 16.66 respectively.

x. Crude fibre content of fruit

The crude fibre content (mean) ranged from 16.66% (cluster III) to 7.90% (cluster IV) followed by clusters VIII, VII, IX, V and II with mean crude fibre contents of 54.00, 45.00, 43.47, 40.67 and 40.00% respectively. The rest of the clusters VI, I and X had values 38.00, 34.08 and 33.67% respectively.

y. Crude protein content of fruit

The maximum crude protein content (mean) was found in cluster II (43.75%) followed by clusters VII, IX and VI with values 32.81, 32.80 and 30.63% respectively. The lowest mean value was found in cluster X (8.75%) followed by clusters III, I, V, IV and VIII with values 14.58, 19.17, 21.88, 26.25 and 26.25% respectively.

B. Assessment of combining ability of parents

Analysis of variance for various characters revealed that variances due to gca were significant for all traits. The variances due to sca were significant for all characters except for total crop duration, sex ratio and fruits/plant (Appendix-II). Estimates of gca effects of parents are presented in Table 9. Estimates of sca effects of crosses are presented in Tables 10a and 10b. The mean performance of parents and F_1 hybrids are presented in Tables 11a and 11b.

Table 9. Estimates of gca effects of 11 snakegourd lines for various characters

Parental lines	Main vine length	Primary branches/ plant	Days to first male flower anthesis	Days to first female flower opening	Male flowers/ plant	Female flowers/ plant	Sex ratio	Nodes on main vine	Fruiting nodes on main vine
P_1	-38.792	-0.510	-1.156	-0.708	117.156	9.396	-3.477	0.837	0.167
P_2	59.927	0.365	1.844	1.354	501.281	-6.104	9.307	0.212	0.042
P_4	-21.135	0.146	-0.688	-0.646	-618.437	-3.292	-5.830	-1.050	-0.208
P_5	44.750	0.625	-2.271	-0.604	-603.198	-2.646	-5.191	2.650	0.333
P_6	-0.167	-0.708	1.312	1.396	262.719	8.354	-2.261	-0.850	-0.167
P_8	64.917	-0.042	1.562	0.896	-705.281	-14.813	0.687	-0.183	-0.333
P_9	-53.500	-0.208	0.146	-2.104	-1179.781	-11.313	-7.734	-4.350	0.250
P_{10}	-36.250	0.792	0.479	-0.271	17.885	-8.479	5.519	-3.183	-0.333
P_{11}	54.750	-1.208	0.646	1.229	244.219	13.354	-4.568	8.150	0.583
P_{12}	-63.583	-0.042	-0.354	-1.271	1411.719	6.187	10.866	-1.683	0.167
P_{13}	-10.917	0.792	-1.521	0.729	551.719	9.354	2.682	-0.550	-0.500

Contd.

Table 9 (contd.)

Parental lines	Days to fruit maturity	Days to first fruit picking maturity	Yield/ plant	Fruits/ plant	Fruit length	Fruit girth	Flesh thickness	Seeds/ fruit	Average fruit weight	Total crop duration
P_1	0.167	-0.292	-0.572	-1.008	4.410	-2.060	-0.055	1.379	-27.688	0.958
P_2	0.417	1.777	0.486	0.442	2.648	0.852	0.014	3.560	48.500	0.865
P_4	-0.583	-0.855	0.086	0.567	-7.058	1.208	0.041	-4.940	-20.813	-1.823
P_5	0.000	-0.729	-1.281	3.471	3.694	-2.248	0.008	-0.075	-44.812	-8.240
P_6	-0.333	1.604	1.441	-9.696	5.694	2.385	0.040	1.208	203.188	9.844
P_8	0.000	0.271	-1.568	-7.413	1.494	2.919	0.013	-3.308	40.354	-6.656
P_9	-0.667	-2.729	-4.359	-1.529	-7.940	0.502	-0.007	-4.742	-70.979	-7.740
P_{10}	-0.333	-0.229	-0.926	5.304	-8.040	-1.052	-0.004	0.825	-45.146	-0.073
P_{11}	0.000	1.687	1.984	5.971	-0.590	-1.065	-0.034	3.008	-61.479	0.427
P_{12}	1.333	-0.146	2.561	-0.496	3.327	-1.605	0.030	-0.742	29.021	7.094
P_{13}	0.000	0.271	2.149	4.387	2.360	-1.881	-0.015	3.825	-50.146	5.344

Table 10a. Estimates of sca effects of 24 F_1 snakegourd hybrids for various characters

Crosses	Main vine length	Primary branches/ plant	Days to first male flowers anthesis	Days to first female flowers opening	Male flowers/ plant	Female flowers/ plant	Sex ratio	Nodes on main vine	Fruiting nodes on main vine
$P_5 \times P_1$	-92.88	-1.16	1.99	2.04	125.26	1.27	0.53	-6.34	-0.33
$P_6 \times P_1$	66.04	1.18	-0.84	-0.96	-532.66	-5.73	-2.56	1.66	0.17
$P_8 \times P_1$	-38.04	0.01	-1.09	-2.96	497.84	-9.06	10.59	3.00	-0.67
$P_9 \times P_1$	20.37	-0.82	0.32	1.04	329.34	-6.56	7.24	2.16	-0.75
$P_{10} \times P_1$	-26.88	-0.32	1.99	0.71	305.68	14.10	-5.50	-1.00	0.33
$P_{11} \times P_1$	122.12	0.18	-2.18	-2.29	-199.16	2.77	-2.27	2.66	0.42
$P_{12} \times P_1$	-4.54	1.51	1.82	1.71	791.84	-4.56	8.74	0.50	0.33
$P_{13} \times P_1$	-42.21	-0.57	-2.01	0.71	-1318.16	7.77	-16.77	-2.64	0.50
$P_5 \times P_2$	-41.59	-1.03	0.74	-0.02	-559.36	-5.73	-3.33	-4.21	-1.21
$P_6 \times P_2$	-1.43	-2.70	1.16	-0.02	657.72	4.27	3.24	1.79	-0.71
$P_8 \times P_2$	43.74	1.64	0.16	1.48	147.72	2.44	1.44	5.62	0.46
$P_9 \times P_2$	-38.34	2.80	0.32	-0.52	-263.28	15.94	-11.44	-4.21	1.88
$P_{10} \times P_2$	144.41	-0.71	-1.51	-0.35	572.05	3.60	4.81	7.62	-0.04
$P_{11} \times P_2$	-56.59	1.80	-2.18	1.15	160.72	4.27	-2.46	-3.71	0.29
$P_{12} \times P_2$	-22.26	-0.36	-1.18	-1.35	-962.78	-8.56	-4.19	1.12	-0.29
$P_{13} \times P_2$	-27.93	-1.45	2.49	-0.35	247.22	-16.23	11.94	-4.01	-0.37
$P_5 \times P_4$	134.47	2.19	-2.73	-2.02	434.10	4.46	2.88	10.55	1.54
$P_6 \times P_4$	-60.61	1.52	-0.31	0.98	-125.06	1.46	-0.68	-3.45	0.54
$P_8 \times P_4$	-5.70	-1.65	0.94	1.48	-645.50	6.63	-12.02	-8.62	0.21
$P_9 \times P_4$	17.97	-1.98	-0.65	-0.52	-66.06	-9.38	4.20	2.05	-1.12
$P_{10} \times P_4$	-117.53	1.02	-0.48	-0.35	-877.73	-17.71	0.69	-6.62	-0.29
$P_{11} \times P_4$	-65.53	-1.98	4.35	1.15	38.44	-7.04	4.73	1.05	-0.71
$P_{12} \times P_4$	26.80	-1.15	-0.65	-0.35	170.94	13.12	-4.55	-1.62	-0.04
$P_{13} \times P_4$	70.14	2.02	-0.48	-0.35	1070.94	8.46	4.83	6.65	-0.12

Table 10b. Estimates of sca effects of 24 F_1 snakegourd hybrids for various characters

Crosses	Days to fruit maturity	Days to first fruit picking maturity	Yield/plant	Fruits/plant	Fruit length	Fruit girth	Flesh thickness	Seeds/fruit	Average fruit weight	Total crop duration
$P_5 \times P_1$	-0.50	1.29	-1.06	-4.16	-2.44	-2.54	0.08	3.79	40.69	-0.79
$P_6 \times P_1$	-0.17	-0.04	0.37	-0.99	-2.84	3.73	0.01	9.35	97.69	-3.88
$P_8 \times P_1$	0.50	-2.71	-0.39	-0.28	9.76	-1.81	0.00	-2.98	15.52	-3.87
$P_9 \times P_1$	0.17	1.29	-0.73	-0.66	-5.81	-0.39	-0.03	-2.05	-35.65	4.21
$P_{10} \times P_1$	-0.17	1.29	1.54	3.51	3.69	-0.44	-0.03	4.91	-43.98	3.54
$P_{11} \times P_1$	1.50	0.12	0.73	-3.16	2.84	0.55	0.00	1.45	-25.15	0.54
$P_{12} \times P_1$	-0.83	-0.54	-0.15	6.31	-9.08	1.88	0.00	-3.05	-40.15	-0.13
$P_{13} \times P_1$	-0.50	-0.71	-0.31	-0.57	3.89	-1.01	-0.05	-1.61	-8.98	0.37
$P_5 \times P_2$	1.25	1.82	-0.73	-0.11	1.32	1.45	0.10	-3.89	-70.50	5.80
$P_6 \times P_2$	-0.42	-0.51	-0.59	-1.44	-5.18	0.79	0.00	2.82	-18.50	-10.78
$P_8 \times P_2$	0.25	2.82	0.82	-0.63	-1.48	3.28	-0.01	11.34	9.33	7.22
$P_9 \times P_2$	-1.08	-1.18	0.21	2.14	0.15	1.70	0.03	-1.23	-14.33	-0.70
$P_{10} \times P_2$	0.58	0.32	1.78	3.56	-1.45	-0.85	0.05	-0.79	44.83	-0.86
$P_{11} \times P_2$	-0.75	-1.09	0.00	4.39	3.60	-3.74	-0.12	-6.48	-3.83	2.64
$P_{12} \times P_2$	-0.08	-1.26	0.79	-2.39	2.39	-0.14	-0.06	6.77	18.17	-1.53
$P_{13} \times P_2$	0.25	-0.93	-2.29	-5.52	0.65	-0.92	0.00	-8.54	34.83	-1.78
$P_5 \times P_4$	-0.75	-3.11	1.79	4.27	1.13	1.09	-0.19	0.11	29.81	-5.01
$P_6 \times P_4$	0.58	0.55	0.21	2.43	8.03	-2.94	-0.01	-12.18	-79.19	14.66
$P_8 \times P_4$	-0.75	-0.11	-0.43	0.90	-8.27	-1.47	0.01	-8.36	-24.85	-3.34
$P_9 \times P_4$	0.92	-0.11	0.51	-1.48	5.66	-1.31	-0.01	3.27	49.98	-3.51
$P_{10} \times P_4$	-0.42	-1.61	-3.32	-7.07	-2.24	1.29	-0.02	5.71	-0.85	-2.68
$P_{11} \times P_4$	-0.75	0.97	-0.73	-1.23	-6.44	3.16	0.12	5.02	28.98	-3.18
$P_{12} \times P_4$	0.92	1.80	-0.65	-3.92	6.69	-1.74	0.05	-3.73	21.98	1.66
$P_{13} \times P_4$	0.25	1.64	2.61	6.10	-4.54	1.93	0.05	10.16	-25.85	1.41

Table 11a (contd.)

1	2	3	4	5	6	7	8	9	10	11
$P_8 \times P_4$	570.0	9.5	37.5	42.0	3034.0	69.0	43.97	38.5	2.5	10.0
$P_9 \times P_4$	570.3	9.0	34.5	37.0	2820.0	65.0	43.38	45.0	2.0	11.0
$P_{10} \times P_4$	500.0	13.0	35.0	38.8	3410.0	96.5	35.34	37.5	2.0	10.0
$P_{11} \times P_4$	600.0	8.0	40.0	42.0	4850.0	110.0	44.09	56.5	2.5	10.0
$P_{12} \times P_4$	574.0	10.0	34.0	38.0	6486.0	108.0	60.06	44.0	2.8	13.0
$P_{13} \times P_4$	670.0	14.0	33.0	40.0	5408.0	110.0	49.16	53.4	2.0	11.0
P_1	372.0	12.8	35.5	41.5	3740.0	87.0	42.99	38.0	2.0	12.0
P_2	777.0	15.5	39.3	48.3	5760.0	75.0	76.80	70.0	2.8	10.0
P_4	510.0	8.5	36.0	42.0	2100.0	72.0	29.17	44.0	3.0	12.0
P_5	610.0	11.4	34.0	41.8	3150.0	86.5	36.42	37.8	3.0	13.0
P_6	553.0	12.0	32.5	46.3	3704.0	84.5	43.83	50.0	2.0	12.0
P_8	500.0	9.3	41.0	46.0	2255.0	98.0	23.01	49.0	2.0	13.0
P_9	495.5	12.3	27.3	34.5	2538.0	110.0	23.07	37.8	2.3	10.0
P_{10}	523.0	11.3	38.3	45.8	5565.0	86.5	64.34	57.5	2.5	11.5
P_{11}	468.0	12.5	36.25	41.5	4771.0	84.0	56.80	37.8	2.0	15.0
P_{12}	752.0	9.5	35.0	50.0	6960.0	108.0	64.44	58.0	2.0	13.0
P_{13}	518.0	10.8	33.5	40.5	5897.0	100.0	58.97	37.5	2.0	13.0

Table 9. Estimates of gca effects of 11 snakegourd lines for various characters

Parental lines	Main vine length	Primary branches/ plant	Days to first male flower anthesis	Days to first female flower opening	Male flowers/ plant	Female flowers/ plant	Sex ratio	Nodes on main vine	Fruiting nodes on main vine
P_1	-38.792	-0.510	-1.156	-0.708	117.156	9.396	-3.477	0.837	0.167
P_2	59.927	0.365	1.844	1.354	501.281	-6.104	9.307	0.212	0.042
P_4	-21.135	0.146	-0.688	-0.646	-618.437	-3.292	-5.830	-1.050	-0.208
P_5	44.750	0.625	-2.271	-0.604	-603.198	-2.646	-5.191	2.650	0.333
P_6	-0.167	-0.708	1.312	1.396	262.719	8.354	-2.261	-0.850	-0.167
P_8	64.917	-0.042	1.562	0.896	-705.281	-14.813	0.687	-0.183	-0.333
P_9	-53.500	-0.208	0.146	-2.104	-1179.781	-11.313	-7.734	-4.350	0.250
P_{10}	-36.250	0.792	0.479	-0.271	17.885	-8.479	5.519	-3.183	-0.333
P_{11}	54.750	-1.208	0.646	1.229	244.219	13.354	-4.568	8.150	0.583
P_{12}	-63.583	-0.042	-0.354	-1.271	1411.719	6.187	10.866	-1.683	0.167
P_{13}	-10.917	0.792	-1.521	0.729	551.719	9.354	2.682	-0.550	-0.500

Contd.

Table 9 (contd.)

Parental lines	Days to fruit maturity	Days to first fruit picking maturity	Yield/ plant	Fruits/ plant	Fruit length	Fruit girth	Flesh thickness	Seeds/ fruit	Average fruit weight	Total crop duration
P_1	0.167	-0.292	-0.572	-1.008	4.410	-2.060	-0.055	1.379	-27.688	-0.958
P_2	0.417	1.777	0.486	0.442	2.648	0.852	0.014	3.560	48.500	0.865
P_4	-0.583	-0.855	0.086	0.567	-7.058	1.208	0.041	-4.940	-20.813	-1.823
P_5	0.000	-0.729	-1.281	3.471	3.694	-2.248	0.008	-0.075	-44.812	-8.240
P_6	-0.333	1.604	1.441	-9.696	5.694	2.385	0.040	1.208	203.188	9.844
P_8	0.000	0.271	-1.568	-7.413	1.494	2.919	0.013	-3.308	40.354	-6.656
P_9	-0.667	-2.729	-4.359	-1.529	-7.940	0.502	-0.007	-4.742	-70.979	-7.740
P_{10}	-0.333	-0.229	-0.926	5.304	-8.040	-1.052	-0.004	0.825	-45.146	-0.073
P_{11}	0.000	1.687	1.984	5.971	-0.590	-1.065	-0.034	3.008	-61.479	0.427
P_{12}	1.333	-0.146	2.561	-0.496	3.327	-1.605	0.030	-0.742	29.021	7.094
P_{13}	0.000	0.271	2.149	4.387	2.360	-1.881	-0.015	3.825	-50.146	5.344

Table 10a. Estimates of sca effects of 24 F_1 snakegourd hybrids for various characters

Crosses	Main vine length	Primary branches/ plant	Days to first male flowers anthesis	Days to first female flowers opening	Male flowers/ plant	Female flowers/ plant	Sex ratio	Nodes on main vine	Fruiting nodes on main vine
$P_5 \times P_1$	-92.88	-1.16	1.99	2.04	125.26	1.27	0.53	-6.34	-0.33
$P_6 \times P_1$	66.04	1.18	-0.84	-0.96	-532.66	-5.73	-2.56	1.66	0.17
$P_8 \times P_1$	-38.04	0.01	-1.09	-2.96	497.84	-9.06	10.59	3.00	-0.67
$P_9 \times P_1$	20.37	-0.82	0.32	1.04	329.34	-6.56	7.24	2.16	-0.75
$P_{10} \times P_1$	-26.88	-0.32	1.99	0.71	305.68	14.10	-5.50	-1.00	0.33
$P_{11} \times P_1$	122.12	0.18	-2.18	-2.29	-199.16	2.77	-2.27	2.66	0.42
$P_{12} \times P_1$	-4.54	1.51	1.82	1.71	791.84	-4.56	8.74	0.50	0.33
$P_{13} \times P_1$	-42.21	-0.57	-2.01	0.71	-1318.16	7.77	-16.77	-2.64	0.50
$P_5 \times P_2$	-41.59	-1.03	0.74	-0.02	-559.36	-5.73	-3.33	-4.21	-1.21
$P_6 \times P_2$	-1.43	-2.70	1.16	-0.02	657.72	4.27	3.24	1.79	-0.71
$P_8 \times P_2$	43.74	1.64	0.16	1.48	147.72	2.44	1.44	5.62	0.46
$P_9 \times P_2$	-38.34	2.80	0.32	-0.52	-263.28	15.94	-11.44	-4.21	1.88
$P_{10} \times P_2$	144.41	-0.71	-1.51	-0.35	572.05	3.60	4.81	7.62	-0.04
$P_{11} \times P_2$	-56.59	1.80	-2.18	1.15	160.72	4.27	-2.46	-3.71	0.29
$P_{12} \times P_2$	-22.26	-0.36	-1.18	-1.35	-962.78	-8.56	-4.19	1.12	-0.29
$P_{13} \times P_2$	-27.93	-1.45	2.49	-0.35	247.22	-16.23	11.94	-4.01	-0.37
$P_5 \times P_4$	134.47	2.19	-2.73	-2.02	434.10	4.46	2.88	10.55	1.54
$P_6 \times P_4$	-60.61	1.52	-0.31	0.98	-125.06	1.46	-0.68	-3.45	0.54
$P_8 \times P_4$	-5.70	-1.65	0.94	1.48	-645.50	6.63	-12.02	-8.62	0.21
$P_9 \times P_4$	17.97	-1.98	-0.65	-0.52	-66.06	-9.38	4.20	2.05	-1.12
$P_{10} \times P_4$	-117.53	1.02	-0.48	-0.35	-877.73	-17.71	0.69	-6.62	-0.29
$P_{11} \times P_4$	-65.53	-1.98	4.35	1.15	38.44	-7.04	4.73	1.05	-0.71
$P_{12} \times P_4$	26.80	-1.15	-0.65	-0.35	170.94	13.12	-4.55	-1.62	-0.04
$P_{13} \times P_4$	70.14	2.02	-0.48	-0.35	1070.94	8.46	4.83	6.65	-0.12

Table 10b. Estimates of sca effects of 24 F_1 snakegourd hybrids for various characters

Crosses	Days to fruit maturity	Days to first fruit picking maturity	Yield/ plant	Fruits/ plant	Fruit length	Fruit girth	Flesh thickness	Seeds/ fruit	Average fruit weight	Total crop duration
$P_5 \times P_1$	-0.50	1.29	-1.06	-4.16	-2.44	-2.54	0.08	3.79	40.69	-0.79
$P_6 \times P_1$	-0.17	-0.04	0.37	-0.99	-2.84	3.73	0.01	9.35	97.69	-3.88
$P_8 \times P_1$	0.50	-2.71	-0.39	-0.28	9.76	-1.81	0.00	-2.98	15.52	-3.87
$P_9 \times P_1$	0.17	1.29	-0.73	-0.66	-5.81	-0.39	-0.03	-2.05	-35.65	4.21
$P_{10} \times P_1$	-0.17	1.29	1.54	3.51	3.69	-0.44	-0.03	4.91	-43.98	3.54
$P_{11} \times P_1$	1.50	0.12	0.73	-3.16	2.84	0.55	0.00	1.45	-25.15	0.54
$P_{12} \times P_1$	-0.83	-0.54	-0.15	6.31	-9.08	1.88	0.00	-3.05	-40.15	-0.13
$P_{13} \times P_1$	-0.50	-0.71	-0.31	-0.57	3.89	-1.01	-0.05	-1.61	-8.98	0.37
$P_5 \times P_2$	1.25	1.82	-0.73	-0.11	1.32	1.45	0.10	-3.89	-70.50	5.80
$P_6 \times P_2$	-0.42	-0.51	-0.59	-1.44	-5.18	0.79	0.00	2.82	-18.50	-10.78
$P_8 \times P_2$	0.25	2.82	0.82	-0.63	-1.48	3.28	-0.01	11.34	9.33	7.22
$P_9 \times P_2$	-1.08	-1.18	0.21	2.14	0.15	1.70	0.03	-1.23	-14.33	-0.70
$P_{10} \times P_2$	0.58	0.32	1.78	3.56	-1.45	-0.85	0.05	-0.79	44.83	-0.86
$P_{11} \times P_2$	-0.75	-1.09	0.00	4.39	3.60	-3.74	-0.12	-6.48	-3.83	2.64
$P_{12} \times P_2$	-0.08	-1.26	0.79	-2.39	2.39	-0.14	-0.06	6.77	18.17	-1.53
$P_{13} \times P_2$	0.25	-0.93	-2.29	-5.52	0.65	-0.92	0.00	-8.54	34.83	-1.78
$P_5 \times P_4$	-0.75	-3.11	1.79	4.27	1.13	1.09	-0.19	0.11	29.81	-5.01
$P_6 \times P_4$	0.58	0.55	0.21	2.43	8.03	-2.94	-0.01	-12.18	-79.19	14.66
$P_8 \times P_4$	-0.75	-0.11	-0.43	0.90	-8.27	-1.47	0.01	-8.36	-24.85	-3.34
$P_9 \times P_4$	0.92	-0.11	0.51	-1.48	5.66	-1.31	-0.01	3.27	49.98	-3.51
$P_{10} \times P_4$	-0.42	-1.61	-3.32	-7.07	-2.24	1.29	-0.02	5.71	-0.85	-2.68
$P_{11} \times P_4$	-0.75	0.97	-0.73	-1.23	-6.44	3.16	0.12	5.02	28.98	-3.18
$P_{12} \times P_4$	0.92	1.80	-0.65	-3.92	6.69	-1.74	0.05	-3.73	21.98	1.66
$P_{13} \times P_4$	0.25	1.64	2.61	6.10	-4.54	1.93	0.05	10.16	-25.85	1.41

Table 11a. Mean performance of 11 parents and 24 F_1 hybrids

Crosses/parents	Main vine length (cm)	Primary branches/ plant	Days to first male flower anthesis	Days to first female flower opening	Male flowers/ plant	Female flowers/ plant	Sex ratio	Nodes on main vine	Fruiting nodes on main vine	days to fruit maturity
1	2	3	4	5	6	7	8	9	10	11
$P_5 \times P_1$	545.0	10.0	34.0	41.0	4518.0	102.0	44.29	45.5	3.0	11.0
$P_6 \times P_1$	655.0	10.5	35.0	40.0	4845.0	105.0	46.14	50.0	3.0	11.0
$P_8 \times P_1$	620.0	10.5	35.0	37.5	4490.0	79.5	56.48	52.0	2.0	12.0
$P_9 \times P_1$	560.0	10.0	35.0	38.5	4060.0	85.0	47.76	51.0	2.5	11.0
$P_{10} \times P_1$	770.0	11.0	36.5	40.0	5341.0	108.5	49.23	45.0	3.0	11.0
$P_{11} \times P_1$	525.0	9.5	33.0	38.5	5000.0	119.0	42.02	60.0	4.0	13.0
$P_{12} \times P_1$	540.0	12.0	36.0	40.0	7632.0	105.0	72.69	48.0	3.5	12.0
$P_{13} \times P_1$	695.0	10.8	31.0	41.0	4699.0	120.0	39.16	46.0	3.0	11.0
$P_5 \times P_2$	690.0	11.0	36.0	41.0	4360.0	78.0	55.90	47.0	2.0	13.0
$P_6 \times P_2$	800.0	8.0	40.0	43.0	6300.0	100.0	63.0	49.5	2.0	11.0
$P_8 \times P_2$	600.0	13.0	39.25	44.0	4284.0	75.0	57.12	54.0	3.0	12.0
$P_9 \times P_2$	800.0	14.0	38.0	39.0	4005.0	93.0	43.06	40.0	5.0	10.0
$P_{10} \times P_2$	690.0	12.0	36.5	41.0	5840.0	82.5	70.79	53.0	2.5	12.0
$P_{11} \times P_2$	606.0	12.0	36.0	44.0	6307.0	105.0	60.07	53.0	3.8	11.0
$P_{12} \times P_2$	653.0	11.0	36.0	39.0	5820.0	80.5	72.30	48.0	2.8	13.0
$P_{13} \times P_2$	790.0	14.0	38.5	42.0	6560.0	92.0	71.30	44.0	2.0	12.0
$P_5 \times P_4$	550.0	12.0	30.0	37.0	3898.0	100.0	38.98	60.5	4.5	10.0
$P_6 \times P_4$	670.0	9.5	36.0	42.0	4171.0	82.0	50.87	43.0	3.0	11.0

Contd

Table 11a (conti.)

1	2	3	4	5	6	7	8	9	10	11
$P_8 \times P_4$	570.0	9.5	37.5	42.0	3034.0	69.0	43.97	38.5	2.5	10.0
$P_9 \times P_4$	570.3	9.0	34.5	37.0	2820.0	65.0	43.38	45.0	2.0	11.0
$P_{10} \times P_4$	500.0	13.0	35.0	38.8	3410.0	96.5	35.34	37.5	2.0	10.0
$P_{11} \times P_4$	600.0	8.0	40.0	42.0	4850.0	110.0	44.09	56.5	2.5	10.0
$P_{12} \times P_4$	574.0	10.0	34.0	38.0	6486.0	108.0	60.06	44.0	2.8	13.0
$P_{13} \times P_4$	670.0	14.0	33.0	40.0	5408.0	110.0	49.16	53.4	2.0	11.0
P_1	372.0	12.8	35.5	41.5	3740.0	87.0	42.99	38.0	2.0	12.0
P_2	777.0	15.5	39.3	48.3	5760.0	75.0	76.80	70.0	2.8	10.0
P_4	510.0	8.5	36.0	42.0	2100.0	72.0	29.17	44.0	3.0	12.0
P_5	610.0	11.4	34.0	41.8	3150.0	86.5	36.42	37.8	3.0	13.0
P_6	553.0	12.0	32.5	46.3	3704.0	84.5	43.83	50.0	2.0	12.0
P_8	500.0	9.3	41.0	46.0	2255.0	98.0	23.01	49.0	2.0	13.0
P_9	495.5	12.3	27.3	34.5	2538.0	110.0	23.07	37.8	2.3	10.0
P_{10}	523.0	11.3	38.3	45.8	5565.0	86.5	64.34	57.5	2.5	11.5
P_{11}	468.0	12.5	36.25	41.5	4771.0	84.0	56.80	37.8	2.0	15.0
P_{12}	752.0	9.5	35.0	50.0	6960.0	108.0	64.44	58.0	2.0	13.0
P_{13}	518.0	10.8	33.5	40.5	5897.0	100.0	58.97	37.5	2.0	13.0

Table 11b. Mean performance of 11 parents and 24 F_1 hybrids

Crosses/parents	Days to first fruit picking maturity	Yield/ plant (kg)	Fruits/ plant	Fruit length (cm)	Fruit girth (cm)	Flesh thickness (cm)	Seeds/ fruit	Average fruit weight (g)	Total crop duration (days)
1	2	3	4	5	6	7	8	9	10
$P_5 \times P_1$	52.0	13.3	32.0	50.0	12.1	0.78	58.0	435.0	121.0
$P_6 \times P_1$	53.0	17.4	22.0	51.6	23.0	0.73	64.3	740.0	129.5
$P_8 \times P_1$	49.0	13.5	25.0	60.0	18.0	0.70	47.5	495.0	125.0
$P_9 \times P_1$	50.0	10.5	35.0	35.0	17.0	0.64	47.0	332.0	115.0
$P_{10} \times P_1$	52.5	16.2	49.5	44.4	17.5	0.65	49.5	350.0	123.0
$P_{11} \times P_1$	53.0	18.3	45.0	51.0	16.4	0.65	57.5	353.0	130.0
$P_{12} \times P_1$	51.0	18.0	40.0	43.0	17.0	0.66	50.0	438.0	125.0
$P_{13} \times P_1$	51.8	17.5	34.0	55.0	14.0	0.68	56.0	388.0	130.0
$P_5 \times P_2$	54.0	14.5	37.5	52.0	19.0	0.86	52.0	400.0	120.0
$P_6 \times P_2$	54.0	17.5	23.0	47.5	21.4	0.79	60.0	700.0	127.5
$P_8 \times P_2$	56.0	15.9	26.5	47.0	26.0	0.85	64.0	600.0	130.0
$P_9 \times P_2$	49.0	12.5	32.0	39.2	22.0	0.78	49.5	430.0	115.0
$P_{10} \times P_2$	53.0	17.5	38.0	37.5	20.0	0.80	56.0	515.0	128.5
$P_{11} \times P_2$	55.0	18.6	45.0	50.0	15.0	0.60	52.5	450.0	120.0
$P_{12} \times P_2$	52.0	20.0	23.0	52.7	18.0	0.67	62.0	562.5	126.5
$P_{13} \times P_2$	52.5	16.5	33.0	50.0	17.0	0.77	51.5	500.0	127.0
$P_5 \times P_4$	47.0	16.8	42.0	42.0	19.0	0.60	47.5	432.0	113.0
$P_6 \times P_4$	53.0	18.0	27.0	51.0	19.6	0.80	36.5	570.0	115.0

Contd.

Table 11b (contd.)

1	2	3	4	5	6	7	8	9	10
$P_8 \times P_4$	51.0	14.3	28.0	30.5	21.4	0.80	35.5	461.0	120.0
$P_9 \times P_4$	47.5	12.4	32.5	35.0	19.4	0.77	46.0	425.0	114.0
$P_{10} \times P_4$	49.0	12.0	25.0	27.0	22.4	0.78	54.0	400.0	120.0
$P_{11} \times P_4$	52.0	17.5	34.5	30.3	22.3	0.86	55.5	413.0	125.0
$P_{12} \times P_4$	52.0	18.3	38.0	47.3	16.7	0.80	43.0	498.0	130.5
$P_{13} \times P_4$	52.0	21.0	54.0	35.1	20.2	0.84	61.5	370.0	131.0
P_1	55.0	10.3	39.0	37.3	15.0	0.65	26.8	345.0	127.5
P_2	59.3	16.0	21.0	40.0	27.9	0.93	57.0	600.0	132.0
P_4	59.0	10.3	31.3	33.0	22.8	0.77	41.5	351.0	108.0
P_5	54.5	10.7	24.8	74.5	14.7	0.79	38.0	459.0	107.0
P_6	58.5	8.0	12.6	51.5	20.0	0.75	61.5	600.0	127.5
P_8	44.8	11.1	19.7	49.5	24.0	0.95	54.0	622.0	119.0
P_9	58.5	11.8	42.6	30.7	16.8	0.72	37.0	304.5	105.0
P_{10}	58.5	17.7	43.0	41.0	20.0	0.08	50.4	481.5	127.0
P_{11}	57.5	16.0	23.5	72.0	21.6	0.90	48.4	800.0	125.0
P_{12}	63.5	10.9	15.4	52.5	17.6	0.81	35.0	677.0	125.0
P_{13}	58.5	10.9	28.0	75.0	13.0	0.68	31.0	563.5	119.5

1. Main vine length

Vine length had highly significant variance due to gca and sca. P_8 had the highest gca value of 64.917 followed by P_2 (59.927). P_{12} showed the lowest gca effect (-63.583). The combination P_{10} x P_2 registered the highest value of sca effect (144.41) followed by P_5 x P_4 (134.47) and P_{11} x P_1 (122.12).

2. Primary branches/plant

The variances due to gca and sca were highly significant for this character. The positive values of gca and sca effects indicated increase and negative values, decrease in branches/plant. The genotypes P_{10} and P_{13} had the highest gca effect (0.792 each) and P_{11} had the lowest gca effect (-1.208). The combination P_9 x P_2 had the highest sca effect (2.80) followed by P_5 x P_4 (2.19) and P_{13} x P_4 (2.02). The lowest sca effect was noticed in P_6 x P_2 (-2.70).

3. Days to first male flower anthesis

The variances due to gca and sca effects were highly significant for this trait. The maximum gca effect was noticed in the parent, P_2 (1.844) followed by P_8 (1.562). The minimum was in the genotype P_5 (-2.271) followed by P_{13} (-1.521) and P_1 (-1.156). The maximum sca effect was observed in the cross P_{11} x P_4 (4.35) followed by P_{13} x P_2 (2.49). The sca effect was minimum in the cross, P_5 x P_4 (-2.73).

4. Days to first female flower opening

The variances due to gca and sca effects were highly significant for days to first female flower opening. The parent P_9 had the highest negative gca value (-2.104) indicating earliness for female flower production. This was followed by P_{12} (-1.271). The parent P_6 had the highest positive gca effect (1.396). The crosses P_8 x P_1 and P_{11} x P_1 were with the highest and negative sca effects of -2.96 and -2.29 respectively.

5. Male flowers/plant

This character had highly significant variances due to gca and sca effects. The highest and negative gca effects were shown by the parent P_9 (-1179.781) followed by P_8 (-705.281). The highest and negative sca effect was shown by the cross P_{13} x P_1 (-1318.16).

6. Female flowers/plant

Highly significant variances due to gca and sca effects were noticed for this trait. The maximum gca effect was noticed in the parent P_{11} (13.354) followed by P_1 (9.396).

The minimum was found in the parent P_8 (-14.813). The sca effect was high in P_9 x P_2 (15.94) and P_{10} x P_1 (14.10).

7. Sex ratio

The sex ratio exhibited highly significant variance due to gca effect. The variance due to gca effect was not significant. The highest and negative gca effect was exhibited by the parent P_9 (-7.734) followed by P_4 (-5.830) and P_5 (-5.191). The gca effect was maximum and positive in P_{12} (10.866). The highest and negative sca effect was noticed in the combination P_{13} x P_1 (-16.77) followed by P_8 x P_4 (-12.02) and P_9 x P_2 (-11.44).

8. Nodes on main vine

The nodes on main vine showed highly significant variances due to sca and gca effects. The highest gca effect was shown by the parent P_{11} (8.150) and the lowest by P_9 (-4.350). High sca effects were shown by the crosses P_5 x P_4 (10.55) and P_{13} x P_4 (6.65).

9. Fruiting nodes on main vine

Highly significant variances due to sca and gca effects were noticed for this trait. The gca effect was maximum for parent P_{11} (0.583). The sca effect was maximum in the combination P_9 x P_2 (1.88) followed by P_5 x P_4 (1.54).

10. Days to fruit maturity

This character exhibited highly significant variances due to gca and sca effects. The highest and negative gca effect was found in the parent P_9 (-0.667) followed by P_4 (-0.583). The highest and positive gca effect was found in P_{12} (1.333). The highest and negative sca effect was noticed in $P_9 \times P_2$ (-1.08).

11. Days to first fruit picking maturity

This trait also exhibited highly significant variances due to sca and gca effects. The highest and negative gca effect was observed in the parent P_9 (-2.729) followed by P_4 (-0.885) and P_5 (-0.729) indicating earliness. The highest and negative sca effects were shown by $P_5 \times P_4$ (-3.11) followed by $P_8 \times P_1$ (-2.71) and $P_{10} \times P_4$ (-1.67).

12. Yield/plant

This character exhibited highly significant variances due to gca and sca effects. The gca effect was maximum in the parent P_{12} (2.561) followed by P_{13} (2.149) and P_{11} (1.984). High sca effects were noticed in $P_{13} \times P_4$ (2.61) and $P_5 \times P_4$ (1.79). The lowest sca effect was exhibited by $P_{10} \times P_4$ (-3.32).

13. Fruits/plant

Fruits/plant exhibited significant variance due to gca effects. The variance due to sca effect was not significant for this trait. The maximum gca effect was shown by the parent P_{11} (5.971) followed by P_{10} (5.304) and P_{13} (4.387) and the minimum by P_6 (-9.696). The sca effect was maximum in $P_{12} \times P_1$ (6.31) followed by $P_{13} \times P_4$ (6.10) and $P_{11} \times P_2$ (4.39).

14. Fruit length

The fruit length exhibited highly significant variances due to gca and sca effects. The highest and negative gca effect was shown by the parent P_{10} (-8.04) followed by P_9 (-7.940). The gca effect was positive and maximum in the parent P_6 (5.699). The highest and negative sca effect was shown by $P_{12} \times P_1$ (-9.08) followed by $P_8 \times P_4$ (-8.27). The maximum and positive sca effect was shown by $P_8 \times P_1$ (9.76) followed by $P_6 \times P_4$ (8.03).

15. Fruit girth

The fruit girth showed highly significant variances due to gca and sca effects. The highest gca effect was shown by P_8 (2.919) followed by P_6 (2.385). This was minimum in P_5 (-2.248). The maximum sca effect was shown by $P_6 \times P_1$ (3.73) followed by $P_8 \times P_2$ (3.28). The sca effect was the lowest in $P_{11} \times P_2$ (-3.74).

16. Flesh thickness

This trait also exhibited highly significant variances due to gca and sca effects. The highest gca effect was shown by P_4 (0.041). The highest sca effect was found in $P_{11} \times P_4$ (0.12).

17. Seeds/fruit

This character manifested highly significant variances due to gca and sca effects. The highest gca effect was shown by P_{13} (3.825) and the lowest by P_4 (-4.940). The maximum sca effect was shown by $P_8 \times P_2$ (11.34) and the minimum by $P_6 \times P_4$ (-12.18).

18. Average fruit weight

This trait exhibited highly significant variances due to gca and sca effects. The maximum gca effect was shown by P_6 (203.188) followed by P_2 (48.5) and the minimum by P_9 (-70.979). The maximum sca effect was shown by $P_6 \times P_1$ (97.69).

19. Total crop duration

This trait exhibited highly significant variances due to gca effect. The variance due to sca effect was not significant for this trait. The gca effect was maximum in P_6 (9.844) followed by P_{12} (7.094) and P_{13} (5.344). The sca effect was maximum in P_6 x P_4 (14.66) followed by P_5 x P_2 (5.80).

C. Crossing and evaluation of hybrid vigour

General analysis of variance for 13 parents and 51 hybrids indicated significant differences among the genotypes in all the traits (Appendix III).

The relative heterosis (RH), heterobeltiosis (HB) and standard heterosis (SH) calculated are presented in Tables 12a-12g. They are presented characterwise below.

1. Main vine length

Out of 51 F_1 hybrids studied, 29 showed significant relative heterosis for main vine length. The crosses P_5 x P_4 showed the highest relative heterosis of 69.31% followed by P_{11} x P_1 (64.77%), P_9 x P_5 (51.96%) and P_{10} x P_8 (45.95%).

Significant heterobeltiosis was observed in 17 F_1 hybrids. The highest heterobeltiosis was found in P_{10} x P_4

Table 12a. Mean performance of parents, F_1 hybrids and extent of heterosis for various characters

Parents/crosses	Main vine length				Primary branches/plant				Days to first male flower anthesis			
	Mean (cm)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)	Mean (days)	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
P_1	370.0				13.00				34.5			
P_2	800.0				16.50				37.5			
P_3	600.0				11.00				34.0			
P_4	490.0				9.00				36.5			
P_5	520.0				10.00				32.0			
P_6	570.0				12.00				31.0			
P_7	500.0				12.00				36.5			
P_8	490.0				8.60				40.0			
P_9	500.0				14.00				26.7			
P_{10}	500.0				11.00				37.0			
P_{11}	510.0				12.00				35.4			
P_{12}	760.0				8.50				35.0			
P_{13}	480.0				10.50				32.0			
$P_2 \times P_1$	570.0	-2.56	-28.75	0.00	8.25	-44.07	-50.00	-31.25	37.5	4.17	8.70	20.97
$P_3 \times P_1$	520.0	7.22*	-13.33	8.77	11.00	-8.33	-15.38	-8.33	29.0	-15.33**	-14.71**	-6.45*
$P_4 \times P_1$	500.0	16.27**	-2.00	-12.28	10.00	9.09	-23.00	-16.67	33.5	-5.63*	-2.90	8.06
$P_4 \times P_2$	377.5	-41.47	-52.81	-33.77	11.25	-11.76	-31.82	-6.25	36.0	-2.70	-1.37	16.13
$P_4 \times P_3$	570.0	4.59	5.00	0.00	7.00	-30.00	-36.36	-41.67	31.5	-10.64**	7.35	1.61
$P_5 \times P_1$	490.0	10.11**	5.77	-14.04	11.00	-4.35	-15.38	-8.33	34.0	2.26	6.25	9.68
$P_5 \times P_2$	700.0	6.06	-12.50	22.80**	10.50	-20.25	-36.36	12.50	34.0	-2.16	6.25	9.68
$P_5 \times P_3$	542.5	-3.13	-9.58	-4.82	13.63	29.81**	23.90**	13.54**	36.0	9.09	12.50	16.33
$P_5 \times P_4$	855.0	69.31**	64.42**	50.00**	16.00	68.42**	60.00**	33.33**	28.0	-18.25**	-12.50**	-9.68**
$P_6 \times P_1$	695.0	47.87**	21.93**	21.93**	11.00	-12.00	-15.38	-8.30	34.0	3.82	9.58	9.68
$P_6 \times P_2$	660.0	-2.92	-17.50	15.79**	6.75	-52.63	-59.09	-43.75	38.0	10.95	22.58	22.58
$P_6 \times P_4$	545.0	2.83	-4.39	-4.39	12.00	14.29**	0.00	0.00	36.5	8.15	17.74	17.74
$P_6 \times P_5$	490.0	-10.09	-14.04	-14.04	12.00	13.64**	0.00	0.00	32.0	1.59	3.23	3.23
$P_7 \times P_2$	650.0	0.00	-15.00	19.30**	13.40	-5.96	-18.76	-11.67	34.5	-6.76**	-5.48*	11.29
$P_7 \times P_3$	570.0	3.64	-5.00	0.00	12.40	7.83	3.33	3.33	37.5	6.38	10.29	20.97
$P_7 \times P_6$	600.0	12.15**	5.26	5.26	13.00	8.33*	8.33	8.33	35.0	3.70	12.90	12.90

Contd.

Table 12a (contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13
$P_8 \times P_1$	560.0	30.23**	14.29**	-1.75	12.00	11.11*	-7.69	0.00	32.5	-12.75**	-5.80*	4.84
$P_8 \times P_4$	640.0	30.61**	30.61**	12.28**	8.50	3.41	-5.55	-29.17	35.5	-7.84**	-2.74	14.52
$P_8 \times P_5$	520.0	2.97	0.00	-8.77	10.50	12.90*	5.00	-12.50	37.5	4.17	17.19	20.97
$P_9 \times P_2$	550.0	-15.38	-31.25	-3.51	15.50	1.64	-6.06	29.17**	36.0	12.15	34.83	16.13
$P_9 \times P_4$	630.0	27.43**	26.16**	10.67**	11.00	-4.35	-21.43	-8.33	32.5	2.85	21.72	4.84
$P_9 \times P_5$	775.0	51.96**	49.04**	35.96**	11.50	-4.17	-17.86	-4.17	30.5	3.92	11.88	1.61
$P_9 \times P_6$	620.0	15.89**	8.77**	8.77**	13.00	0.00	-7.14	8.33	33.0	14.38	23.60	6.45
$P_{10} \times P_1$	520.0	19.54**	4.00	-8.77	11.00	-8.33	-15.38	-8.33	34.5	-3.50	0.00	11.29
$P_{10} \times P_3$	670.0	21.82**	11.67**	17.54**	11.00	0.00	0.00	-8.33	35.5	0.00	4.41	14.52
$P_{10} \times P_4$	855.0	35.35**	71.00**	50.00**	13.50	35.00**	22.73**	12.50**	33.5	-8.84**	-8.22**	8.06
$P_{10} \times P_6$	590.0	10.28**	3.51	3.51	13.00	13.04**	8.33	8.33**	34.0	0.00	9.68	9.68
$P_{10} \times P_7$	540.0	8.00**	8.00**	-5.26	13.50	17.39**	12.50**	12.50**	35.0	-4.76*	-4.11*	12.90
$P_{10} \times P_8$	722.5	45.95**	44.50**	26.75**	13.75	40.30**	25.00**	14.58**	36.0	6.49	-2.70	16.13
$P_{11} \times P_1$	725.0	64.77**	42.16**	27.19**	10.25	-18.00	-21.15	-14.58	31.5	-10.00**	-8.70**	1.61
$P_{11} \times P_2$	745.0	13.74**	-6.86	30.70**	11.75	-17.54	-28.79	-2.08	33.0	-9.47**	-6.78**	6.45
$P_{11} \times P_4$	560.0	12.00**	9.80**	-1.70	6.50	-38.09	-27.78	-45.83	41.0	14.05	15.82	32.76
$P_{11} \times P_6$	600.0	11.00**	5.26	5.26	11.50	-4.17	-4.17	-4.17	33.5	1.11	8.06	8.06
$P_{11} \times P_8$	670.0	34.00**	31.37**	17.54**	8.00	-22.33	-33.33	-33.33	32.0	-15.12**	-9.60**	3.23
$P_{11} \times P_9$	500.0	-0.99	-1.96	-12.28	11.50	-11.54	-17.86	-4.17	34.0	8.96	27.34	9.68
$P_{12} \times P_1$	540.0	-3.14	-27.50	-5.26	13.00	20.93**	0.00	8.33**	33.5	-3.60	-2.90	8.06
$P_{12} \times P_2$	585.0	-25.00	-26.85	-2.63	11.75	-6.00	-28.79	-2.08	36.5	0.69	4.29	17.74
$P_{12} \times P_4$	615.0	-1.65	-12.50	16.67**	9.75	11.43**	8.33**	-18.75	35.0	-2.10	0.00	12.90
$P_{12} \times P_5$	645.0	0.78	-15.13	13.16**	8.50	-8.11	-15.00	-29.17	31.0	-7.46**	-3.13	0.00
$P_{12} \times P_6$	740.0	11.28**	-2.63	29.82**	11.00	7.32**	-8.33	-8.33	33.5	1.52	8.06	8.06
$P_{12} \times P_8$	775.0	24.00**	1.97	35.96**	7.75	-9.36	-9.85	-35.42	32.8	-6.67**	0.00	5.81
$P_{12} \times P_9$	565.0	-10.32	-25.65	-0.88	11.50	2.22	-17.86	-4.17	34.0	12.50	34.83	9.68
$P_{12} \times P_{11}$	585.0	-7.87	-23.03	2.63	12.50	21.95**	4.17	4.17	35.0	-0.57	0.00	12.90
$P_{13} \times P_1$	500.0	15.29**	4.16	-14.04	12.50	8.70**	-3.85	-4.17	28.5	-14.29**	-10.94**	-8.06**
$P_{13} \times P_4$	640.0	27.83**	26.53**	8.77**	13.25	39.47**	32.50**	10.42**	30.0	-12.41**	-6.25*	-3.26
$P_{13} \times P_6$	485.0	-7.62	-14.91	-14.91	14.00	27.27**	16.66**	16.66**	31.5	0.00	1.61	0.00
$P_{13} \times P_7$	520.0	6.12	4.00	-8.70	8.80	-20.00	-26.67	-26.67	41.5	21.17	29.69	33.87
$P_{13} \times P_8$	700.0	44.32**	42.86**	22.81**	10.50	12.90**	5.00	-12.50	35.0	-2.78	9.38	12.90
$P_{13} \times P_{10}$	480.0	-2.04	-4.00	-15.79	9.75	-7.14	-2.27	-18.75	34.5	0.00	7.81	11.29
$P_{13} \times P_{11}$	632.0	27.78**	24.02**	10.96**	8.75	-20.45	-27.08	-27.08	36.5	8.31	14.06	17.74
$P_{13} \times P_{12}$	600.0	-3.23	-21.05	5.26	10.50	13.51**	-5.00	-12.50	39.0	16.42	21.88	25.81
CD (P = 0.05)		32.53	37.56	37.56		0.91	1.05	1.05		1.51	1.74	1.74
CD (P = 0.01)		43.26	49.96	49.56		1.21	1.39	1.39		2.01	2.32	2.32

(71.00%). The other combinations exhibited heterobeltiosis were P_5 x P_4 (64.42%), P_{10} x P_8 (44.50%), P_{13} x P_8 (42.86%) and P_{11} x P_1 (42.16%).

Standard heterosis was significant in 22 F_1 hybrids. The highest value was observed in P_5 x P_4 and P_{10} x P_4 (50.00% each). The combinations P_{12} x P_8 and P_9 x P_5 showed standard heterosis of 35.96% each.

2. Primary branches/plant

Out of 51 combinations, 20 F_1 hybrids showed significant relative heterosis for primary branches/plant. The cross, P_5 x P_4 showed maximum relative heterosis of 68.42% followed by P_{10} x P_8 (40.30%), P_{13} x P_4 (39.47%) and P_{10} x P_4 (35.00%).

Heterobeltiosis was shown by 8 combinations. Heterobeltiosis was maximum in P_5 x P_4 (60.00%) followed by P_{13} x P_4 (32.50%), P_{10} x P_8 (25.00%) and P_5 x P_3 (23.90%).

Standard heterosis was significant in 10 combinations. It was maximum in P_5 x P_4 (33.33%) followed by P_9 x P_2 (29.17%) and P_{13} x P_6 (16.66%).

3. Days to first male flower anthesis

Relative heterosis was significant in 16 combinations. It was the highest in P_5 x P_4 (-18.25%) followed by P_3 x P_1

(-15.33%), P_{11} x P_8 (-15.12%), P_{13} x P_1 (-14.29%) and P_8 x P_1 (-12.75%). Heterobeltiosis was manifested in 10 combinations. This was high in P_3 x P_1 (-14.71%), P_5 x P_4 (-12.50%), P_{13} x P_1 (-10.94%), P_{11} x P_8 (-9.60%) and P_{11} x P_1 (-8.70%).

Out of 51 F_1 hybrids, significant standard heterosis was exhibited by three combinations. They were P_5 x P_4 (-9.68%), P_{13} x P_1 (-8.06%) and P_3 x P_1 (-6.45%).

4. Days to first female flower opening

Significant relative heterosis was noticed in 36 crosses. Relative heterosis was the highest in P_{10} x P_7 (-19.27%) followed by P_7 x P_6 (-18.91%), P_{13} x P_7 (-18.10%), P_8 x P_1 (-17.65%) and P_{12} x P_8 (-17.20%). Heterobeltiosis was significant in 14 crosses. It was the highest in P_{10} x P_4 (-16.82%) followed by P_5 x P_4 (-15.63%), P_{12} x P_8 (-14.44%), P_{12} x P_2 (-13.54%) and P_{10} x P_8 (-13.33%).

Standard heterosis was significant in 42 F_1 hybrids. It was maximum in P_5 x P_4 (-25.00%) followed by P_8 x P_1 (-22.22%). The crosses, P_{10} x P_4 and P_{13} x P_{10} were having the same standard heterosis of -18.89%.

5. Male flower/plant

Out of 51 hybrids evaluated, 14 showed significant relative heterosis. The highest and negative relative

Table 12b. Mean performance of parents, F_1 hybrids and extent of heterosis for various characters

Parents/crosses	Days to first female flower opening				Male flowers/plant				Female flowers/plant			
	Mean (days)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
P_1	40.00				5200.0				127.0			
P_2	47.00				6400.0				96.5			
P_3	38.00				9000.0				80.0			
P_4	40.00				2700.0				87.0			
P_5	40.00				4500.0				89.0			
P_6	45.00				4900.0				102.0			
P_7	65.00				10500.0				85.0			
P_8	45.00				2400.0				69.0			
P_9	33.50				3500.0				107.0			
P_{10}	44.00				7200.0				129.0			
P_{11}	40.00				5420.0				92.0			
P_{12}	48.00				8500.0				96.0			
P_{13}	40.00				7000.0				105.0			
$P_2 \times P_1$	40.00	-8.05**	0.00	-11.11**	6820.0	12.41	31.15	33.06	113.0	1.12	-11.02	10.78**
$P_3 \times P_1$	38.00	15.38	18.42	0.00	8020.0	12.96	54.23	36.73	117.5	13.53**	-7.48	15.20**
$P_4 \times P_1$	36.75	-8.12**	-8.12**	-18.33**	4750.0	20.25	75.95	-3.06	91.0	-0.82	-5.70	-10.78
$P_4 \times P_2$	39.25	-9.77**	-0.52	-12.78**	6000.0	31.87	122.22	22.45	91.0	-0.82	-5.70	-10.78
$P_4 \times P_3$	37.00	-5.13*	-2.63	-17.78**	7600.0	29.91	181.48	55.01	104.0	24.58**	19.54**	1.96
$P_5 \times P_1$	40.00	0.00	0.00	-11.11**	5050.0	3.51	12.22	2.45	110.0	1.85	-13.04	7.84
$P_5 \times P_2$	40.00	-8.05**	0.00	11.11**	5000.0	-8.26**	11.11	2.04	91.0	-1.89	-5.70	-10.78
$P_5 \times P_3$	37.00	-5.12*	-2.63	-17.78**	7130.0	5.63	58.44	45.51	106.0	25.44**	19.10**	3.02
$P_5 \times P_4$	33.75	-15.63**	-15.63**	-25.00**	4200.0	16.67	55.56	-14.29**	108.0	22.73**	21.35**	5.88
$P_6 \times P_1$	40.50	-4.71*	1.25	-10.00**	5000.0	-0.99	2.04	2.04	120.0	4.80	-5.51	17.65**
$P_6 \times P_2$	41.50	-9.78**	-11.70**	-7.78**	7160.0	6.20	46.12	22.45	99.0	-0.25	-2.94	-2.94
$P_6 \times P_4$	43.50	2.35	3.33	-3.33	5010.0	3.58	85.56	2.04	107.5	13.76**	5.39	5.39
$P_6 \times P_5$	46.00	8.23	2.22	2.22	5200.0	10.64	15.56	6.12	109.0	14.14**	6.86	6.86
$P_7 \times P_2$	50.75	-9.38**	7.98	12.78	7275.0	-13.91**	13.67	48.47	84.5	-6.89	-12.44	-17.16
$P_7 \times P_3$	50.40	-2.44	32.63	12.00	9200.0	-5.64**	-2.22	87.76	93.4	13.21**	9.88*	-8.43
$P_7 \times P_6$	44.60	-18.91**	-0.89	-0.89	6700.0	-12.99**	36.73	36.73	94.5	-8.70	-7.35	-7.35
$P_8 \times P_1$	35.00	-17.65**	-12.50**	-22.22**	5000.0	31.58	108.33	2.04	88.5	19.69**	-30.31	-13.33
$P_8 \times P_4$	40.50	-4.71*	1.25	-10.00**	2712.0	10.78	13.00	42.34	91.5	17.30**	5.17	-10.29

Contd

Table 12b (contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13
$P_8 \times P_5$	43.50	2.35	8.75	-3.33	3790.0	9.86	57.92	-22.65**	87.00	10.13*	-2.25	-14.71
$P_9 \times P_2$	37.00	-8.07**	10.44	-17.78**	3500.0	-29.29**	0.00	-28.57**	100.00	-1.57	-6.54	-1.96
$P_9 \times P_4$	38.00	3.40	13.43	-15.56**	3000.0	-3.23	11.11	-38.78**	98.50	1.54	-7.94	-3.43
$P_9 \times P_5$	37.50	2.04	11.94	-18.89**	5100.0	27.50	45.71	4.08	127.50	30.12**	19.16**	25.00**
$P_9 \times P_6$	42.70	8.79	21.55	-5.11*	4500.0	7.14	28.57	-8.10**	106.00	1.44	-0.93	3.92
$P_{10} \times P_1$	38.00	-9.52**	-5.00	-15.50**	6000.0	-3.22	15.38	22.45	124.00	-1.56	-2.32	23.53**
$P_{10} \times P_3$	39.50	3.66	3.95	-12.22**	8500.0	4.94	18.06	73.47	123.00	17.70**	-4.65	20.59**
$P_{10} \times P_4$	36.50	-13.09**	-16.82**	-18.89**	3890.0	-21.41**	28.51	-20.61**	72.00	-33.33	-44.96	-29.41
$P_{10} \times P_6$	41.50	-6.74**	-5.68*	-7.78**	6670.0	10.25	36.10	36.12	107.90	-7.36	-16.36	5.78
$P_{10} \times P_7$	44.00	-19.27**	0.00	-2.22	8400.0	-5.08**	16.67	71.43	104.50	-2.34	-18.99	2.45
$P_{10} \times P_8$	39.00	-12.35**	-13.33*	-13.33**	6000.0	25.00	150.00	22.45	103.50	4.55	-19.77	1.25
$P_{11} \times P_1$	38.00	-2.50*	-2.50	-15.55**	5400.0	3.58	3.85	12.24	130.00	18.76**	2.36	27.45**
$P_{11} \times P_2$	41.00	-5.75*	2.50	-8.89**	6220.0	3.21	85.56	24.49	112.00	18.83**	16.06**	9.80*
$P_{11} \times P_4$	38.00	-5.00*	-5.00	-15.56**	5260.0	23.15	94.81	2.04	107.75	8.94**	16.85**	5.63
$P_{11} \times P_6$	42.50	0.00	6.25	-5.56*	5170.0	0.19	5.51	5.51	109.00	12.37**	6.86	6.86
$P_{11} \times P_8$	42.75	0.59	6.88	-5.00*	5750.0	47.44	139.58	26.53	80.00	-0.62	-13.04	-21.50
$P_{11} \times P_9$	37.00	0.68	10.45	-17.78**	4500.0	0.90	28.57	-8.16**	100.00	0.50	-6.54	-1.96
$P_{12} \times P_1$	37.50	-14.77**	-6.25**	-16.67**	9000.0	35.33	73.08	34.35	117.50	5.38	-7.48	15.12**
$P_{12} \times P_2$	41.50	-12.63**	-13.54**	-7.78**	6700.0	-12.75**	4.69	36.73	90.00	-6.48	-6.74	-11.76
$P_{12} \times P_4$	39.75	-9.66**	-0.625	-11.67**	6850.0	22.32	153.70	39.80	118.50	29.51**	23.44**	16.18**
$P_{12} \times P_5$	38.50	-12.50**	-3.75	-14.44**	9000.0	38.46	100.00	83.67	121.50	31.33**	26.56**	19.12**
$P_{12} \times P_6$	42.50	-9.20**	-5.56*	-5.56*	6300.0	-5.97**	28.57	28.57	88.00	-11.11	-13.73	-13.73
$P_{12} \times P_8$	38.50	-17.20**	-14.44**	-14.44**	8850.0	46.79	268.75	63.27	110.00	33.33**	14.58**	7.84
$P_{12} \times P_9$	39.00	-4.29*	16.42	-13.33**	7000.0	16.67	100.00	42.86	106.50	4.93	-0.47	4.41
$P_{12} \times P_{11}$	38.75	-11.93**	-3.13	-13.89**	6000.0	-13.17**	10.70	22.45	86.00	-8.51	-10.42	15.69
$P_{13} \times P_1$	38.50	-3.75	-3.75	-14.44**	4900.0	-19.67**	-5.77	0.00	127.50	9.91**	0.39	24.57**
$P_{13} \times P_4$	37.50	-6.25**	-6.25*	-16.67**	7000.0	44.33	191.67	42.85	122.50	21.88**	11.43**	14.71**
$P_{13} \times P_6$	36.50	-14.12**	-8.75**	-18.81**	3050.0	4.20	-37.76**	37.76**	103.00	-0.48	-1.94	0.98
$P_{13} \times P_7$	43.00	-18.10**	7.50	-4.44	8600.0	-1.71	22.86	75.51	110.00	15.79**	4.76	-7.35
$P_{13} \times P_8$	38.50	-9.41**	-3.75	-14.44**	7860.0	65.96	227.50	59.18	92.25	6.03**	-12.14	-9.56
$P_{13} \times P_{10}$	36.50	-13.09**	-8.75**	-18.89**	5000.0	-29.58**	-44.43**	2.04	104.00	-11.11	-19.38	1.96
$P_{13} \times P_{11}$	39.75	-0.63	-0.63	-11.67**	4927.0	-20.66**	-9.10**	0.55	89.50	-9.14	-14.76	-12.25
$P_{13} \times P_{12}$	40.00	-9.09**	0.00	-12.50**	6300.0	-18.71**	-10.00**	28.57	100.00	-0.50	-4.76	-1.96
CD (P=0.05)*		1.74	2.01	2.01		271.08	313.02	313.02		7.05	8.14	8.14
CD (P=0.01)**		2.31	2.67	2.67		360.54	416.31	416.31		9.38	10.83	10.83

heterosis was exhibited by the cross, P_{13} x P_{10} (-29.58%) followed by P_9 x P_2 (-29.29%), P_{10} x P_4 (-221.41%) and P_{13} x P_1 (-19.67%).

Heterobeltiosis was expressed by four combinations. The combinations were P_{13} x P_{10} (-44.43%), P_{13} x P_{11} (-9.10%), P_{13} x P_{12} (-10.00%) and P_{13} x P_6 (-37.76%).

Significant standard heterosis was found in eight combinations. The highest and negative standard heterosis was shown by P_9 x P_4 (-38.78%) followed by P_9 x P_2 (-28.57%) and P_8 x P_5 (-22.65%).

6. Female flowers/plant

Out of 51 F_1 hybrids, 23 hybrids showed significant relative heterosis. Relative heterosis was maximum in P_{12} x P_8 (33.33%). The crosses P_{12} x P_5, P_9 x P_5, P_{12} x P_4, P_5 x P_4 and P_4 x P_3 showed relative heterosis of 31.33%, 30.12%, 29.51%, 22.73% and 24.58% respectively. Heterobeltiosis was observed in 11 combinations. Heterobeltiosis was maximum in P_{12} x P_5 (26.56%). The combinations, P_{12} x P_4, P_5 x P_4, P_4 x P_3 and P_9 x P_5 showed heterobeltiosis of 23.44%, 21.35%, 19.54% and 19.16% respectively.

Standard heterosis was significant in 13 F_1 hybrids. The standard heterosis was maximum in P_{11} x P_1 (27.45%),

Table 12c. Mean performance of parents, F_1 hybrids and extent of heterosis for various characters

Parents/crosses	Sex ratio				Nodes on main vine				Fruiting nodes on main vine			
	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
P_1	40.94				39.00				1.00			
P_2	66.32				69.00				4.00			
P_3	112.50				45.00				2.00			
P_4	31.03				40.00				3.50			
P_5	50.56				35.00				3.50			
P_6	48.04				45.00				1.50			
P_7	123.50				39.00				0.50			
P_8	34.78				48.00				2.50			
P_9	32.71				40.00				1.50			
P_{10}	55.81				56.00				1.50			
P_{11}	58.90				36.00				1.00			
P_{12}	88.54				56.00				2.00			
P_{13}	66.67				36.00				1.50			
$P_2 \times P_1$	60.38	12.59	47.48	25.60	43.50	-19.44	-36.96	-3.33	3.50	40.00*	-12.50	133.33**
$P_3 \times P_1$	68.25	-11.04**	66.71	42.07	42.00	0.00	-6.67	-6.67	3.00	100.00**	50.00*	100.00**
$P_4 \times P_1$	40.25	11.84	29.71	-16.22**	38.75	-1.90	-3.13	-13.89	4.00	77.78**	14.29	166.67**
$P_4 \times P_2$	65.93	35.85	112.47	37.24	38.50	-29.36	-44.20	-14.44	2.00	-46.67	-50.00	33.33
$P_4 \times P_3$	73.00	-3.95	143.33	51.96	43.00	1.18	-4.44	-4.44	5.50	100.00**	57.14**	266.67**
$P_5 \times P_1$	45.90	0.39	12.12	-2.13	40.80	8.11**	2.50	-11.11	3.50	55.56*	0.00	133.33**
$P_5 \times P_2$	55.00	-5.84	8.91	14.57	50.00	-0.99	-10.71	11.11**	2.75	-26.67	-31.25	83.33*
$P_5 \times P_3$	67.29	-17.53**	32.99	39.97	33.25	-16.88	-26.11	-26.11	2.50	-9.09	-28.57	66.67*
$P_5 \times P_4$	38.89	-4.68	25.33	-19.05**	65.60	74.61**	63.75**	45.56**	5.50	57.14**	57.14**	266.67**
$P_6 \times P_1$	41.67	-6.34	1.78	-13.26*	55.00	30.95**	22.22**	22.22**	2.50	100.00**	66.67*	66.67*
$P_6 \times P_2$	72.32	26.48	50.54	50.54	54.00	-5.26	-21.74	20.00**	2.50	-9.09	-37.50	66.67*
$P_6 \times P_4$	46.60	17.90	50.18	-3.00	41.00	-3.53	-13.54	-8.89	2.50	0.00	-28.57	66.67*
$P_6 \times P_5$	47.71	-3.23	-0.69	54.00	37.00	-7.50	-17.78	-17.78	3.20	28.00	-8.57	113.33**
$P_7 \times P_2$	86.00	-6.43**	29.67	29.02	49.50	-8.33	-28.26	10.00**	3.75	66.67**	-6.25	150.00**
$P_7 \times P_3$	98.50	-16.53**	-12.44**	105.04	43.00	2.38	-4.44	-4.44	3.50	180.00**	75.00**	133.33**
$P_7 \times P_6$	70.90	-17.34**	47.59	47.59	47.50	13.10**	5.56	5.56	2.75	175.00**	83.33*	83.33*
$P_8 \times P_1$	56.49	49.23	62.42	17.61	47.00	8.05	-2.08	4.44	1.50	-14.29	-40.00	0.00

Contd.

Table 12c (contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13
$P_8 \times P_4$	29.64	-9.91	-4.48	1.08	34.00	-22.73	-29.17	-24.44	2.50	-16.67	-28.57	66.67*
$P_8 \times P_5$	43.56	2.16	25.24	-9.33	53.50	28.92**	11.46**	18.89**	2.75	-8.33	-21.43	83.33*
$P_9 \times P_2$	35.00	-29.33**	7.00	-27.14**	33.00	-39.44	-52.17	-26.67	5.00	81.82**	25.00*	233.33**
$P_9 \times P_4$	30.46	-4.42	-1.84	-36.59**	43.00	7.50*	7.50	-4.44	3.50	250.00**	0.00	133.33**
$P_9 \times P_5$	40.00	-3.94	22.29	-16.74**	51.00	36.00**	27.50**	13.33**	5.50	120.00**	57.14**	266.67**
$P_9 \times P_6$	42.45	5.13	29.78	-11.64	49.00	15.29**	8.89*	8.89*	3.00	100.00**	100.00**	100.00**
$P_{10} \times P_1$	48.39	0.02	18.19	0.73	58.00	22.10**	3.14	28.89**	2.25	80.00**	50.00	50.00
$P_{10} \times P_3$	69.00	-22.91**	21.05	43.63	54.00	6.93*	-3.50	20.00**	6.00	242.86**	200.00**	300.00**
$P_{10} \times P_4$	54.03	24.44	74.12	1.47	33.75	-28.19	-39.73	-25.00	1.25	-50.00	-64.24	-50.00
$P_{10} \times P_6$	61.82	19.04	28.68	28.68	54.30	7.52**	-0.33	20.67**	1.75	16.67	16.67	16.67
$P_{10} \times P_7$	80.38	-10.34**	44.05	67.32	39.00	-17.89	-30.36	-13.33	4.00	300.00**	166.67**	166.67**
$P_{10} \times P_8$	58.25	28.62	67.48	21.25	45.00	-13.46	-19.64	0.00	3.50	75.00**	45.00*	133.33**
$P_{11} \times P_1$	41.54	-16.79**	1.47	-13.53*	58.00	54.67**	48.72**	28.89**	5.00	400.00**	400.00**	233.33**
$P_{11} \times P_2$	55.54	-11.29**	-5.70	15.61	60.50	15.24**	-12.32	34.44**	4.50	80.00**	12.50	200.00**
$P_{11} \times P_4$	48.93	8.80	57.69	1.87	56.00	47.37**	40.00**	24.44**	2.75	22.22	-21.43	83.33*
$P_{11} \times P_6$	47.43	11.28	-1.27	-1.27	49.00	20.99**	8.89**	8.89*	2.00	60.00**	33.33	33.33
$P_{11} \times P_8$	71.88	53.46	106.67	70.44	41.50	-1.19	-13.54	-7.81	3.00	71.43**	20.00	100.00**
$P_{11} \times P_9$	45.00	1.75	37.57	-6.33	45.00	18.42**	12.50**	0.00	3.00	140.00**	100.00**	100.00**
$P_{12} \times P_1$	78.89	21.86	92.70	30.85	47.50	0.00	-15.18	5.56	4.75	216.67**	137.50**	216.67**
$P_{12} \times P_2$	74.44	-3.86	12.26	54.95	44.00	-29.60	-36.23	-2.22	2.75	-8.33	-31.25	83.33*
$P_{12} \times P_4$	57.81	-3.31	86.24	20.34	50.25	4.69	-10.27	11.67**	2.25	-18.14	-35.71	50.00
$P_{12} \times P_5$	74.07	6.50	44.50	54.18	48.50	6.59*	-13.39	7.78**	3.50	27.27	0.00	133.33**
$P_{12} \times P_6$	71.60	4.85	49.04	49.04	58.00	14.85**	3.57	28.89**	2.25	28.57	12.50	50.00
$P_{12} \times P_8$	80.00	29.74	130.00	66.53	51.00	-1.92	-8.93	13.33**	5.50	122.22**	100.00**	233.73**
$P_{12} \times P_9$	65.72	8.41	100.92	36.80	47.50	-1.04	-8.50	5.56	3.00	71.43**	50.00*	100.00**
$P_{12} \times P_{11}$	69.76	-5.37*	18.44	45.21	47.75	3.86	-14.73	6.11	2.25	50.00**	12.50	50.00
$P_{13} \times P_1$	38.44	-28.58**	-6.13	20.00	39.00	4.00	0.00	-13.33	2.75	120.00**	83.33**	83.33*
$P_{13} \times P_4$	59.83	22.48	92.81	24.54	49.00	28.94**	22.50**	8.89*	2.00	-20.00	-42.86	33.33
$P_{13} \times P_6$	30.50	-46.83**	-36.51**	-36.51**	47.00	16.05**	4.44	4.44	2.50	66.67*	66.67*	66.67*
$P_{13} \times P_7$	78.20	-17.61**	17.90	62.78	36.50	-2.67	-6.41	-6.41	2.50	150.00**	66.67*	66.67*
$P_{13} \times P_8$	84.78	67.12	143.76	76.48	41.50	-1.19	-13.54	-7.78	1.75	-12.50	-30.00	16.67
$P_{13} \times P_{10}$	48.68	-21.49**	-13.85**	0.08	34.50	-25.00	-21.50	-23.33	3.00	100.00**	100.00**	100.00**
$P_{13} \times P_{11}$	55.05	-12.33**	-6.54	14.59	45.50	26.39**	26.39**	1.11	2.50	100.00**	66.67*	66.67*
$P_{13} \times P_{12}$	63.00	-18.81**	-5.50	14.09	53.00	15.22**	-5.36	17.78**	1.75	0.00	-12.50	16.67
CD (P=0.05)*		3.93	4.53	4.53		2.68	3.09	3.09		0.85	0.98	0.98
CD (P=0.01)**		5.22	6.03	6.03		3.56	4.11	4.11		1.13	1.31	1.31

followed by P_9 x P_5 (25.00%), P_{13} x P_1 (24.05%), P_{10} x P_1 (23.53%), P_{10} x P_3 (20.59%) and P_{12} x P_5 (19.12%).

7. Sex ratio

Out of 51 F_1 hybrids evaluated, 17 expressed significant relative heterosis for sex ratio. Relative heterosis was maximum in P_{13} x P_6 (-46.83%). The combinations P_9 x P_2, P_{13} x P_1, P_{10} x P_3 and P_{13} x P_{10} showed relative heterosis of -29.31%, -28.58%, -22.91% and -21.49% respectively. Heterobeltiosis was significant only in three combinations, P_{13} x P_6, P_{13} x P_{10} and P_7 x P_3 with values -36.51%, -13.85% and -12.44% respectively.

Standard heterosis was observed in eight crosses. It was maximum in P_9 x P_4 (-36.59%), followed by P_{13} x P_6 (-13.53%), P_9 x P_2 (-27.14%) and P_5 x P_4 (-19.05%).

8. Nodes on main vine

Out of 51 F_1 hybrids studied, 22 showed significant relative heterosis. Relative heterosis was maximum in P_5 x P_4 (74.61%). The crosses, P_{11} x P_1, P_{11} x P_4, P_9 x P_5, P_6 x P_1 and P_{13} x P_4 exhibited relative heterosis of 54.67%, 47.37%, 36.00%, 30.95% and 28.94% respectively.

Significant heterobeltiosis was noticed in 11 F_1 hybrids for nodes on main vine. The combination, P_5 x P_4

expressed the highest heterobeltiosis of 63.75% followed by P_{11} x P_1 (48.72%), P_{11} x P_4 (40.00%), P_9 x P_5 (27.50%), P_{13} x P_{11} (26.39%) and P_{13} x P_4 (22.50%).

Significant standard heterosis was exhibited by 21 combinations. It was maximum in the cross, P_5 x P_4 (45.56%). The other combinations having high standard heterosis were P_{11} x P_2 (34.44%), P_{10} x P_1 (28.89%), P_{11} x P_1 (28.89%), P_{12} x P_6 (28.89%), P_{11} x P_4 (24.44%), P_6 x P_1 (22.22%) and P_{10} x P_6 (20.67%).

9. Fruiting nodes on main vine

Significant relative heterosis was expressed by 31 F_1 hybrids. The relative heterosis was maximum in P_{11} x P_1 (400.00%) followed by P_{10} x P_7 (300.00%), P_9 x P_4 (250.00%), P_{10} x P_3 (242.86%), P_{12} x P_1 (216.67%) and P_7 x P_6 (175.00%). Heterobeltiosis was observed in 22 crosses. It was maximum in P_{11} x P_1 (400.00%) followed by P_{10} x P_3 (200.00%), P_{10} x P_7 (166.67%) and P_{12} x P_6 (137.50%).

Out of 51 F_1 hybrids, 39 showed significant standard heterosis. The combination, P_{10} x P_3 showed maximum standard heterosis of 300.00%. This was followed by P_4 x P_3 (266.67%), P_5 x P_4 (266.67%), P_9 x P_5 (266.67%), P_{11} x P_1 (233.33%) and P_{12} x P_8 (233.33%).

10. Days to fruit maturity

For days to fruit maturity, significant relative heterosis was noticed in 24 F_1 hybrids. The F_1 hybrids P_{11} x P_6 and P_{11} x P_4 had the highest relative heterosis of -24.52% followed by P_4 x P_3 (-22.22%). The combinations, P_{11} x P_8, P_{13} x P_6, P_5 x P_4, P_6 x P_5 and P_8 x P_4 showed relative heterosis of -20.0% each. Heterobeltiosis was noticed in 19 F_1 hybrids. The hybrids P_5 x P_4, P_6 x P_5, P_8 x P_4, P_{11} x P_4, P_{11} x P_6 and P_{13} x P_6 expressed heterobeltiosis of -16.67% each. The crosses P_{11} x P_8 and P_{13} x P_{12} showed heterobeltiosis of -15.38% each. Significant standard heterosis was noticed in 24 combinations. The crosses, P_5 x P_4, P_6 x P_5, P_8 x P_4, P_9 x P_2, P_9 x P_5, P_{10} x P_4, P_{11} x P_4, P_{11} x P_6 and P_{13} x P_6 showed standard heterosis of -16.67% each.

11. Days to first fruit picking maturity

Out of 51 F_1 hybrids evaluated, 15 showed significant relative heterosis. Relative heterosis was maximum in P_5 x P_3 (-19.63%) followed by P_{12} x P_1 (-19.30%), P_{12} x P_2 (-19.30%), P_7 x P_6 (-18.64%) and P_{13} x P_6 (-18.40%).

Heterobeltiosis was significant in five F_1 hybrids. It was maximum in P_5 x P_3 (-18.87%) followed by P_{13} x P_6 (-16.96%), P_{13} x P_{10} (-16.51%), P_3 x P_1 (-16.04%) and P_8 x P_1 (-15.09%).

Standard heterosis was significant in 21 F_1 hybrids. The combinations showed high standard heterosis were P_{11} x P_9 (-25.86%), P_3 x P_1 (-23.28%), P_5 x P_4 (-22.41%), P_8 x P_1 (-22.41%), P_9 x P_2 (-22.41%), P_4 x P_1 (-20.69%), P_{12} x P_1 (-20.69%), P_{13} x P_6 (-19.83%), P_{13} x P_{10} (-19.40%), P_{10} x P_4 (-19.40%), P_4 x P_3 (-18.10%) and P_9 x P_5 (-17.67%).

12. Yield/plant

Out of 51 F_1 hybrids, 46 crosses showed significant relative heterosis for yield/plant. Relative heterosis was maximum in P_{12} x P_8 (130.41%) followed by P_6 x P_5 (112.06%), P_4 x P_3 (110.53%), P_6 x P_4 (107.99%), P_6 x P_1 (105.80%), P_{12} x P_4 (104.49%), P_{12} x P_1 (97.27%) and P_{13} x P_4 (94.98%).

Heterobeltiosis was shown by 34 crosses. The cross, P_{12} x P_5 showed the maximum of 114.03% followed by P_{12} x P_8 (113.68%), P_4 x P_3 (110.53%), P_{12} x P_4 (91.93%), P_{13} x P_4 (86.40%), P_3 x P_1 (82.58%), P_9 x P_5 (81.42%), P_{12} x P_1 (80.83%) and P_{13} x P_8 (78.08%).

All the F_1 hybrids showed significant standard heterosis for yield. Standard heterosis was maximum in the cross, P_{12} x P_5 (218.38%). The other crosses having high values were P_{12} x P_8, P_{10} x P_3, P_4 x P_3, P_{11} x P_2, P_{13} x P_4, P_{11} x P_1 and P_{12} x P_4 with standard heterosis of 212.50%, 208.75%, 200.00%, 199.75%, 191.25%, 185.00% and 173.50% respectively.

Table 12d. Mean performance of parents, F_1 hybrids and extent of heterosis for various characters

Parents/crosses	Days to fruit maturity				Days to first fruit picking maturity				Yield/plant			
	Mean (days)	RH (%)	HB (%)	SH (%)	Mean (days)	RH (%)	HB (%)	SH (%)	Mean (kg)	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
P_1	12.00				53.00				12.00			
P_2	10.00				57.50				17.00			
P_3	15.00				54.00				11.40			
P_4	12.00				51.50				11.40			
P_5	13.00				53.00				11.90			
P_6	12.00				58.00				08.00			
P_7	14.50				80.00				08.40			
P_8	13.00				57.00				11.70			
P_9	10.00				43.50				10.90			
P_{10}	11.50				58.00				19.20			
P_{11}	14.50				56.50				17.50			
P_{12}	14.00				61.00				10.00			
P_{13}	13.00				56.00				12.50			
$P_2 \times P_1$	11.00	0.00	10.00	-8.33*	51.00	-7.69	-3.77	-12.07	23.63	62.97**	39.00**	195.38**
$P_3 \times P_1$	11.00	-18.50**	-8.33*	-8.33*	44.50	-16.82**	-16.04**	-23.28**	21.91	87.26**	82.58**	173.88**
$P_4 \times P_1$	10.75	-10.41**	-10.41**	-10.41**	46.00	-11.96	-10.68	-20.69**	17.20	47.01**	43.33**	115.00**
$P_4 \times P_2$	11.25	2.27	12.50	-6.25	51.25	-5.96	0.00	-11.64	16.66	16.90**	-2.35	107.50**
$P_4 \times P_3$	10.50	-22.22**	-12.50**	-12.50**	47.50	-9.87	-7.77	-18.10**	24.00	110.53**	110.53**	200.00**
$P_5 \times P_1$	11.00	-12.00**	-8.33*	-8.33*	50.00	-5.60	-5.66	-13.79*	15.78	32.13**	31.58**	97.38**
$P_5 \times P_2$	13.00	13.04	30.00	8.33	53.40	3.17	7.55	-7.93	16.20	12.11**	-4.70	102.50**
$P_5 \times P_3$	15.00	7.14	15.38	25.00	48.00	-19.63**	-18.87**	-25.86*	18.24	56.57**	53.28**	128.00**
$P_5 \times P_4$	10.00	-20.00**	-16.67**	-16.67**	45.00	-13.88*	-12.62	-22.41**	18.83	61.63**	58.24**	135.38**
$P_6 \times P_1$	11.00	-8.33*	-8.33*	-8.33*	52.00	-6.31	-1.89	-10.34**	20.58	105.80**	71.46**	173.88**
$P_6 \times P_2$	11.00	0.00	10.00	-8.33*	53.50	-7.36	-9.56	-7.76	19.13	53.00**	12.50**	139.00**
$P_6 \times P_4$	11.00	-8.33*	-8.33*	-8.33*	54.50	0.00	-5.83	-6.03	20.18	107.99**	76.91**	152.19**
$P_6 \times P_5$	10.00	-20.00**	-16.67**	-16.67**	54.00	-2.70	1.89	-6.90	21.11	112.06**	77.31**	163.75**
$P_7 \times P_2$	12.00	-2.04	20.00	0.00	62.00	-9.82	7.83	6.90	15.43	21.50**	-9.24	92.88**
$P_7 \times P_3$	12.50	-15.25**	-13.79**	4.17	62.50	-6.72	15.74	7.76	13.75	38.89**	20.61**	71.88**
$P_7 \times P_5$	13.00	-1.89	8.33	8.33	56.00	-18.84*	-3.45	-3.45	14.64	78.54**	74.29**	83.00**
$P_8 \times P_1$	12.00	-4.00	0.00	0.00	45.00	-18.18*	-15.09**	-22.41**	14.20	19.83**	18.33**	77.50**
$P_8 \times P_4$	10.00	-20.00**	-16.67**	-16.67**	53.75	-0.92	4.36	-7.33	15.30	31.91**	30.77**	91.25**

Contd.

Table 12d (contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13
$P_8 \times P_5$	12.50	-3.85	-3.85	4.17	56.00	1.82	5.66	-3.45	15.00	27.12**	26.05**	87.50**
$P_9 \times P_2$	10.00	0.00	0.00	-16.67**	45.00	-10.89	-3.45	-22.41**	11.53	-17.50	-32.35	43.75**
$P_9 \times P_4$	12.00	9.09	20.00	0.00	50.00	5.26	14.94	-13.79*	13.50	21.08**	18.42**	68.75**
$P_9 \times P_5$	10.00	-13.04**	0.00	-16.67**	47.75	-1.04	-8.26	-17.67*	21.59	81.38**	81.42**	169.88**
$P_9 \times P_6$	12.50	13.64	25.00	4.17	54.00	6.40	24.14	-6.90	14.30	51.32**	31.19**	78.75**
$P_{10} \times P_1$	11.00	-6.38	-4.35	-8.33*	51.00	-8.11	-3.77	-12.07	18.30	14.38**	-4.69	128.75**
$P_{10} \times P_3$	12.50	-5.66	8.70	4.17	52.00	-7.14	-3.70	-10.34	24.70	61.44**	28.65**	208.75**
$P_{10} \times P_4$	10.00	-14.89**	-13.04**	-16.67**	46.75	-14.61*	-9.22	-19.40*	09.25	-42.99	-55.25	11.88*
$P_{10} \times P_6$	12.00	2.13	4.35	0.00	53.00	3.45	3.45	3.45	15.35	12.87**	-20.05	91.87**
$P_{10} \times P_7$	12.50	-3.85	8.70	4.17	56.50	-18.12**	-2.59	-2.59	16.70	21.01**	-13.02	106.25**
$P_{10} \times P_8$	12.00	-2.04	4.35	0.00	53.50	-6.96	-6.14	-7.76	19.08	23.03**	-0.78	143.75**
$P_{11} \times P_1$	13.00	-1.89	8.33	8.33	48.00	-12.33	-9.43	-17.24*	22.88	55.07**	30.71**	185.94**
$P_{11} \times P_2$	11.00	-10.20**	10.00	-8.33*	51.75	-9.21	-8.41	-10.78	23.98	39.01**	39.01**	199.75**
$P_{11} \times P_4$	10.00	-24.52**	-16.67**	-16.67**	53.25	-1.39	3.40	-8.19	20.13	39.27**	15.00**	151.50**
$P_{11} \times P_6$	12.50	-24.52**	-16.67**	-16.67**	55.00	-2.22	0.92	-5.17	16.00	25.49**	-8.57	100.00**
$P_{11} \times P_8$	11.00	-20.00**	-15.28**	-8.33**	56.75	0.00	-0.44	-2.16	12.33	-15.55	-29.54	54.13**
$P_{11} \times P_9$	11.00	10.20	10.00	-8.33*	43.00	-14.00*	-1.15	-25.86**	10.35	-27.29	-41.00	29.06**
$P_{12} \times P_1$	12.00	-7.69*	0.00	0.00	46.00	-19.30**	-13.21	-20.69**	21.70	97.27**	80.83**	171.25**
$P_{12} \times P_2$	12.75	6.25	27.50	6.25	52.75	-19.30	-8.26	-9.05	15.20	14.28**	-8.43	90.00
$P_{12} \times P_4$	13.00	0.00	8.33	8.33	50.00	-11.11	-2.91	-13.79*	21.88	104.49**	91.93**	173.50**
$P_{12} \times P_5$	12.50	-7.41*	-3.84	4.17	47.50	-16.67**	-10.37	-18.10**	25.47	132.60**	114.03**	218.38**
$P_{12} \times P_6$	12.50	-3.85	4.17	4.17	55.00	-7.56	-5.17	-5.17	15.40	66.67**	50.00**	87.50**
$P_{12} \times P_8$	13.00	-3.70	0.00	8.33	51.50	-12.71*	-9.65	-11.21	24.98	130.41**	113.68**	212.50**
$P_{12} \times P_9$	13.50	12.50	35.00	12.50	53.00	1.44	21.84	-8.62	17.60	68.71**	61.74**	120.38**
$P_{12} \times P_{11}$	14.00	-1.75	0.00	16.66	52.75	-10.21	6.63	-9.05	16.50	260.00**	-5.71	106.28**
$P_{13} \times P_1$	11.00	-12.00**	-8.33*	8.33	48.00	-24.77	-9.43	-17.24*	20.43	66.73**	63.40**	155.31**
$P_{13} \times P_4$	11.00	-12.00**	-8.33*	-8.33*	48.50	-9.77	-5.83	-16.38*	23.03	94.98**	86.40**	191.25**
$P_{13} \times P_6$	10.00	-20.00**	-16.67**	-16.67**	46.50	-18.40**	-16.96*	-19.83*	12.20	19.02**	-2.40	52.50**
$P_{13} \times P_7$	14.00	1.82	7.69	16.67	57.00	-16.18**	1.79	-1.72	17.90	71.29**	43.20**	123.75**
$P_{13} \times P_8$	13.50	3.85	3.85	12.50	51.75	-8.40	-7.59	-10.78	22.30	83.97**	78.08**	182.50
$P_{13} \times P_{10}$	11.00	-10.20**	-4.35	-8.33*	46.75	-17.98**	-16.51*	-19.40**	13.73	-15.51	-28.52	71.63**
$P_{13} \times P_{11}$	12.00	-12.73**	-7.69*	0.00	52.00	-7.56	-7.14	-10.34	19.47	29.80**	11.26**	143.38**
$P_{13} \times P_{12}$	11.00	-18.52**	-15.38**	-8.33*	50.75	-13.24*	-9.38	-12.50	11.80	4.98**	-5.52	47.63**
CD (P=0.05)*		0.80	0.92	0.92		6.80	7.85	7.85		0.98	1.13	1.13
CD (P=0.01)**		1.06	1.22	1.22		9.04	10.44	10.44		1.31	1.51	1.51

Table 12e. Mean performance of parents, F_1 hybrids and extent of heterosis for various characters

Parents/crosses	Fruits/plant				Fruit length				Fruit girth			
	Mean	RH (%)	HB (%)	SH (%)	Mean (cm)	RH (%)	HB (%)	SH (%)	Mean (cm)	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
P_1	47.0				38.50				15.30			
P_2	24.0				42.00				30.00			
P_3	19.0				50.00				17.50			
P_4	36.5				34.00				23.00			
P_5	28.0				78.00				17.00			
P_6	14.5				53.50				21.50			
P_7	16.0				100.00				14.00			
P_8	22.0				52.00				25.50			
P_9	48.0				33.00				17.00			
P_{10}	46.0				44.00				21.00			
P_{11}	27.0				75.00				22.50			
P_{12}	18.0				55.00				18.50			
P_{13}	33.0				78.00				13.00			
$P_2 \times P_1$	52.5	47.89**	11.70**	262.70**	39.63	-1.57	-11.07	-25.94**	20.10	-11.26	-33.00	-6.51
$P_3 \times P_1$	45.5	37.88**	-3.19	213.79**	53.00	11.66	37.66	-9.72	18.30	11.59*	4.57	-14.88
$P_4 \times P_1$	47.5	13.77*	1.06	227.58**	32.00	-12.45**	7.51	-40.19**	21.00	9.66*	-8.70	-2.33
$P_4 \times P_2$	38.5	27.27**	5.48	165.52**	34.75	-9.27*	0.04	-35.05**	29.15	11.32**	-2.83	35.38**
$P_4 \times P_3$	59.0	112.61**	61.64**	306.90**	30.00	-29.08**	-13.29**	-43.93**	24.50	20.99**	6.52	13.95**
$P_5 \times P_1$	37.0	-1.33	-21.28**	155.17**	55.05	-5.49*	42.86	2.90	13.75	-14.86	-19.12	-36.05
$P_5 \times P_2$	39.0	27.87**	18.18**	168.97**	57.70	-3.83*	37.38	7.85	19.80	-15.74	-30.00	-7.91
$P_5 \times P_3$	47.5	102.13**	69.64**	227.59**	58.00	-9.38*	16.00	8.41	17.21	-0.29	-1.71	-20.00
$P_5 \times P_4$	52.5	62.79**	48.39**	262.01**	44.25	-21.40**	-27.89**	-17.29**	19.65	-1.75	-14.57	-8.60
$P_6 \times P_1$	26.5	-13.82	-43.60	82.76**	57.25	24.78	6.41	6.41	24.90	35.33**	15.81**	15.81**
$P_6 \times P_2$	27.0	27.27**	2.08	68.97**	51.00	6.81	21.43	-4.67*	22.25	-13.59	-25.83	3.49
$P_6 \times P_4$	31.5	23.53**	-13.70	117.24**	54.10	22.81	56.36	1.12	20.85	-6.22	-9.35	-3.02
$P_6 \times P_5$	55.5	161.18**	98.21**	282.76**	48.33	-48.29**	0.00	-36.45**	16.10	-16.36	-25.12	-25.12
$P_7 \times P_2$	28.7	43.50**	19.58**	97.93**	50.50	-28.27**	20.24	-5.61	17.50	-20.45	-41.67	-18.60
$P_7 \times P_3$	30.0	71.43**	57.89**	106.90**	54.30	-27.60**	8.60	1.50	18.00	14.29**	2.86	-16.28
$P_7 \times P_6$	29.5	93.44**	84.38**	103.44**	59.00	-22.62**	10.28	10.28	20.00	12.68**	-6.98	-6.98
$P_8 \times P_1$	28.5	-17.39	-39.36	96.55**	62.35	38.12	61.94	16.54	18.40	-9.80	-27.84	-14.42
$P_8 \times P_4$	31.5	7.69	-13.70	117.24**	33.35	-22.98**	-3.61	-37.38	23.00	-5.15	-9.80	6.98

Contd

Table 12e (contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13
$P_8 \times P_5$	31.00	20.00	7.14	106.90**	60.00	-13.88**	7.69	4.67	21.00	-1.18	-17.65	-2.33
$P_9 \times P_2$	23.00	-18.06	-38.54	103.45**	40.00	9.59	21.21	-25.23**	24.00	2.13	-20.00	11.63**
$P_9 \times P_4$	43.00	1.78	-10.42	196.55**	36.00	6.51	9.09	-32.70**	20.00	0.00	-3.04	-6.98
$P_9 \times P_5$	73.00	100.00**	58.33**	424.14**	39.50	-28.85**	19.70	-26.17**	17.00	0.00	0.00	-20.93
$P_9 \times P_6$	35.50	16.80**	-23.96	151.72**	46.70	7.98	41.52	-12.71**	21.00	9.09*	-2.33	-2.33
$P_{10} \times P_1$	55.00	20.43**	19.15**	286.21**	47.25	14.55	22.73	-11.68**	18.10	-0.28	-13.81	-15.81
$P_{10} \times P_3$	45.00	41.54**	0.00	217.24**	53.00	12.77	20.45	-0.93	22.50	16.88**	7.14	4.65
$P_{10} \times P_4$	24.50	-40.61	-46.74	68.96**	29.83	-24.94**	-13.79**	-44.86**	24.00	9.09*	4.35	11.63*
$P_{10} \times P_6$	33.50	10.74**	-27.17	131.03**	49.00	0.51	11.36	-8.41**	21.00	-1.18	-2.33	-2.33
$P_{10} \times P_7$	31.70	24.84**	-15.87	164.63**	53.30	-30.78**	21.14	-0.37	16.00	-8.57	-23.81	-25.38
$P_{10} \times P_8$	23.50	-13.23	-35.86	103.44**	48.85	1.77	1.02	-8.69**	21.90	-5.81	-14.12	1.86
$P_{11} \times P_1$	53.00	43.24**	12.77**	265.52**	56.00	-1.32	45.45	4.67	17.25	-8.73	-23.33	-19.17
$P_{11} \times P_2$	57.00	123.33**	111.11**	293.10**	53.35	-8.80**	26.90	-0.28	16.25	-38.09	-45.83	-24.42
$P_{11} \times P_4$	42.00	32.28**	15.07**	189.66**	34.00	-37.96**	-1.73	-36.45**	25.25	10.99**	9.78*	17.44**
$P_{11} \times P_6$	27.00	30.12**	0.00	86.21**	52.00	-19.13**	-2.80	-2.80	20.00	-8.05	-11.11	-6.98
$P_{11} \times P_8$	22.00	-10.20	-18.52	51.72**	59.90	-5.67**	15.19	11.96	22.00	-8.33	-13.73	2.33
$P_{11} \times P_9$	47.00	-1.05	-2.08	224.14**	28.50	-47.22**	-13.64**	-46.73**	14.75	-25.32	-34.44	-32.56
$P_{12} \times P_1$	51.50	60.94**	9.57**	255.17**	47.10	0.75	22.34	-11.96**	18.50	9.47*	0.00	-13.95
$P_{12} \times P_2$	26.50	26.19**	10.42	82.76**	55.00	13.40	30.95	2.80	18.40	-24.12	-38.67	-14.42
$P_{12} \times P_4$	43.00	65.14**	23.29**	210.34**	50.35	12.39	45.52	-5.89*	18.00	-13.25	-27.74	-16.28
$P_{12} \times P_5$	57.50	150.00**	105.36**	295.55**	92.00	38.35	67.27	71.96	14.90	-16.06	-19.46	-30.70
$P_{12} \times P_6$	30.00	84.62**	66.67**	106.90**	53.00	-2.30	-0.93	-0.93	19.50	-2.50	-9.30	-9.30
$P_{12} \times P_8$	37.50	87.50**	70.45**	158.62**	76.10	42.24	46.15	42.24	17.85	-20.45	-30.00	-16.98
$P_{12} \times P_9$	43.00	27.27**	-12.50	189.66**	54.00	22.73	63.63	0.93	17.35	-2.25	-6.22	-19.30
$P_{12} \times P_{11}$	32.50	44.44**	-30.85	124.14**	58.65	-9.77**	4.82	9.63	15.40	-24.88	-31.56	-28.37
$P_{13} \times P_1$	43.75	14.375**	-2.66	215.52**	59.30	1.80	54.03	10.84	14.25	0.71	-6.86	-33.72
$P_{13} \times P_4$	62.00	78.42**	69.86**	327.59**	36.25	-35.61**	4.77	-32.24**	21.65	20.28**	-5.87	0.68
$P_{13} \times P_6$	63.50	168.42**	92.42**	337.90**	34.00	-48.29**	-36.45**	-36.45**	15.00	-13.04	-30.23	-30.23
$P_{13} \times P_7$	24.00	-2.04	-27.27	65.52**	100.00	12.36	28.21	86.92	13.50	0.00	-3.70	-3.70
$P_{13} \times P_8$	25.75	-11.21	-21.97	77.59**	92.00	41.54	76.92	71.96	21.90	13.77**	-14.12	1.86
$P_{13} \times P_{10}$	31.50	-20.25	-31.52	117.24**	52.00	-21.66**	18.18	-2.61	17.12	0.75	-18.45	-20.35
$P_{13} \times P_{11}$	31.50	5.00	-4.55	117.24**	83.30	8.89	11.07	55.07	16.85	-5.18	-24.02	-21.72
$P_{13} \times P_{12}$	21.50	-15.69	-34.85	48.28**	80.00	21.73	45.45	51.31	15.00	-4.76	-18.92	-30.23
CD (P=0.05)*		2.94	3.41	3.41		2.56	2.96	2.96		1.52	1.76	1.76
CD (P=0.01)**		3.92	4.53	4.53		3.41	3.94	3.94		2.03	2.34	2.34

Table 12f. Mean performance of parents, F_1 hybrids and extent of heterosis for various characters

Parents/crosses	Flesh thickness				Seeds/fruit				Average fruit weight			
	Mean (cm)	RH (%)	HB (%)	SB (%)	Mean	RH (%)	HB (%)	SH (%)	Mean (g)	RH (%)	HB (%)	SH (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
P_1	0.64				29.00				364.00			
P_2	1.00				63.00				630.00			
P_3	0.70				30.00				500 00			
P_4	0.75				45.00				395.00			
P_5	0.85				46.00				484.00			
P_6	0.75				69.50				620.00			
P_7	0.68				40.00				519.00			
P_8	0.95				60.00				650.00			
P_9	0.70				40.00				300.00			
P_{10}	0.75				55.00				500.00			
P_{11}	0.90				47.00				830.00			
P_{12}	0.90				33.00				670.00			
P_{13}	0.65				34.00				545.00			
$P_2 \times P_1$	0.68	-17.68	-32.50	-13.33	61.00	32.61**	-3.17	-12.23	470.00	-5.43	-25.4	-24.19
$P_3 \times P_1$	0.68	-0.75	-3.57	-10.00	46.77	46.77**	37.77**	-34.53	510.00	18.06**	2.00	-17.74
$P_4 \times P_1$	0.75	7.91	0.00	0.00	43.00	16.22	-4.41	-38.13	395.00	4.08	0.00	-36.29
$P_4 \times P_2$	0.80	-8.57	-20.0	6.67	71.50	32.41**	13.49	2.88	471.50	-8.00	-25.16	-23.95
$P_4 \times P_3$	0.80	10.34	6.67	6.67	52.00	33.33**	15.50**	-25.18	436.50	-2.57	-14.68	-29.68
$P_5 \times P_1$	0.75	0.67	-11.76	0.00	39.50	6.67	-3.04	-42.45	443.75	4.66**	-8.32	-28.43
$P_5 \times P_2$	0.88	-4.86	-12.0	17.33*	57.00	4.59	-9.52	-17.99	460.00	-17.41	-26.98	-25.81
$P_5 \times P_3$	0.70	-9.68	-17.65	-6.67	48.00	21.52**	4.35	-30.94	489.00	-0.61	-2.20	-21.13
$P_5 \times P_4$	0.56	-31.25	-35.29	-26.67	43.00	-1.18	-4.44	-38.13	435.00	-1.02	-10.12	-29.84
$P_6 \times P_1$	0.80	15.11**	6.67	6.67	64.00	29.95**	-7.71	-7.71	795.00	61.59**	28.23**	28.23**
$P_6 \times P_2$	0.80	-8.57	-20.00	-20.00	56.00	-15.47	-19.42	-19.42	758.13	21.30**	20.34**	22.28**
$P_6 \times P_4$	0.82	6.67*	6.67	6.67	64.00	13.54	-6.48	-6.48	710 55	20.49**	-1.45	-1.45
$P_6 \times P_5$	0.83	2.50	-3.53	9.33	48.00	-16.88	-30.94	-30.94	482.50	-17.17	-22.18	-22.18
$P_7 \times P_2$	0.78	-1.19	-17.00	10.67	56.00	8.74	-11.11	-19.42	580.00	0.96	-7.94	-6.45
$P_7 \times P_3$	0.70	1.45	11.43	4.00	42 00	15.07	5.00	-39.67	526.00	3.24	1.35	-15.16
$P_7 \times P_6$	0.70	-2.10	-6.67	-6.67	55.60	1.50	5.00	-39.67	535.00	-6.06	-13.71	-13.71
$P_8 \times P_1$	0.70	-11.95	-26.32	-6.67	49.00	10.11	-18.33	29.50	517.50	1.97	-20.38	-19.81
$P_8 \times P_4$	0.83	0.61	-12.63	-10.67	57.50	9.52	-4.17	-17.27	479.00	-8.33	-26.31	-22.74

Contd.

Table 12f (contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13
$P_8 \times P_5$	0.83	-7.78	-12.63	10.67	53.50	0.94	-10.83	-23.02	600.00	10.19*	-0.83	-3.23
$P_9 \times P_2$	0.82	-3.53	-18.00	9.33	55.00	-8.74	-25.40	-32.37	452.50	-2.69	-28.17	-27.02
$P_9 \times P_4$	0.75	3.45	0.00	0.00	43.25	1.76	-3.89	-37.77	373.00	7.34	-5.57	-39.84
$P_9 \times P_5$	0.70	-9.68	-17.64	-6.67	38.20	-4.50	-4.50	-45.04	314.50	-17.77	-35.02	-49.27
$P_9 \times P_6$	0.75	3.45	0.00	0.00	53.00	-3.20	-23.74	-23.74	460.00	0.00	-25.81	-25.81
$P_{10} \times P_1$	0.60	-13.67	-20.00	-20.00	47.50	13.10	-13.64	-31.65	345.00	-20.14	-31.00	-44.35
$P_{10} \times P_3$	0.80	10.34	6.67	6.67	60.00	36.36**	9.09	-13.67	588.00	-17.60**	17.60**	-5.16
$P_{10} \times P_4$	0.77	2.66	2.66	2.66	50.00	0.00	-9.09	-28.06	395.00	-11.73	-21.00	-36.29
$P_{10} \times P_6$	0.75	0.00	0.00	0.00	60.00	-3.61	-13.67	-13.67	527.00	-5.89	-15.00	-15.00
$P_{10} \times P_7$	0.75	4.90	0.00	0.00	42.50	-10.53	-22.73	-38.85	532.00	4.52	2.50	-14.19
$P_{10} \times P_8$	0.95	11.76**	0.00	0.00	58.75	-2.26	-2.00	-15.40	690.00	20.00**	6.15*	11.29**
$P_{11} \times P_1$	0.70	-9.09	-22.22	-6.67	67.50	77.63**	43.62**	-2.96	363.00	-39.20	-56.26	-41.45
$P_{11} \times P_2$	0.60	36.84	-40.00	-20.00	41.20	-25.18	-34.68	-40.78	470.50	-35.35	-43.77	-24.11
$P_{11} \times P_4$	0.95	15.15**	5.56	26.67**	51.25	-11.41	9.04	-26.26	436.00	-28.83	-47.50	-29.68
$P_{11} \times P_6$	0.80	-3.03	-11.11	6.67	56.00	-2.18	-19.42	-19.42	630.00	-13.10	-24.10	1.61
$P_{11} \times P_8$	0.85	-8.11	-10.53	-13.33	53.00	-0.93	-11.67	-23.74	796.00	7.57**	-4.10	28.39**
$P_{11} \times P_9$	0.81	1.25	-10.00	8.00	45.00	3.44	-4.26	-35.25	200.00	-64.60	-75.90	-67.74
$P_{12} \times P_1$	0.60	-22.00	-33.30	-20.00	51.50	66.13**	56.06**	-25.90	457.50	-11.51	-29.03	-23.31
$P_{12} \times P_2$	0.70	-26.31	-30.00	-6.67	65.00	34.42**	3.17	-6.47	593.50	-8.69	-11.43	-4.27
$P_{12} \times P_4$	0.77	-6.67	-14.44	2.67	49.00	25.64*	8.89	-29.50	518.50	-2.63	-22.61	-16.37
$P_{12} \times P_5$	0.70	-20.00	-24.69	-6.67	52.00	31.65**	13.04	-25.18	457.00	-20.79	-31.79	-26.29
$P_{12} \times P_6$	0.78	-5.45	-13.33	4.00	55.90	-8.49	-32.52	-32.52	590.00	-8.53	-11.94	-4.84
$P_{12} \times P_8$	0.85	-8.11	-10.53	13.83	57.50	24.09*	-3.83	-16.98	805.00	21.97**	20.15**	29.84**
$P_{12} \times P_9$	0.70	-12.50	-22.22	-6.67	39.00	6.85	-2.50	-43.88	411.00	-15.26	-38.66	-33.71
$P_{12} \times P_{11}$	0.60	-33.33	-33.33	-20.00	48.50	21.25*	3.19	-30.22	504.50	-33.33	-25.37	-19.35
$P_{13} \times P_1$	0.65	6.78	0.00	-13.33	60.00	90.48**	76.47**	-13.67	400.00	-11.91	-26.61	-35.48
$P_{13} \times P_4$	0.83	17.86**	10.00	10.00	67.75	70.25**	49.44**	-3.24	397.50	-15.43	-27.06	-35.89
$P_{13} \times P_6$	0.72	2.86	-9.33	-9.33	38.50	-24.64	-43.88	-43.88	150.50	-74.25	-75.81	-75.81
$P_{13} \times P_7$	0.75	12.78**	10.29	0.00	43.00	16.22	7.50	-38.13	950.00	78.57**	74.31	-53.23
$P_{13} \times P_8$	0.90	12.50	-5.26	20.00**	63.50	35.11	5.83	-8.63	1047.50	75.31**	61.15**	68.95**
$P_{13} \times P_{10}$	0.82	14.29*	6.67	6.67	50.00	12.36	-9.04	-28.06	550.00	5.26	0.97	-11.29
$P_{13} \times P_{11}$	0.80	3.23	-11.11	6.67	56.00	38.27**	19.15*	-19.42	625.00	-9.09	-24.70	0.81
$P_{13} \times P_{12}$	0.70	-9.68	-22.22	-6.67	30.50	-8.96	-10.29	-56.12	514.00	-12.51	-18.41	-17.10
CD (P=0.05)*		0.11	0.13	0.13		8.43	9.74	9.74		29.26	33.79	33.79
CD (P=0.01)**		0.15	0.17	0.17		11.22	12.95	12.95		38.92	44.94	44.94

Table 12g. Mean performance of parents, F_1 hybrids and extent of heterosis for total crop duration

Parents/crosses	Total crop duration			
	Mean (day)	RH (%)	HB (%)	SH (%)
1	2	3	4	5
P_1	130.00			
P_2	129.50			
P_3	126.00			
P_4	106.50			
P_5	102.00			
P_6	123.50			
P_7	135.50			
P_8	111.00			
P_9	104.50			
P_{10}	123.50			
P_{11}	122.00			
P_{12}	125 00			
P_{13}	123.00			
$P_2 \times P_1$	135 00	4.05*	3.84	9 31**
$P_3 \times P_1$	128.50	0.39	-1.15	4.05**
$P_4 \times P_1$	125.50	5.90**	-3.46	1.62
$P_4 \times P_2$	118.50	0.42	-8.49	-4.45
$P_4 \times P_3$	123.00	5.81	0.00	-0.40
$P_5 \times P_1$	120.00	3.45	-7.69	-2.83
$P_5 \times P_2$	118.75	2.59	-8.30	-3.85
$P_5 \times P_3$	119 00	4.39	-5.56	-3.64
$P_5 \times P_4$	110 00	5.52*	3.23	-10.93
$P_6 \times P_1$	127.50	0.59	-1.92	3.24
$P_6 \times P_2$	124.50	-1.58	-3.86	0.81
$P_6 \times P_4$	119.75	4.13	-3.04	-3.04
$P_6 \times P_5$	117.00	3.76	-5.26	-5.26
$P_7 \times P_2$	131.00	1.13	-3.32	6.07**
$P_7 \times P_3$	129 00	-1.34	-4.97	-4.45
$P_7 \times P_6$	129.00	-0.39	-4.81	4.45
$P_8 \times P_1$	128 50	-6.63	-1.15	4.05
$P_8 \times P_4$	116.25	7.13**	4.73	-5.87
$P_8 \times P_5$	114 00	7.04**	2.70	-7.69

Contd.

Table 12g. (Contd.)

1	2	3	4	5
$P_9 \times P_2$	111.50	-4.49	-10.81	-9.72
$P_9 \times P_4$	111.75	6.18*	4.93	-9.51
$P_9 \times P_5$	121.50	17.96**	14.08**	-1.62
$P_9 \times P_6$	120.50	5.93**	-2.43	-2.43
$P_{10} \times P_1$	127.50	0.59	-1.92	3.24
$P_{10} \times P_3$	130.00	4.20*	3.17	5.26*
$P_{10} \times P_4$	119.75	4.13	-3.00	-3.00
$P_{10} \times P_6$	127.00	2.83	2.83	2.83
$P_{10} \times P_7$	131.50	1.54	-2.95	6.48
$P_{10} \times P_8$	119.00	1.49	-3.64	-3.64
$P_{11} \times P_1$	128.50	1.98	-1.15	4.05
$P_{11} \times P_2$	122.00	-2.98	-5.79	-1.21
$P_{11} \times P_4$	122.50	7.22**	0.41	-0.81
$P_{11} \times P_6$	123.00	0.20	-0.40	-0.40
$P_{11} \times P_8$	119.50	2.58	-2.05	-3.24
$P_{11} \times P_9$	119.00	5.31*	-2.46	-3.64
$P_{12} \times P_1$	129.25	0.73	-0.58	4.66*
$P_{12} \times P_2$	128.00	0.59	-1.16	3.64
$P_{12} \times P_4$	129.75	12.12**	3.80	5.06*
$P_{12} \times P_5$	129.00	13.66**	3.20	4.45
$P_{12} \times P_6$	125.00	0.60	0.00	0.00
$P_{12} \times P_8$	126.00	6.78**	0.80	2.02
$P_{12} \times P_9$	122.00	6.55**	-2.40	-1.21
$P_{12} \times P_{11}$	125.00	1.21	0.00	1.21
$P_{13} \times P_1$	130.00	2.77	0.00	5.26*
$P_{13} \times P_4$	127.50	11.11**	3.64	3.22
$P_{13} \times P_6$	125.00	1.42	1.21	1.21
$P_{13} \times P_7$	132.50	2.51	-2.21	7.29**
$P_{13} \times P_8$	120.00	2.56	-0.41	-2.83
$P_{13} \times P_{10}$	122.00	-1.01	1.21	1.21
$P_{13} \times P_{11}$	123.00	0.41	-0.40	-0.40
$P_{13} \times P_{12}$	125.00	0.81	0.00	1.63
CD (P = 0.05)*		4.85	5.60	5.60
CD (P = 0.01)**		6.45	7.45	7.45

13. Fruits/plant

Out of 51 F_1 hybrids evaluated, 36 showed significant relative heterosis for fruits/plant. Relative heterosis was maximum in P_{13} x P_6 (168.42%). Other combinations exhibited heterosis were P_6 x P_5 (161.18%), P_{12} x P_5 (150.00%), P_{11} x P_2 (123.53%), P_4 x P_3 (112.61%), P_5 x P_3 (102.13%) and P_9 x P_5 (100.00%).

Significant heterobeltiosis was observed for 22 crosses. Heterobeltiosis was maximum in P_{11} x P_2 (111.11%). Other crosses expressed heterobeltiosis were P_{12} x P_5 (105.36%), P_6 x P_5 (98.21%), P_{13} x P_6 (92.42%), P_7 x P_6 (84.38%), P_{13} x P_4 (78.42%), P_{12} x P_8 (70.45%), P_5 x P_3 (69.64%), P_{12} x P_6 (66.67%), P_4 x P_3 (61.64%) and P_9 x P_5 (58.33%).

Standard heterosis was noticed in all hybrids. The standard heterosis was the highest in P_9 x P_5 (424.14%) followed by P_{13} x P_6 (337.90%), P_{13} x P_4 (327.59%), P_4 x P_3 (306.00%), P_{12} x P_5 (296.55%), P_{10} x P_1 (286.21%), P_6 x P_5 (282.76%), P_{11} x P_1 (265.52%), P_2 x P_1 (262.07%), P_5 x P_4 (262.01%) and P_{12} x P_1 (255.17%).

14. Fruit length

Out of 51 F_1 hybrids evaluated, 25 showed significant relative heterosis. The relative heterosis was maximum in

P_6 x P_5 and P_{13} x P_6 (-48.29% each). Other crosses with high values were P_{11} x P_9, P_{11} x P_4, P_{13} x P_4, P_{10} x P_7 and P_4 x P_3 with heterotic values -47.22%, -37.96%, -35.61%, -30.78% and -29.08% respectively. Significant heterobeltiosis for fruit length was observed in five crosses. They were P_{13} x P_6 (-36.45%), P_5 x P_4 (-27.89%), P_{10} x P_4 (-13.79%), P_{11} x P_9 (-13.64%) and P_4 x P_3 (-13.29%).

Significant standard heterosis was observed in 20 crosses. The standard heterosis was maximum in the combination P_{11} x P_9 (-46.73%) followed by P_{10} x P_4 (-44.86%), P_4 x P_3 (-43.93%), P_4 x P_1 (-40.19%), P_6 x P_5 (-36.45%) and P_{13} x P_6 (-36.45%).

15. Fruit girth

Out of 51 F_1 hybrids studied, 14 showed significant relative heterosis for fruit girth. The heterosis was highest for P_4 x P_3 (20.99%), followed by P_{13} x P_4 (20.28%), P_{10} x P_3 (16.88%), P_7 x P_3 (14.29%) and P_{13} x P_8 (13.77%). Heterobeltiosis for fruit girth was noticed only in two hybrids, P_6 x P_1 (15.81%) and P_{11} x P_4 (9.78%).

Significant standard heterosis was observed in six hybrids. The highest was in P_4 x P_2 (35.38%), P_{11} x P_4 (17.44%), P_6 x P_1 (15.81%) and P_4 x P_3 (13.95%).

16. Flesh thickness

Relative heterosis was significant in six F_1 hybrids. It was maximum in P_{13} x P_4 (17.86%) followed by P_6 x P_1 (15.11%), P_{13} x P_{10} (14.20%), P_{13} x P_7 (12.78%) and P_{13} x P_8 (12.50%). No hybrids exhibited significant heterobeltiosis.

Significant standard heterosis was noticed in three hybrids. The maximum was found in P_{11} x P_4 (26.67%) followed by P_{13} x P_8 (20.00%) and P_5 x P_2 (17.33%).

17. Seeds/fruit

Significant relative heterosis was observed in 18 combinations. The relative heterosis was high in P_{13} x P_1 (90.48%) followed by P_{11} x P_1 (77.63%), P_{13} x P_4 (70.25%) and P_{12} x P_1 (66.13%).

Heterobeltiosis was significant in eight combinations. It was maximum in P_{13} x P_1 (76.47%) followed by P_{12} x P_1 (56.06%), P_{13} x P_4 (49.44%), P_{11} x P_1 (43.62%) and P_3 x P_1 (37.88%).

None of the hybrids showed significant standard heterosis for seeds/fruit.

18. Average fruit weight

Out of 51 F_1 hybrids evaluated, 12 showed significant relative heterosis for average fruit weight. The relative heterosis was maximum in P_{13} x P_7 (78.57%) followed by P_{13} x P_8 (75.31%), P_6 x P_1 (61.59%), P_{12} x P_8 (21.97%) and P_6 x P_2 (21.30%).

Significant heterobeltiosis was found in seven hybrids. Heterobeltiosis was maximum in P_{13} x P_7 (74.31%) followed by P_{13} x P_8 (61.15%), P_6 x P_1 (28.23%), P_6 x P_2 (20.34%), P_{12} x P_8 (20.15%) and P_{10} x P_3 (17.60%).

Standard heterosis was significant in seven F_1 hybrids. It was maximum in P_{13} x P_8 (68.95%), followed by P_{13} x P_7 (53.23%), P_{12} x P_8 (29.84%), P_{11} x P_8 (28.39%) and P_6 x P_1 (28.23%).

19. Total crop duration

Out of 51 combinations, 16 showed significant relative heterosis for total crop duration. The crosses showed high relative heterosis were P_9 x P_5 (17.96%), P_{13} x P_4 (11.11%) and P_{11} x P_4 (7.22%).

Heterobeltiosis was significant only in the cross, P_9 x P_5 (14.08%).

Standard heterosis was significant in eight combinations. The highest value was found in $P_2 \times P_1$ (9.31%) followed by $P_{13} \times P_7$ (7.29%), $P_7 \times P_2$ (6.07%), $P_{10} \times P_3$ (5.26%) and $P_{13} \times P_1$ (5.26%).

Identification of marker gene

In the present investigation a white patch is identified on the seed coats of genotype, TA-102. This marker character would be of use for hybrid seed production.

Discussion

DISCUSSION

Snakegourd (<u>Trichosanthes</u> <u>anguina</u> L.) is a common vegetable consumed and relished by many people, especially South Indians. It is an important source of minerals, fibre and other nutrients, making the food wholesome and healthy. It is a high yielding vegetable and can compete with any other cucurbits in respect of yield/unit area. The medicinal values of sankegourd has been recognised lately. The popularity of this vegetable is at its low ebb mainly due to the non-availability of ideal varieties. There exists high variability among the genotypes of snakegourd with respect to the various vegetative and productive characters. Snakegourd being a cross pollinated crop, there exists good scope for exploitation of heterosis. Hence the present study was contemplated to investigate the genetic variability, combining ability and exploitation of heterosis. The results of the investigation are discussed below.

A. Assessment of variability and divergence and grouping of genotypes based on D^2 values

1. Assessment of genetic variability, heritability and genetic distance

On the various estimates of quantitative variability, range and variation around the mean are very basic ones.

Success in genetic improvement of a crop depends upon the extent of genetic variability present. Among the 25 quantitative characters observed, the 48 snakegourd accessions exhibited significant difference for all characters.

The accession TA-99 had the shortest vine (303.5 cm) and TA-70 had the longest vine (785.0 cm). The genotype TA-82 took 33.5 days from germination to the opening of the first female flower and TA-84 took 65.0 days. The genotype TA-82 was harvested 43.5 days after germination and TA-84 was the latest and harvested 81.0 days after germination. The accession TA-96 yielded 7.33 kg and TA-94 yielded as high as 20.23 kg. The lowest number of fruits were produced by TA-71 (11.0) and the maximum by TA-94 (57.5). The minimum number of seeds/fruit was produced by TA-55 (30.0) and the maximum by TA-19 (72.5). The crude fibre content was minimum in TA-34 (25.0%) and maximum in genotype TA-94 (71.8%). Snakegourd being a cross pollinated crop, there exists much variation and therefore the present observation is quite rational as reported earlier by Srivastava and Srivastava (1976), Ramachandran and Gopalakrishnan (1979), Mangal et al. (1981), Chaudhary (1987) and Vahab (1989) in bittergourd, Tyagi (1972) in bottlegourd, Rajendran (1989) in watermelon and Joseph (1978) in snakegourd.

Estimates of quantitative variation like range and standard error around mean do not indicate relative amount of variability for which coefficient of variation appears to be a better index, when the characters with different units of measurements are to be compared. The highest phenotypic coefficient of variation was found for fruiting nodes on main vine (70.05) followed by male flowers/plant (47.55), sex ratio (45.65), fruits/plant (39.99), fruit length (32.56), crude protein (33.69) and yield/plant (31.35). The pcv was the lowest for crop duration (9.25) followed by days to first male flower anthesis (10.13), days to first fruit picking maturity (11.93), days to fruit maturity (12.4), flesh thickness (13.09) and days to first female flower opening (15.01). For other traits such as main vine length, primary branches/plant, node at which first female flower appeared, female flowers/ plant, nodes on main vine, fruit girth, seeds/fruit, seed weight/fruit, 100 seed weight, average fruit weight, vitamin C and crude fibre content of fruit the pcv was between 15.01 and 45.65. These results were comparable to the reports by Reddy and Rao (1984) in ridgegourd, Arora et al. (1983) in spongegourd, Sureshbabu (1989) in pumpkin and Vahab (1989) in bittergourd. The low estimates of pcv for early female flower formation and earliness obtained by Chaudhary (1987) in bittergourd also draw parallel to the present findings.

The plant improvement programmes like selection and hybridization cannot be undertaken based on the phenotypic performance alone, since it is the sum total of genotypic effect and environmental influence. The highest gcv was found for fruiting nodes on main vine (62.99) followed by male flowers/plant (47.49), sex ratio (45.61), fruits/plant (38.93), crude fibre content (26.25) and fruit length (32.15). This indicates low impact of environments on the expression of these traits. The lowest gcv was found for total crop duration (9.24) followed by days to first fruit picking maturity (11.19) and days to fruit maturity (12.09). Similar observations were made by Tyagi (1972) in bottlegourd, Gopalakrishnan (1979) and Sureshbabu (1989) in pumpkin, Arora et al. (1983) in spongegourd, Reddy and Rao (1984) in ridgegourd, Rajendran (1989) in watermelon and Vahab (1989) in bittergourd.

A character can be improved only if it is highly heritable. The magnitude of heritability indicates the effectiveness with which the selection of genotypes can be made based on phenotypic performance (Johnson et al., 1955). The heritability was maximum for total crop duration and crude protein content (99.8%). The heritability was the lowest for female flowers/plant (62.0%), followed by seeds/fruit (78.7%). The results were in consonance with the findings of Ramachandran (1978) in bittergourd, Gill and Kumar (1986) in watermelon and Vijay (1987) in muskmelon.

Eventhough the heritability values give indication of effectiveness of selection based on the phenotypic performance, it does not necessarily mean a high genetic advance for a particular character. Heritability along with estimates of expected genetic advance should be considered while making selection. In crop improvement only the genetic component of variation is important since only this component is transmitted to the next generation. The estimates of heritability serve as a useful guide to the breeder. If the heritability of a character is high (0.8 or more), selection for this is very effective. This is because there would be close correspondence between genotype and phenotype due to a relatively smaller contribution of environment to the phenotype. But for character with low heritability (less than 0.4), selection may be considerably ineffective or virtually impractical due to masking effect of environment on the genotypic effects.

In the present investigation, genetic advance was estimated in absolute values and also as percentage of mean. The characters exhibited high heritability with high genetic gain were male flowers/plant (99.0% and 97.95%), sex ratio (99.00% and 93.86%), fruiting nodes on main vine (81.00% and 116.57%) and fruits/plant (95.00% and 78.08%). This indicates additive gene action, suggesting the possibility of improvement through selection (Burton, 1952). Similar observations were made by Srivastava and Srivastava (1976) in bittergourd Chonkar et al. (1979) in muskmelon, Solanki and Seth (1980) in cucumber and Arora et al. (1983) in spongegourd.

The characters exhibited high heritability along with low genetic gain were yield/plant (92.00% and 0.29%), fruit length (97.50% and 0.84%), total crop duration (99.80% and 19.02%), days to first fruit picking maturity (88.00% and 21.62%) and days to first male flower anthesis (86.00% and 17.93%). The high heritability coupled with low genetic gain indicates non-additive gene action including epistasis and dominance. Similar observations were made by Krishnaprasad and Singh (1989) in ridgegourd.

2. Assessment of genetic divergence and grouping of genotypes

The D^2 statistic is a tool for estimating the genetic divergence in plant breeding experiments. It presents precise comparison among all possible pairs of population in any group. All the 48 genotypes were grouped into 10 clusters by the computer oriented iterative (check whether) algorithm, proposed by Suresh (1986).

Cluster I contained maximum of 13 genotypes. Cluster II had only one genotype, TA-70 having the longest vine and had the highest cluster mean for yield. It had the highest number of nodes on main vine and highest fruit girth. Cluster III had genotypes with long fruits and more male flowers/plant. Cluster IV with two genotypes had the highest yielding accession, TA-94. These two genotypes recorded the shortest vine, highest fruit number and highest fibre content of the fruit. Cluster V had seven genotypes. Cluster VI had the genotypes with the highest sex ratio, lowest fruit number and maximum fruit length. Genotypes in cluster VII had the lowest sex ratio and the shortest fruit. Cluster VIII was with three genotypes characterised by the lowest fruit weight. Cluster IX was with three low yielding genotypes having long fruits of thin flesh. Cluster X had six genotypes.

B. **Assessment of combining ability of parents**

In a heterosis breeding programme for evolving high yielding hybrids, the breeder is often confronted with problem of choice of parents. The common approach of selecting parents on the basis of per se performance does not necessarily lead to the best result in hybridization programme (Allard, 1960). Selection of best parents based on complete genetic information and knowledge of combining ability leads to fruitful results in the identification of promising F_1 hybrids.

In the present study by line x tester analysis, there were 24 crosses along with eight lines and three testers. The study revealed that variances due to gca were significant for all the characters considered. The sca variances were also significant for all the characters except for total crop duration, sex ratio and fruits/plant. The significance of gca and sca variances indicated the role of additive as well as non-additive gene action in the control of most of the characters.

The mean squares for the progenies were significant for all the vegetative and productive characters studied indicating the presence of adequate variability which could be exploited by selection. The magnitude of gca variance was much higher than that of sca effect for female flowers/plant. This indicated the preponderance of additive type of gene action. The variation in the gca effects of various male parents can be attributed to genetic as well as geographic diversity in the material. High sca effects observed for different characters may be helpful for sorting out outstanding parents with favourable allels for the different components of yield. Significant gca and sca values were noted for vine length, fruits/plant, fruit weight, yield/plant, fruit diameter, flesh thickness and seeds/fruit by Brar and Sukhija (1977) in watermelon, Sirohi and Chaudhary (1977) and Vahab (1989) in bittergourd. For the improvement of such characters recurrent selection could be resorted to.

It was noted that parents showing high gca effect for yield/plant and other characters also gave good <u>per se</u> performance. The parents like P_{10}, P_{11} and P_{13} which gave high yield also possessed significant gca effects for yield. These parents also showed higher gca effects for fruits/plant.

Among the parents P_{10}, P_{11}, P_{12} and P_{13} as females recorded the highest value for yield and fruits/plant. This showed that these female parents passess its specific genetic architecture to the off-spring. The parents P_9 and P_4 had the highest and negative gca effects for first harvest. The crosses involving them had high sca effects. The parent P_9 showed highest and negative sca effect for first female flower opening, days to fruit maturity and days to first fruit picking maturity. It also exhibited the highest negative gca effect for fruit length. The parents P_8 and P_6 showed high gca effect for fruit girth. The crosses involving any one of these parents gave high sca effect for fruit girth, viz. P_8 x P_2 and P_6 x P_1. For flesh thickness, the parent P_4 had the highest gca effect and its cross with P_{11} had the highest sca effect.

C. **Crossing and evaluation of hybrid vigour**

Heterosis was studied in a 13 x 13 diallel for 19 characters. Significant differences were observed among the genotypes.

Significant relative heterosis, heterobeltiosis and standard heterosis were observed in many F_1 hybrids for main vine length. Relative heterosis was high in the crosses, P_5 x P_4 (69.31%) and P_9 x P_5 (51.96%). High heterobeltiosis was obtained in P_{10} x P_4 (71.00%), P_5 x P_4 (64.42%) and P_9 x P_5

(49.04%). Standard heterosis was high in P_5 x P_4 and P_{10} x P_4 with heterosis of 50.00% each and P_9 x P_5 showed a heterosis of 35.96%. It could be seen that the crosses involving P_4 exhibited high heterosis for vine length. The cross, P_9 x P_5 had high heterosis for vine length which also had high sca effect (134.47) and one of its parents, P_5 had a high gca effect of 44.75 too. These parents also belonged to different clusters indicating high genetic distance. The *per se* performances of the crosses were also high. Heterosis for vine length was earlier reported by Pal and Singh (1946), Aggrawal *et al*. (1957) and Vahab (1989) in bittergourd.

Significant heterosis was observed for the trait, primary branches/plant. The F_1 hybrid, P_5 x P_4 exhibited the highest relative and standard heterosis and heterobeltiosis. This could be attributed to the high gca effect of P_5 (0.625). The sca effect was high for the above combination (2.19). These parents belonged to different clusters, thereby showing greater genetic distance. The other crosses which exhibited high heterosis were P_{10} x P_8 and P_{13} x P_4. The parents P_{13} and P_{10} had the highest gca effect of 0.792 each. The cross, P_{13} x P_4 exhibited the second highest sca effect. The parents of the above crosses belonged to different clusters having high genetic distance. The *per se* performance of the crosses were also high. Heterosis for branches/plant was earlier reported by Lal *et al*. (1976), Singh and Joshi (1979) and Vahab (1989) in bittergourd.

Several combinations showed high and negative heterosis for days to first male flower anthesis. The relative and standard heterosis were the highest in $P_5 \times P_4$ (-18.25% and -9.68%). Heterobeltiosis was high in the crosses, $P_3 \times P_1$ (-14.71%) and $P_5 \times P_4$ (-12.50%). The parent P_5 had the highest and negative gca effect (-2.271) and the sca effect was the highest and negative in the cross $P_5 \times P_4$ (-2.73). In the cross $P_3 \times P_1$, the parent P_1 had low sca effect (-1.156). The parents of the above crosses also belonged to different clusters indicating high genetic distance. Comparable results were obtained by Lal et al. (1976) and Singh and Joshi (1979) in bittergourd and Solanki et al. (1982) in cucumber.

Significant and negative relative heterosis, heterobeltiosis, and standard heterosis for days to first female flower opening were exhibited by several F_1 hybrids. Heterobeltiosis was the highest in the cross $P_{10} \times P_4$ (-16.82%) followed by $P_5 \times P_4$ (-15.63%), $P_{12} \times P_8$ (-14.44%), $P_{12} \times P_2$ (-13.54%) and $P_{10} \times P_8$ (-13.33%). Standard heterosis was high in the crosses $P_5 \times P_4$ (-25.00%), $P_8 \times P_1$ (-22.22%), $P_9 \times P_5$ (-18.89%), $P_{10} \times P_4$ (-18.89%) and $P_{13} \times P_{10}$ (-18.89%). It is observed that at least one of the parents involved in the above mentioned five crosses had negative gca effects. The genetic divergence between these parents might also have contributed to the earliness. Similar observations were obtained by Aggrawal et al. (1957), Chaudhary (1987) and Vahab (1989) in bittergourd.

Significant and negative relative heterosis, heterobeltiosis and standard heterosis were exhibited by several crosses for male flowers/plant. Relative heterosis was high in the crosses, P_{13} x P_{10} (-29.58%), P_9 x P_2 (-29.29%), P_{10} x P_4 (-21.41%) and P_{13} x P_{11} (-20.66%). Heterobeltiosis was high and negative in the crosses, P_{13} x P_{10} (-44.43%), P_{13} x P_6 (-37.76%) and P_{10} x P_4 (-28.57%). Standard heterosis was maximum in the cross P_9 x P_4 (-38.78%) followed by P_9 x P_2 (-28.57%) and P_{11} x P_8 (-26.53%). Most of the above crosses comprised at least one parent having negative gca effect for male flowers/plant and P_9 is the parent having the highest and negative gca effect. The parents of other crosses belonged to different clusters showing high genetic distance.

Out of 51 F_1 hybrids evaluated, 23 showed significant relative heterosis, 11 showed heterobeltiosis and 13 showed standard heterosis for female flowers/plant. The combinations P_{12} x P_5, P_9 x P_5, P_{12} x P_4, P_5 x P_4 and P_4 x P_3 showed high heterobeltiosis and relative heterosis. Standard heterosis was observed in P_{11} x P_1, P_9 x P_5, P_{13} x P_1, P_{10} x P_1, P_{10} x P_3 and P_{12} x P_5. High gca effects were also exhibited by the parents P_1, P_{11}, P_{12} and P_{13}. In other crosses, heterosis can be attributed to high genetic distance. The *per se* performance were also good. Similar observations were made by Aggrawal et al. (1957) and Vahab (1989) in bittergourd, Tyagi (1972) in bottlegourd and Solanki et al. (1982) in cucumber.

For sex ratio, high and negative heterosis was exhibited by many crosses. The combinations with high relative heterosis, heterobeltiosis and standard heterosis were P_{13} x P_6 and P_{13} x P_{10}. The parents of the above crosses belonged to different clusters indicating high genetic distance.

Several crosses exhibited significant and high relative heterosis, heterobeltiosis and standard heterosis for nodes on main vine. The crosses exhibited high relative heterosis and heterobeltiosis were P_5 x P_4 (74.61% and 63.75%), P_{11} x P_1 (54.67% and 48.72%), P_{11} x P_4 (47.37% and 40.00%) and P_9 x P_5 (36.00% and 27.50%). Standard heterosis was found in crosses P_5 x P_4 (45.56%), P_{11} x P_2 (34.44%) and P_{11} x P_1 (28.89%). The gca effect was maximum for P_{11} and sca effect was maximum in the cross P_5 x P_4. The parents involved in the above crosses belonged to different clusters indicating genetic diversity between parents.

Significant relative heterosis, heterobeltiosis and standard heterosis were observed for fruiting nodes on main vine. The relative heterosis and heterobeltiosis were high in the crosses, P_{11} x P_1, P_{10} x P_7, P_9 x P_4, P_{10} x P_3 and P_{12} x P_1. The crosses, P_{10} x P_3, P_4 x P_3, P_5 x P_4, P_9 x P_5 and

P_{11} x P_1 showed significant standard heterosis. The gca effect was maximum in the parent P_{11}. Majority of the crosses had parents drawn from different clusters with high genetic distance.

For days to fruit maturity, relative heterosis was noticed in 24, heterobeltiosis in 19 and standard heterosis in 24 combinations. The combinations with high negative relative heterosis were P_{11} x P_6, P_{11} x P_4, P_5 x P_4, P_6 x P_5, P_8 x P_4 and P_{13} x P_6. The above crosses except P_8 x P_4 were with parents belonging to different clusters indicating high genetic distance. The parent, P_4 was with high and negative gca effect (-0.583).

For days to first fruit picking maturity, many F_1 hybrids exhibited significant and high negative heterosis. Relative heterosis was high in the crosses, P_5 x P_3 (-9.63%) and P_{12} x P_1 (-19.30%). Heterobeltiosis was high in P_5 x P_3 (-18.87%), P_{13} x P_{10} (-16.51%), P_3 x P_1 (-16.04%) and P_8 x P_1 (-15.04%). Standard heterosis was high in P_{11} x P_9 (-25.86%), P_{13} x P_1 (-23.28%), P_5 x P_4 (-22.41%), P_8 x P_1 (-22.41%), P_4 x P_1 (-20.69%), P_{12} x P_1 (-20.69%), P_4 x P_3 (-18.10%) and P_9 x P_5 (-17.67%). The _per se_ performane also were good. All the above crosses contained genetically diverse parents with negative gca effects. Similar observation were made by Aiyadurai (1951), Pal _et al_. (1983), Aggrawal _et al_. (1957) and Chaudhary (1987) in bittergourd and More and Seshadri (1980) in muskmelon.

Out of 51 F_1 hybrids evaluated, 46 expressed relative heterosis and 34 expressed heterobeltiosis for yield/plant and all F_1 hybrids were (standard) heterotic for yield/plant. The relative heterosis was high in the crosses, P_{12} x P_8 (130.41%), P_4 x P_3 (110.53%), P_6 x P_1 (105.80%), P_{12} x P_4 (104.49%), P_{12} x P_1 (97.27%) and P_{13} x P_4 (94.98%). The *per se* performance also were good. The gca effects of the parents P_{11}, P_{12} and P_{13} were high in addition to being genetically distant.

The heterobeltiosis for yield/plant was high in the crosses, P_{12} x P_5 (114.03%), P_{12} x P_8 (113.68%), P_4 x P_3 (110.53%), P_{12} x P_4 (91.93%), P_{13} x P_4 (86.40%), P_3 x P_1 (82.58%), P_9 x P_5 (81.42%) and P_{12} x P_1 (80.83%). The gca effects of the parents P_{11}, P_{12} and P_{13} were high. The parents of the above crosses belonged to different clusters indicating high genetic distance. The *per se* performance of the hybrids were also good.

All the crosses were (standard) heterotic for yield/plant. It was high in the crosses P_{12} x P_5 (218.38%), P_{10} x P_3 (208.75%), P_4 x P_3 (200.00%), P_{13} x P_4 (191.25%), P_{11} x P_1 (185.00%) and P_{12} x P_4 (173.50%). The parents of the above crosses except P_{10} x P_3 belonged to different clusters. The parents P_{11}, P_{12} and P_{13} and high gca effects. The *per se* performance also were good. Heterosis for yield was earlier reported by Srivastava and Nath (1983), Chaudhary (1987) and Vahab (1989) in bittergourd, and Kale and Seshadri (1981) in watermelon.

Out of 51 F_1 hybrids, 36 showed significant relative heterosis and 22 showed heterobeltiosis for fruits/plant. Heterobeltiosis was high in P_{11} x P_2 (111.11%), P_{12} x P_5 (105.36%), P_6 x P_5 (98.21%), P_{13} x P_4 (78.42%), P_{12} x P_8 (70.45%), P_4 x P_3 (61.64%) and P_9 x P_5 (58.33%). The parent P_{11} showed the highest gca effect and it was comparatively high in P_{13} and P_5. The _per se_ performance of the most of the hybrids were also good. The parents of these crosses except in P_6 x P_5 belonged to different clusters indicating high genetic distance. Heterosis for fruits/plant was earlier reported by Lal _et al_. (1976), Singh and Joshi (1979), Srivastava and Nath (1983), Chaudhary (1987) and Vahab (1989) in bittergourd and Solanki _et al_. (1982) in cucumber.

For fruit length, 25 F_1 hybrids showed significant relative heterosis, five showed heterobeltiosis and 20 had standard heterosis. Heterobeltiosis was high and negative in P_{13} x P_6 (-36.45%), P_5 x P_4 (-27.89%), P_{10} x P_4 (-13.79%) and P_4 x P_3 (-13.29%). The parents P_4, P_{10} and P_{11} had high negative gca effects, besides being genetically distant.

Several F_1 hybrids showed significant heterosis for fruit girth. Heterobeltiosis was high in the crosses P_6 x P_1

and P_{11} x P_4 and standard heterosis was high in P_4 x P_2, P_{11} x P_4 and P_4 x P_3. High gca effects of parents with high genetic distance might be attributed to the heterosis in these crosses. Similar observations were reported by Srivastava (1970), Lal et al. (1976) and Chaudhary (1987) in bittergourd.

Out of 51 F_1 hybrids evaluated, six showed relative heterosis and three showed standard heterosis for flesh thickness. Standard heterosis was high in the crosses P_{11} x P_4 and P_{13} x P_8. The gca effect was maximum in P_4. The sca effect was maximum in P_{11} x P_4. The parents of the above crosses also belonged to different clusters indicating high genetic distance. Similar observations were made by Dixit and Kalloo (1983) in muskmelon, Pal et al. (1983) and Chaudhary (1987) in bittergourd.

For seeds/fruit, 18 F_1 hybrids showed relative heterosis and eight showed heterobeltiosis. Heterobeltiosis was high in P_{12} x P_1 (56.06%) and P_{11} x P_1 (43.62%). The gca effect was high for P_{11}. The parents of the above crosses belonged to different clusters. Comparable findings were also reported by Tyagi (1972) in bottlegourd and Chaudhary (1987) in bittergourd.

Out of 51 F_1 hybrids, 12 showed significant relative heterosis, seven showed heterobeltiosis and seven showed standard heterosis for average fruit weight. Heterobeltiosis was high in P_{13} x P_7 (74.31%), P_{13} x P_8 (61.15%), P_6 x P_1 (28.23%) and P_{12} x P_8 (20.15%). The parents of the above crosses belonged to different clusters. The gca effect was high in the parent P_6. Observations were made by Tyagi (1972) in bottlegourd, Lal *et al.* (1976) and Lawande and Patal (1989) in bittergourd, Kale and Seshadri (1981) in watermelon and Solanki *et al.* (1982) in cucumber which are comporting with the present findings.

Out of 51 F_1 hybrids evaluated, few hybrids exhibited significant heterosis for total crop druation. Significant and high relative heterobeltiosis was found in P_9 x P_5 (17.96%), P_{13} x P_4 (11.11%) and P_{11} x P_4 (7.22%). Significant and high standard heterosis was found in P_2 x P_1 (9.31%), P_{13} x P_7 (7.29%), P_7 x P_2 (6.07%) and P_{10} x P_3 (5.26%). The parents of the above crosses belonged to different clusters with high genetic distance.

Another important finding during the investigation was the identification of a seed marker character. The genotype, TA 102 (P_{10}) was having a white patch on the seed coat (Plate XXII). This marker character is of considerable importance in the hybrid seed production of snakegourd. Conditioning of the female parent for natural crossing is usually done by the mechanical removal of male inflorescence. Even the hand emasculation may not ensure production of hybrid seeds. If a marker gene is available on the seed itself, it will be more helpful than the seedling marker. The inheritance of this marker character needs further study. In muskmelon, white seed coat colour is dominant to yellow (Roberts, 1929). Weetman (1973) in watermelon found that the development of black bands along the edges of the seed, a phenotype termed 'clump' (Poole et al., 1941) was recessive to nonbanded due to a single gene.

In the present investigation, the F_1 hybrids with outstanding performance were P_{12} x P_5 (Plate XV), P_{12} x P_8 (Plate XVI), P_9 x P_5 (Plate XVII), P_4 x P_3 (Plate XVIII), P_{12} x P_4 (Plate XIX), P_{13} x P_4 (Plate XX) and P_{13} x P_8 (Plate XXI). The F_1 hybrid P_{12} x P_5 exhibited heterobeltiosis of 105.36% for fruits/plant and 114.03% for yield/plant. The cross P_{12} x P_8 expressed heterobeltiosis of 113.08% for yield/plant and 70.45% for fruits/plant. The F_1 hybrid P_9 x P_5 exhibited heterobeltiosis of 53.33% for fruits/plant and 81.42% for yield/plant and standard heterosis for earliness was -17.67%. The corresponding values for P_4 x P_3 were 61.64%, 110.53% and -18.10% respectively. The F_1 hybrid P_{12} x P_4 had heterobeltiosis of 91.93% for yield/plant and standard heterosis for earliness was -13.79%. For P_{13} x P_4 the heterobeltiosis for yield/plant was 86.40% and for fruits/plant it was 78.42%. The F_1 hybrid P_{13} x P_8 exhibited heterobeltiosis of 78.08% for yield/plant.

The parents and parental combinations manifested high gca and sca effects respectively, as divulged in the *a posteriori* studies. The above mentioned F_1 hybrids are worthwhile for recommending for cultivation after assessing their consistency of performance.

Plate XV P_{12} x P_5 (TA-87 x TA-77). Heterobeltiotic F_1 for fruits/plant (105.36%) and for yield/plant (114.03%)

Plate XVI P_{12} x P_8 (TA-87 x TA-30). Heterobeltiotic F_1 hybrid for yield/plant (113.08%) and heterobeltiotic for fruits/plant (70.45%)

Plate XV

Plate XVI

Plate XVII P_9 x P_5 (TA-82 x TA-77). Heterobeltiotic F_1 hybrid for yield/plant (81.42%), heterobeltiotic for fruits/plant (58.33%) and standard heterotic for days to first fruit picking maturity (-17.67%)

Plate XVIII P_4 x P_3 (TA-41 x TA-55). Heterobeltiotic F_1 hybrid for yield/plant (110.53%), heterobeltiotic for fruits/plant (58.33%) and standard heterotic for days to first fruit picking maturity (-18.10%)

Plate XVII

Plate XVIII

Plate XIX P_{12} x P_4 (TA-87 x TA-41). Heterobeltiotic F_1 hybrid for yield/plant (91.83%) and standard heterotic for days to first fruit picking maturity (-13.79%)

Plate XX P_{13} x P_4 (TA-89 x TA-41). Heterobeltiotic F_1 hybrid for yield/plant (86.40%) and hetero-beltiotic for fruits/plant (78.42%)

Plate XIX

Plate XX

Plate XXI P_{13} x P_8 (TA-89 x TA-30). Heterobeltiotic F_1 hybrid for yield/plant (78.08%)

Plate XXII Seed marker character on seeds of TA-102 (3.0 x)

Plate XXI

Plate XXII

Summary

SUMMARY

The present investigation "Heterosis in snakegourd" was conducted at the College of Horticulture during 1988-1990. The objectives were estimation of genetic divergence, combining ability and identification of heterotic F_1 hybrids.

The extent of genetic variability in 48 snakegourd lines were assessed. Significant differences were observed among the 48 genotypes for all 25 characters studied. The genotype TA-99 had the shortest vine (303.5 cm) and TA-90 the longest (785.0 cm). The genotype TA-82 was the earliest (female flower) flowering (33.5 days). The genotype TA-84 was the latest (65.0 days). The genotype TA-82 took 43.5 days for first harvest. The genotype TA-94 was the highest yielding (20.23 kg). The lowest number of fruits were produced by TA-71 (11.0) and the maximum by TA-94 (57.5). Crude fibre content was minimum in TA-34 (25.0%) and maximum in TA-94 (71.8%). The highest phenotypic coefficient of variation was observed for fruiting nodes on main vine (70.05) followed by male flowers/plant (47.55), sex ratio (45.65), fruits/plant (39.99), fruit length (32.56) and crude protein content of fruit (33.69). The pcv was the lowest for crop duration (9.25) followed by days to first male flower anthesis (10.13), days to first fruit pcking maturity (11.93), days to fruit

maturity (12.4) and flesh thickness (13.09). The genotypic coefficient of variation was the highest for fruiting nodes on main vine (62.99) followed by male flowers/plant (47.49), sex ratio (45.61), fruits/plant (38.93), crude fibre content of fruit (33.6) and fruit length (32.15). The characters exhibited high heritability with high genetic gain were male flowers/plant (99.0% and 97.5%), sex ratio (99.0% and 93.86%), fruiting nodes on main vine (81.0% and 116.57%) and fruits/plant (95.0% and 78.08%). The characters exhibited high heritability along with low genetic gain were yield/plant (92.0% and 0.29%), fruit length (97.5% and 0.84%), total crop duration (99.8% and 19.02%), days to first fruit picking maturity (88.0% and 21.62%) and days to first male flower anthesis (86.0% and 17.93%).

The 48 snakegourd genotypes were grouped into 10 clusters (Suresh, 1986). Cluster I contained maximum of 13 genotypes. Cluster II had only one genotype, TA-70 having the longest vine and the highest cluster mean for yield. Cluster IV with two genotypes had the highest yielding accesstion TA-94. They had the shortest vine, highest fruit number and highest fibre content of fruit. Cluster VIII had three genotypes of the lowest fruit weight. Cluster IX had three poor yielding genotypes having lowest flesh thickness and with the maximum fruit length.

A line x tester analysis using eight lines and three testers was conducted to estimate the combining ability. Analysis for combining ability showed significance of gca and sca variances for all characters except for sex ratio, fruits/plant and total crop duration, indicating role of both additive and non-additive gene action. Parents showing high gca for yield/plant and other characters also gave good per se performance. The parents like P_{10}, P_{11} and P_{13} which gave high yield also possess significant gca effects for yield. Among the females P_{10}, P_{11}, P_{12} and P_{13} were the highest contributors for yield/plant and fruits/plant. The parents P_9 and P_4 had the highest and negative gca effects for first harvest and their crosses possessed high sca effects.

Thirteen diverse snakegourd lines selected from the original germplasm were corssed in all possible combinations to develop F_1 hybrids. Several hybrids recorded significant relative heterosis, heterobeltiosis and standard heterosis for all vegetative and productive characters. Significant and negative heterosis, heterobeltiosis and standard heterosis for days to first female flower opening were exhibited by several F_1 hybrids. Heterobeltiosis was the highest kin P_{10} x P_4 (-16.28%) followed by P_5 x P_4 (-15.63%), P_{12} x P_8 (-14.44%), P_{12} x P_2 (-13.54%) and P_{10} x P_8 (-13.33%). Standard heterosis was high in P_5 x P_4 (-25.00%), P_8 x P_1 (-22.22%), P_9 x P_5 (-18.89%) and P_{13} x P_{10} (-118.89%). The F_1 hybrids P_{12} x P_5, A seed marker was identified during the course of investigation. The genotype, TA-102 was identified as having a white patch on the seed coat which would be of much significance in F_1 hybrid seed production.

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* Originals not seen

Appendices

Appendix I

Analysis of variance for different characters in 48 snakegourd genotypes

	Characters	Mean square values		
		Replication df = 1	Genotypes df = 47	Error df=47
1.	Main vine length	0.00	20267.53**	333.920
2.	Primary branches/plant	0.34	10.95	0.540
3.	Days to first male flower anthesis	0.47	21.99**	1.660
4.	Days to first female flower opening	3.42	72.31**	5.380
5.	Node at which first female flower appeared	1.65	28.97**	0.600
6.	Male flowers/plant	1024.00	14285329.82**	16661.790
7.	Female flowers/plant	875.38	562.54**	133.550
8.	Sex ratio	0.19	1886.10**	1.870
9.	Nodes on main vine	44.00**	93.14**	8.610
10.	Fruiting nodes on main vine	0.51	1.86**	0.200
11.	Days to fruit maturity	11.35	4.93**	0.150
12.	Days to first fruit picking maturity	4.19	81.20**	5.210
13.	Yield/plant	780287.98	22330760.96**	43551740.650
14.	Fruits/plant	4.52	185.81**	4.960
15.	Fruit length	7.16	781.70**	9.880
16.	Fruit girth	0.03	31.32**	1.460
17.	Flesh thickness	0.00	0.02**	0.001
18.	Seeds/fruit	41.16	175.30**	20.860
19.	Seed weight/fruit	1.93	17.72**	2.240
20.	100 seed weight	0.98	43.22**	0.460
21.	Average fruit weight	16.0	34268.21**	805.230
22.	Total crop duration	0.63	241.79**	0.170
23.	Vitamin C content of fruit	4.95	54.54**	0.127
24.	Crude fibre content of fruit	23.79	225.24**	0.550
25.	Crude protein content of fruit	5.25	165.07**	0.162

** - P = 0.01

Appendix II

Analysis of variance for combining ability in a line x tester analysis in snakegourd

Sources of variation	df	Mean squares				
		Main vine length	Primary branches/ plant	Days to first male flower anthesis	Days to first female flower opening	Male flowers/ plant
gca (line and tester pooled)	9	21555.99**	3.172**	17.545**	3.52**	4270720.00**
Sca	14	15439.714**	7.865**	9.618**	5.593**	1129197.84**
Error	34	579.353	0.761	1.038	0.972	158250.94

Appendix-II (contd.)

Sources of variation	df	Mean squares						
		Female flowers/ plant	Sex ratio	Nodes on main vine	Fruiting nodes on main vine	Days to fruit maturity	Days to first fruit picking maturity	Yield/ plant
gca (line and tester pooled)	9	775.90**	415.21**	74.21**	0.824**	2.592**	13.088**	28.445**
sca	14	269.594**	163.70	74.964**	1.768**	1.667**	7.049**	5.437**
Error	34	25.599	92.580	5.675	0.307	0.381	1.304	1.122

Appendix-II (contd.)

Sources of variation	df	Mean squares						
		Fruits/ plant	Fruit length	Fruit girth	Flesh thickness	Seeds/ fruit	Average fruit weight	Total crop duration
gca (line and tester pooled)	9	167.136**	264.247**	30.14**	0.0114**	109.16**	45737.664**	240.92**
sca	14	41.086	84.612**	13.262**	0.014**	124.492**	5487.00**	80.344
Error	34	34.814	1.409	0.430	0.002	4.271	324.412	63.421

** - (P = 0.01)

* - (P = 0.05)

Appendix III

Analysis of variance for different characters for 13 parents and 51 hybrids of snakegourd

Characters	Mean square values: Replication df = 1	Genotypes df=63	Error df=63
1. Main vine length	376.000	22104.573**	352.698
2. Primary branches/plant	0.025	9.222**	0.275
3. Days to first male flower anthesis	6.656	16.847**	0.760
4. Days to first female flower opening	1.234	46.521**	1.007
5. Male flowers/plant	1536.000	7000096.321**	24494.790
6. Female flowers/plant	15.750	435.252**	16.570
7. Sex ratio	-0.031	763.698**	5.138
8. Nodes on main vine	7.031	132.221**	2.387
9. Fruiting nodes on main vine	0.010	3.035**	0.241
10. Days to fruit maturity	0.564	3.595**	0.211
11. Days to first fruit picking maturity	0.906	49.679**	15.414
12. Yield/plant	4.984	41.060**	0.322
13. Fruits/plant	27.562	343.691**	2.899
14. Fruit length	13.406	568.960**	2.189
15. Fruit girth	0.328	26.339**	0.774
16. Flesh thickness	0.005	0.019**	0.004
17. Seeds/fruit	104.062	214.964**	23.712
18. Average fruit weight	176.000	50036.969**	285.397
19. Total crop duration	95.375	98.044**	7.849

** P = 0.01

HETEROSIS IN SNAKEGOURD
(*Trichosanthes anguina* L.)

By
PHILIP VARGHESE

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirement for the degree

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ABSTRACT

The present investigation "Heterosis in snakegourd" was conducted at the College of Horticulture during 1988-1990. Assessment of genetic variability showed significant differences of 25 characters in 48 snakegourd genotypes. The highest phenotypic coefficient of variation was observed for fruiting nodes on main vine, male flowers/plant, sex ratio and fruits/plant. The pcv was lowest for total crop duration. The gcv resulting in high heritability was high for majority of the characters. High heritability coupled with high genetic gain was noticed for male flowers/plant, sex ratio and fruiting nodes on main vine. The 48 genotypes were grouped into 10 clusters.

The combining ability analysis revealed significant gca variances for all characters. The sca variances were also significant for all characters except for total crop duration, sex ratio and fruits/plant.

The combinations exhibited high heterobeltiosis for yield were P_{12} x P_5 (114.03%), P_{12} x P_8 (113.68%), P_4 x P_3 (110.53%), P_{12} x P_4 (91.93%), P_{13} x P_4 (86.40%), P_3 x P_1 (82.58%), P_9 x P_5 (81.42%) and P_{12} x P_1 (80.83%).

The genotype, TA-102 was identified to carry a marker character - white patch - on the seed coat.