EVALUATION OF BHINDI HYBRIDS FOR YIELD AND ITS COMPONENTS

By

SHEELA M. N.

THESIS

submitted in partial fulfilment of the requirement

for the degree

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

Department of Plant Breeding

College of Agriculture

Vellayani - Trivandrum

1986

DECLARATION

I hereby declare that this thesis entitled "Evaluation of bhindi hybrids for yield and its components" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Sheela M.N.

Vellayani,

30-8-1986.

C E R T I F I C A T E

Certified that this thesis, entitled "Evaluation of bhindi hybrids for yield and its components" is a record of research work done independently by Kumari SHEELA M.N. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Dr.P.MANIKANTAN NAIR
Chairman
Advisory Board
Professor of Plant Breeding

Vellayani,
30-8-1986.

APPROVED BY

CHAIRMAN

Dr.P. MANIKANTAN NAIR

MEMBERS

1. Dr.V.GOPINATHAN NAIR

2. SRI.S.G. SREEKUMAR

3. SRI.R. BALAKRISHNAN ASAN

25/x/86

(Dr. S. PALANISAMY)
External Examiner

ACKNOWLEDGEMENT

It is my pleasant duty to express my deep sense of gratitude and indebtedness to my guide Dr.P.Manikantan Nair, Professor of the Department of Plant Breeding for suggesting the project work, excellent and patient guidance, critical suggestions and enthusiastic encouragement during the course of my studies and in the preparation of the thesis.

I extent my heartfelt thanks and indebtedness to Dr.V.Gopinathan Nair, Professor and Head of the Department of Plant Breeding for his valuable advice and constant encouragement through out the course of my studies and for providing the necessary facilities for carrying out the research work.

I owe immense gratitude to Sri S.G.Sreekumar, Assistant Professor of Plant Breeding for his constructive and helpful criticisms and for making valuable suggestions in the preparation of the thesis.

I place on record my gratefulness to Sri.R.Balakrishnan Asan, Assistant Professor of Agricultural Statistics for the help in designing the field experiment, statistical analysis of data and for making critical suggestions in the preparation of the thesis.

(contd..2.)

I extent my gratefulness to Dr.S.N.Murthy, Scientist, C.T.C.R.I, Sreekaryam, for his valuable assistance during the chemical assay carried out at the Institute.

I wish to acknowledge my sincere thanks to Sri C.T. Mukundan, Technical Assistant, Department of Agricultural Statistics, for his help in the computer analysis of the data, Sri L.Radhakrishnan Potti, Senior Office Superintendent for the excellent and neat typing of the thesis, Sri. Kuriakose for his help in taking photographs and all others who helped me directly or indirectly in the preparation of thesis.

I am thankful to the staff and students of the Department of Plant Breeding for the sincere help extended to me through out the research programme.

I also thank the ICAR for the fellowship made available to me during the course of Post-graduate programme.

Lastly I am highly indebted to my parents and brothers without whose prayers, blessings and encouragement this work would not have been possible.

SHEELA M.N.

C O N T E N T S

LIST OF TABLES

LIST OF TABLES (CONTD.)

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

1. INTRODUCTION

Vegetables play a pivotal role in human diet by virtue of its noble attributes by providing nourishment to the body besides being able to supply the roughage which the human body requires. The importance of vegetable dishes has now become increasingly aware among western countires, where non-vegetarianism was dominant hitherto. Vegetarianism as a way of life has been accepted in Britain in order to protect the circulatory system of the body. Furthermore, the production potential per unit area of these categories of crops surpasses many folds all other crops. It has been estimated that for the well being of a human being a minimum of 300 gm of vegetables are required per day. When the population of Kerala is taken into account 13,36,076 tons of vegetables are needed to cater to this demand. But the present production stands near 2,04,865 tons (Peter, 1984) and the gap is to be filled in the near future. Lack of production potential is one of the major constraints in the way of achieving the goal. Heterosis breeding has been amply proved to be an effective tool in augmenting the production potential of vegetables.

Bhindi (Abelmoschus esculentus (L.) Moench) is a member of the Malvaceae family which occupies an important place among vegetables on account of its tender green fruits.

Further, Bhindi is one of the choice vegetables grown extensively in India in kitchen gardens and market gardens as well. Bhindi is also a crop of significant nutritional value. Besides its use as a vegetable, Bhindi has an array of industrial and medicinal uses also.

The chromosome number of Bhindi is as high as 130 (Joshi and Hardas, 1956). Abelmoschus esculentus is reported as an allopolyploid, a conclusion reached from observations of its hybrids with other species. Despite its high chromosome number the species behaves as diploids. Bhindi responds well to breeding efforts and is easy to manage (Martin and Ruberte, 1978). Its quick growth, duration and photo insensitive nature enable the farmer to cultivate the crop round the year. In India and abroad genetic improvement of okra has been centred on selection. But recently attempts are underway to popularise intervarietal hybrids.

The cultivated varieties of Bhindi are heterozygous in constitution inspite of its adaptation for self pollination. An outcrossing range of 11.80 - 60.00 per cent was reported by Martin (1989). Natural crossing is attributed to the entomophilous nature of the flowers. Honey bees and black ants are observed to be the chief agents of cross pollination. The ease in emasculation and very high percentage of fruit setting point towards the possibilities of exploitation of

hybrid vigour in bhindi. Heterosis breeding as a tool for genetic improvement in bhindi has been advocated by many earlier workers.

The economic traits such as earliness, yield of fruit, disease resistance and quality are scattered in different cultivars. A wide spectrum of variation exists in this crop. As such the scope for heterosis breeding as a means of genetic improvement is immense.

The present study envisages evaluation of the performance of six top ranking hybrids already identified in an earlier trial (Balachandran, 1984) on large scale basis. The parent cultivars were selfed for a single generation and then the inbreds were crossed in selected combinations. The six hybrids and six parent cultivars were evaluated by conducting two field trials (January to April and April to July, 1985) at the Department of Plant Breeding, College of Agriculture, Vellayani.

The various biometrical techniques were employed in six parents and six selected hybrids of bhindi with a view to analyse the genetic variability between parents and hybrids, yield and its components, correlation, different types of heterosis and to fix parents and hybrid

combinations suitable for proper utilization in vegetable improvement programme.

The investigation revealed that heterosis breeding could be effectively employed as a potent tool in augmenting the yield potential and allied attributes in bhindi.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Eventhough Bhindi (Abelmoschus esculentus (L.)Moench) is a self pollinated crop, the population is found to be highly heterogeneous due to outcrossing. Natural crossing is attributed to the entomophilous nature of bhindi flower. Honey bees and black ants were observed to be the chief agents of cross pollination.

The extent of natural cross pollination was reported by different authors. Purewal and Randhawa (1947) reported that natural cross pollination in okra varied from 4.00 to 18.75 per cent, average being 8.75 per cent. According to Venkataramani (1953) the amount of natural crossing ranged from 31.7 per cent to 40.0 per cent depending on the distance between the two parents. Choudhary and Anothai Choomsai (1970) observed that cross pollination in okra ranged from 3.54 to 9.16 per cent. Shalaby (1972) reported natural cross pollination of 9.3 per cent. The percentage of cross pollination often goes to upto 42.2 per cent as observed by Mitidieri and Vencovsky (1974). According to Ramu (1976) the natural cross pollination due to insects in okra accounted to 3.05 per cent. Martin and Ruberte (1978) showed that cultivated varieties are expected to be somewhat heterozygous inspite of observed uniformity. Martin (1983) also reported an outcrossing range of 11.8 - 60.0 per cent in okra.

As a result of this high degree of cross pollination, large number of cultivars in this species display wide spectrum of variation with regard to the economic traits. Many of the yield components have high estimates of heritability and genetic advance. Significant positive heterosis has been reported in crosses between different cultivars. Because of the high degree of heterosis shown by this crop, the commercial utilization of hybrid vigour through the development of hybrids with high yield potential assumes paramount importance. Genetic evaluation will help us to find the genetically superior hybrids which would perform well at least for two to three seasons.

2.1 GENETIC PARAMETERS AND CORRELATION STUDIES IN BHINDI

2.1.1 Yield and its components

2.1.1.1 Genetic parameters

Trivedi and Prakash (1969) observed greater variability in the yield contributing fruit characters, length and thickness of pods and greater heritability values of 74.15 per cent for length and 63.77 per cent for thickness. The greater variability along with high heritability of these two characters can impose an effective selection for longer and thicker fruits in bhindi.

High heritability estimates were observed for plant height, days to flower, yield per plant, seeds per pod and

thousand seed weight by Padda et al. (1970). In a study by Rao (1972) with 22 varieties of bhindi, wide variation with regard to quantitative characters was observed. Plant height and number of days to flowering showed high genetic coefficients of variation coupled with high estimates of heritability and genetic advance.

Ngah and Graham (1973) reported that among the major yield components, fruit length had the highest heritability of 84 per cent and the fruit weight had the lowest, being 48 per cent. The values for plant height and internode length were about 79 per cent each.

In a study by Singh et al.(1974) with thirty varieties of bhindi, high heritability values and estimates of genetic advance were obtained for fruit diameter and fruit length. Marketable fruit yield per plant had 22.49 per cent genotypic coefficient of variation. The genotypic coefficient of variation was highest for fruit diameter (47.02 per cent) and lowest for number of fruits/branches (0.00 per cent) High heritability and genetic advance were displayed by fruit diameter and fruit length. Genetic advance expressed as percentage of mean was relatively low for number of fruits per plant, weight of fruit and stem diameter. Variability for yield was primarily dependent on weight of fruit, number of fruits per plant and number of flowers per plant.

Majumdar et al.(1974) observed high magnitude of genotypic coefficient of variation for several plant characters like yield per plant, number of fruits per plant and weight of fruit.

Lal et al. (1977) showed high phenotypic and genotypic variability for all characters studied except for yield per plant. Heritability estimates were high for all characters except yield per plant, the highest estimates being for days to flowering, internode length, fruit length and fruit thickness. The fruit thickness gave the lowest estimate for genetic advance.

Studies conducted by Rao and Kulkarni (1977) revealed that the estimates of heritability and expected genetic advance were highest for number of fruits per plant. They also observed that number of days to flowering was influenced less by the environment than plant height and number of fruits per plant. High heritability for all economic character except height in the F_2 of a half-diallel cross involving six varieties was recorded by Rao and Sathyavathi (1977). Rao et al. (1977) observed good amount of genetic variability in the population for all quantitative characters under study. Further, high heritability values for days to flowering, plant height, number of pods and yield per plant were also recorded by them. Expected genetic advance was moderate for

number of pods and yield per plant, whereas the values were very low for other characters.

Rao and Kulkarni (1978) observed the contribution of height to the total variability to be 57.75 per cent higher than that of days to flowering.

Singh and Singh (1978 b) reported highly significant variances due to treatments for the characters, namely days to flower, plant height, first fruiting node, number of branches per plant, internodal distance, fruit length, number of fruits per plant and yield per plant.

Kaul et al. (1979) observed considerable genetic variation for number of pods per plant, pod yield per plant, seed yield per plant and number of pods per plant.

In a line X tester analysis, Mahajan and Sharma (1979) observed high heritability estimates for number of fruits, fruit length and fruit diameter. Mishra and Chhonkar (1979) reported high heritability, genetic advance and genotypic coefficient of variation for number of branches per plant, pods per plant, seeds per pod, pod length and plant height.

In a study of genotypic X environmental interaction by Rao (1979), the variance due to genotypes and genotype X environment interaction was found to be highly significant. Days to flower, number of fruits per plant and fruit

bearing branches were observed to be important contributors to genetic divergence by Singh and Singh (1979 a) and hence they stressed the importance of these characters in augmenting yield.

Murthy and Bavaji (1980) observed appreciable amount of variability in respect of fruit length, number of fruits and fruit yield per plant. Plant height, days to flowering, fruit length and yield displayed high heritability. Days to flowering was seemed to be controlled by non-additive gene action as it had very low genetic advance. Yield displayed high estimate of genetic advance.

High heritability estimates in the narrow sense was found for all the characters such as number of days to 50 per cent flowering, fruit length, fruit diameter etc. except yield per plant, number of pods per plant and plant height by Parthap et al.(1980).

In a genetic divergence study of a seven parent diallel set with 21 F_1 hybrids of okra, Parthap et al. (1980) found that length of fruit contributed maximum to total divergence. Rao (1980) in a study of six populations derived from a 6 x 6 diallel cross found that the response to artificial selection was quite encouraging for fruit number and yield per plant. Maximum heritability in the narrow sense was recorded for days to flowering followed by plant height and number of fruits per

plant. Genetic advance was maximum for plant height followed by number of fruits per plant and days to flowering.

Singh et al.(1980) studied 43 genetic stocks of okra comprising 13 parents and 30 hybrids to measure the genetic divergence. Analysis of variance for treatments showed highly significant difference for all the characters indicating a wide range of variability.

In a study of genetic parameters and heterosis, Rao and Ramu (1981) obtained results which suggested the phenotypic selection for number of pods and yield to be promising. Wide range of phenotypic variability was observed for more of the plant characters studied by Thaker et al. (1981). The genetic coefficient of variation was high for plant height, leaf area, fruits per plant, fruit weight and yield per plant. The heritability values were moderate for plant height, fruits per plant and fruit length whereas the parameters were low for leaf area, fruit weight and yield. High genetic advance was observed for five characters namely plant height, leaf area, fruits per plant fruit weight and yield per plant.

Palaniveluchamy et al.(1982) reported that plant height had the highest estimates of heritability and genetic advance among the yield components. In a study of parental and F_1 generations of a 7 x 7 half diallel cross Parthap et al.(1982) reported that first fruiting node and days to 50 per cent

flowering were under the control of additive gene action whereas for number of fruits and yield per plant both additive and non-additive gene action played their role. High heritability coupled with additive gene action for first fruiting node and days to 50 per cent flowering indicated that simple selection would be effective for their improvement. For number of fruits and fruit yield per plant recurrent selection would be desirable.

Vashistha et al.(1982) reported significant differences for yield per plant and other agronomic characters except number of ridges per fruit. High values for heritability and genetic advance for fruits per plant, plant height and root length indicated scope for improving these characters. Yield variability was depended primarily on number of fruits per plant, plant height and root length.

High phenotypic and environmental coefficient of variation for fruit yield and number of fruits per plant was observed by Balachandran (1984) indicating greater influence of environment on these characters. Genotypic coefficient of variation was maximum for percentage of fruit set followed by number of non-bearing nodes, number of branches per plant, number of fruits per plant and fruit yield. Relatively high heritability was manifested by days to 50 per cent flowering,

flowering duration, percentage of fruit set and number of branches per plant. Plant yield displayed low heritability and low genetic advance. The paramount components of yield, namely number of fruits and length and weight of individual fruit displayed moderately low heritability and genetic advance. The prospects of heterosis breeding programme seemed to be promising for the improvement of these characters.

2.1.1.2 Correlation studies on yield and its components

A number of studies were on record with regard to correlation of the different plant and fruit characteristics in bhindi.

Kohle and Chavan (1967) reported that yield of okra was directly correlated with the length and thickness of the fruit and number of fruits per plant. In a study of correlation in bhindi, Martha Mary (1969) recorded that yield per plant was directly correlated with height of plant, fruit length, fruit girth and number of fruits, when the varieties were considered as a whole. On the other hand, when they were considered separately, the only character which was found to be highly significant and positively associated with yield was the length of the fruit. Padda et al.(1970) observed positive correlation between days to flowering and seeds per fruit only.

Other correlations between yield and its components were found to be nonsignificant.

Significant positive correlation between yield and fruit weight and total number of nodes per plant was reported by Thamburaj and Kamalanathan (1973). Majumdar et al.(1974) reported that days to flowering was negatively correlated with yield per plant.

Singh et al. (1974) studied fifteen quantitative traits in thirty varieties of bhindi and found that the marketable fruit yield per plant was positively correlated with number of flowers, number of fruits and number of branches per plant, number of fruits on branches and fruit weight. Yield was primarily dependent on number of flowers per plant, number of fruits per plant and fruit weight.

In a study of correlation and regression coefficients in 20 varieties of bhindi, Rao and Ramu (1975a) reported that yield per plant was significantly correlated with pod and node number and plant height, pod number per plant with node number and plant height, node number with plant height and seed number with pod ridge number. An increase in yield of 0.1580, 0.0406 and 0.0305 g per plant was associated with unit increase in plant height (in cm), node number and pod number respectively. Partial regression coefficients indicated

that among three yield components (plant height, node number and pod number) directly correlated with yield, pod number per plant had the most significant effect.

Roy and Chhonkar (1976) from their study of total and partial correlation coefficients concluded that fruit number per plant and branch number per plant were the most important yield contributing characters. Rao et al.(1977) were of the opinion that number of pods per plant and plant height should be given major emphasis in bhindi during selection breeding programme to increase yield.

Kawthalkar and Kunte (1978) reported that height of plant was more useful for the prediction of yield than the number of leaves per plant.

In a study of correlation and path coefficient analysis in six varieties of bhindi by Korla and Rastogi (1978), yield was found to be correlated with number of fruits per plant and days to flowering. Further, they suggested early flowering types with a large number of fruits for the yield enhancement.

Rao and Kulkarni (1978) in a diallel cross with six varieties observed highly significant positive correlation between height and number of pods per plant. The direct effect of height was greater than that of days to flowering, being positive in the former and negative in the latter.

In a discriminant function study of Singh and Singh (1978 a) using data from thirteen strains of bhindi showed that among selection indices having two character combinations, yield and number of fruits per plant were the best resulting in about ten per cent increase over selection based on yield alone.

In a study on 30 strains, Singh and Singh (1978 c) reported that yield was positively correlated with fruits per plant, branches per plant, plant height, and fruit length.

Ajmal et al. (1979) observed that fruit yield was positively correlated with fruit number and number and length of nodes. Number of days to first flowering made the greatest direct contribution to yield followed by number of nodes and fruit number.

Kaul et al. (1979) reported that primary branches per plant followed by pod yield per plant had the greatest direct effect on seed yield. In a study of line X tester analysis, Mahajan and Sharma (1979) observed that yield had a positive and significant association with plant height, number of fruits per plant and fruit length. The main characters contributing to yield were found to be the stem diameter, flower number/plant, fruit number per branch and plant, fruit length and weight (Parthap, et al., 1979). Fruit number per plant and fruit weight made a direct positive contribution to yield

via fruit number per plant.

Singh and Singh (1979 b) in a path-coefficient analysis using data from 30 varieties of bhindi reported that fruit yield was positively and significantly correlated with number of fruits per plant, number of branches per plant, fruit length and plant height. Plant height followed by internode length and fruit number per plant had the greatest direct effect on fruit yield.

In a study of correlation analysis Elangovan et al. (1980) observed that fruit number per plant, fruit length, fruit width and number of branches were the preliminary yield determining components in bhindi. Though plant height was found to have significant positive correlation with number of fruits per plant, it had only a nonsignificant positive correlation with fruit yield.

Murthy and Bavaji (1980) observed that fruit number per plant and number of days to flowering had the greatest direct effect on yield. The fruit yield per plant possessed positive correlation with fruit number while it registered negative correlation with days to flowering.

Arumugam and Muthukrishnan (1981) reported that number of fruits and length of fruit were highly correlated with fruit yield. Plant height and days taken to flower were

reported to have lesser degree of correlation with yield.

Balachandran (1984) observed that number of fruits per plant, earliness in flowering, flowering duration and length of fruit were the important contributing characters of yield. Number of branches per plant was found to contribute negatively to total yield.

Korla et al. (1984) reported positive and significant correlation between number of fruits per plant and yield per plant. They suggested that either number of fruits per plant at one or in combination with plant height may improve the yield per plant.

2.1.2 Crude fibre content

Bhindi cultivars producing fruits with lower fibre content get higher consumer preference. The different cultivars of bhindi exhibit variation with respect to the crude fibre content. The fibre content also vary much with age of the fruits at harvest. A wide variation in crude fibre content, depending on the cultivars studied, was reported by different workers.

Sistrunk et al.(1960) reported that fibre developed in the pods, destroyed their edibility, as the dry matter percentage increased beyond the eighth or nineth days from flowering. Ravindra (1964) observed that crude fibre which

determines the edibility of bhindi was much influenced by the season.

Chauhan and Bhandari (1971) reported that crude fibre content was negligible upto the age of nine days (0.57 per cent) and it increased rapidly from 12-15 days (maximum 7.21 per cent at 30 days age). It was observed that though there was an increase in weight and size of the pods beyond nine days, the quality deteriorated because of a steep rise in the crude fibre content.

In a genetic variability study Singh et al.(1974) observed high genotypic coefficient of variation (24.09), phenotypic coefficient of variation (29.44), heritability (96.76) and genetic advance (52.63 per cent) for crude fibre content.

Kakar (1976) reported that cultivar effects were not significant for fibre content based on dry weight.

Rao and Sulladmath (1977) observed a rapid rise in crude fibre content in fruits after eight days of development. In a study of fifteen hybrids, Maurya et al.(1978) found wide variation in crude fibre content between the cultivars.

Parthasarathy and Sambandam (1979) reported that the fruits of the different varieties studied were edible upto the sixth or seventh day of flower opening and that crude fibre content of edible pods to be only 26.40 per cent of that of fully developed pods. Parthap et al. (1982) recorded low heritability for crude fibre content. Non-additive and environmental variation constituted the major portion of the phenotypic variation of this character.

In a study consisting of 56 hybrids from a line X tester analysis involving 14 lines and four testers, Elangovan et al. (1983) observed that the overall crude fibre range was narrow 13.1 to 14.3 per cent. Oyolu (1983) recommended that okra pods be harvested between the fourth and the sixth day to have high quality pods. The crude fibre increases significantly after this.

Balachandran (1984) observed that the heritability and genetic advance estimates were low for crude fibre content. Correlation studies among yield factors and quality attributes revealed that higher the yield, greater will be the crude fibre content. Heavier and longer fruits were found to contain less crude fibre. Fruits with low fibre content possessed higher quantities of vitamin A but lesser vitamin C.

2.1.3 Yellow vein mosaic disease

Yellow vein mosaic disease is one of the most dreadful disease of okra which causes serious loss of fruits as well as seed yield. High heritability (70 per cent) was observed for resistance to yellow vein mosaic by Padda et al.(1970). The expected genetic advance as percentage of mean was also moderate to high. Negative correlation was found to be existing between yellow vein mosaic incidence and yield. Sastry and Singh (1974) reported that the average loss in yield due to yellow vein mosaic disease was as high as 93.80 per cent.

Arumugam and Muthukrishnan (1979) observed strong negative correlation between disease resistance and values for a hybrid index, but there was no association between disease reaction and the various yield components and associated traits.

In a study of 20 genotypes, Kaul et al. (1979) observed considerable genetic variation for number of plants at stage IV of infection with yellow vein mosaic virus. Mishra and Chhonkar (1979) reported high heritability estimates (61.12 per cent), expected genetic advance (64.96 per cent) and genotypic coefficient of variation (59.20 per cent).

Non-additive inheritance for resistance to yellow vein mosaic disease was recorded by Parthap et al.(1982) Low heritability estimates for disease incidence further substantiated that non-additive and environmental variation constituted the major portion of phenotypic variation of genotypes. They suggested that this variation should be exploited by developing F_1 hybrids.

Inheritance studies by Sharma and Sharman (1984) revealed that tolerance was probably controlled by two dominant complementary genes or under polygenic control.

2.1.4 Fruit and shoot borer incidence

Very little work on the genetic aspects of fruit and shoot borer attack was available.

Raut and Sonone (1979) reported a strain AE71 which was tolerant to both fruit and shoot infestation. In a study of twenty one varieties and seven F_1 crosses of okra by Teli and Dalaya (1981), varieties AE79, AE52, Sel 1-1 X AE 79 and AE 69 were concluded to be least susceptible to insect attack with fruits having hard skin and tough sparse hairs. Dhawan and Sidhu (1984) observed that maximum damage was in fruits (67.7 per cent) and bud (52.4 per cent) at the end of October. The maximum shoot and flower damage was in mid August. Heavy rainfall had detrimental effect on the build up of the pest population.

2.2 Heterosis

2.2.1 Yield and its components

Bhindi being a cross pollinated crop, the scope for heterosis breeding is immense. Further, many workers have reported non-additive gene action for yield, which also augments the proposition for heterosis breeding.

Sigh et al. (1938) observed hybrid vigour in interspecific F_1 plants of bhindi. The F_1's showed increased height, branching and number of fruits. Vijayaraghavan and Warrier (1946) reported heterosis for various characters in intervarietal hybrids in okra. Pal et al. (1952) observed strong heterosis in growth and fruiting of interspecific hybrids in this crop.

Venkataramanai (1952) reported an yield increase of 5.4 - 14.5 per cent in intervarietal hybrids over the better parents. The F_1 plants were found to be intermediate between their parents with respect to height. The number of pods per plant was higher or intermediate compared with the respective parents.

In a study of six varieties and their F_1 hybrids, Joshi et al. (1958) recorded heterosis with respect to plant height, fruit size, number of branches per plant and number and weight fruits per plant. Thirteen of the twenty-nine combinations gave a greater weight of fruits per plot

than their respective higher yielding parents whereas ten hybrids yielded less than the parents with lower yields. They attributed the increased yield to increase in fruit number. Further they found that in general crosses between varieties with five ridged and eight ridged fruits resulted in hybrids with higher yields than those within these groups. They also opined that male sterility would facilitate the production of hybrid seed on a commercial scale.

Durantia (1964) found that inbreeding for three years produced no deliterious effect on yield, plant size or other characteristics in okra. In an investigation on hybrid vigour, Isack (1965) found significant heterotic effects in hybrids with regard to the number of flowers, number of fruits and girth of fruits compared to the better parent. He could not find significant heterosis with regard to height of plant, earliness in flowering and length of fruit in comparison with the better parent.

Raman (1965) reported that most of the hybrids from crosses between different cultivars of bhindi displayed hybrid vigour. Hybrids manifested early flowering, early maturity and high individual fruit weight.

Mathews (1966) reported that the vigour for earliness exhibited in the F_1 generation of two crosses out of six persisted in the F_2 and F_3 generations. Increase in fruit production and length of fruits in F_1 hybrids of some crosses also were found to persist in the F_2 generation. Hybrid vigour in comparison to weight of fruits persisted upto F_3 in one of the crosses.

Akram et al.(1973) in a study of 20 crosses reported that the F_1's had better looking fruits, which were also softer and more tender in nature.

Heterosis for germination percentage, precocity in flowering, plant height and yield performance as indicated by fresh weight of fruits per plant were reported from Malaya by Jalani and Graham (1973) from their study with hybrids between Malayasian and American varieties of okra. The evidence suggested that the heterosis for size shown by the F_1 hybrids might be due to the initial advantage conferred by their embryos which tended to be heavier and longer than those of the parents.

Lal and Srivastava (1973) observed positive heterosis with respect to plant height, number of branches per plant, fruit length, fruit thickness, number of fruits per plant and fruit yield.

Rao and Girirej (1974) reported that ten out of fifteen hybrids studied gave higher yields of fruit than the control (Pusa Sawani), mainly due to many pods per plant and seeds per fruit.

Lal et al.(1975) reported positive heterosis for plant height, days to flower, internodal length, fruit thickness, number of fruits per plant and yield per plant. Inbreeding depression was observed in four characters compared to F_1 with yield per plant having maximum depression and number of fruits per plant having minimum depression.

In a study of 24 hybrids from crosses involving 15 parents, Singh et al.(1975) observed significant heterosis for plant height, number of branches per plant, first fruiting node, fruit length, fruit width, number of fruits per plant and yield per plant. Rao and Ramu (1975) reported positive heterosis for pod length and number of ridges on the pod.

Kulkarni and Virupakshappa (1977) observed significant heterosis over better parent for earliness, plant height and fruit number per plant. Inbreeding depression was observed in the F_2 in all the cases of the diallel crosses.

Rao and Kulkarni (1977) in a study of fourteen hybrids from crosses involving two lines and seven testers were found to be taller, maturing earlier and producing

more fruits. From a study of thirteen geographically diverse strains and thirty of their F_1 hybrids, Singh et al.(1977) observed that the cross combinations involving the parents of diverse origin were found to be high yielders and showed higher heterosis. Maximum heterosis was shown in the characters like fruit yield per plant, number of fruits per plant and plant height.

In a study of 6 x 6 diallel cross, Rao (1978) observed significant F_1 heterosis in nine of the hybrids for number of days to flowering relative to the better parent. Progeny from 64 crosses with four male lines and sixteen female lines showed heterosis for all the nine agronomic traits studied by Sharma and Mahajan (1978) and all the characters were influenced by non-additive gene action. Overdominance was observed for days to first flowering, plant height, fruit weight and yield.

Singh and Singh (1978 b) observed substantial heterosis for days to flowering, plant height, first fruiting node, number of branches per plant, internodal distance, fruit length, number of fruits per plant and yield per plant.

Singh and Singh (1979 c) in a study with 125 hybrids observed highest heterosis relative to the better parent for fruit number per plant (71.46 per cent) followed by

yield per plant (70.28 per cent). Parthap and Dhankar (1980) reported heterosis for fruit yield and fruit number per plant, fruit number per branch and fruit length.

In a study of 56 hybrids produced by crossing 14 lines, Elangovan et al.(1981) reported heterosis over the mid parental and higher parental values for plant height, number of branches, first fruiting node, earliness, fruit length, width and number, fruit yield and hundred seed weight.

Parthap et al.(1981) in a study of a seven-parent half diallel cross observed heterosis for fruit yield per plant.

Thaker et al.(1982) studied 21 crosses of seven varieties and found that percentage increase over the better parent in the F_1 was highest for fruit yield per plant followed by number of fruits per plant and fruit length. Seven crosses showed significant increase over the better parent for fruit yield and four showed increase over the best parent. Inbreeding depression was noted in the F_2 for these characters.

Balachandran (1984) observed desirable heterosis in respect of all the seventeen characters studied in the three types of heterosis comparisons. The major yield

contributing characters, namely, number of fruits per plant and length and weight of fruits displayed relatively higher percentage of increase over the mid parental, better parental and standard cultivar values in higher proportion of hybrids.

Elmaksoud et al.(1984) reported heterosis for plant height, earliness in flowering, pod number per plant, pod weight and pod length and they justified the commercial utilization of hybrid vigour in okra.

2.2.2 Crude fibre content

Heterosis was observed for fruit sugar and fibre content by Parthap et al.(1981). Non-additive type of inheritance was observed for crude fibre content by Parthap et al.(1982). The non-additive and environmental variation constitute the major portion of phenotypic variation and they suggested that this variation should be exploited by developing F_1 hybrids.

Elangovan et al.(1983) estimated heterosis for crude fibre content of bhindi fruits in 56 crosses and reported desirable heterosis expression over midparental and higher parental values in seven and six hybrids respectively. The range of heterosis was -0.394 per cent to 3.62 per cent and -2.18 per cent to 9.02 per cent with

respect to relative heterosis and heterobeltiosis respectively. The values for standard heterosis ranged between -0.75 per cent to 10.60 per cent. Balachandran (1984) observed desirable negative standard heterosis in 66.67 per cent of the hybrids studied.

2.2.3 Yellow vein mosaic disease

Parthap et al.(1981) recorded that some hybrids had a lower incidence of yellow vein mosaic virus than their respective parents. Combining ability variances were found to be non-significant. Further, they suggested that the variation with regard to tolerance to yellow vein mosaic virus can be exploited by developing F_1 hybrids.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study was undertaken at the Department of Plant Breeding, College of Agriculture, Vellayani, during 1983-'84 and 1984-'85. The experiment consisted of:

1 Raising six selected cultivars already identified from a 6 x 6 diallel cross and production of inbreds.

2 Crossing plot consisted of six inbreds.

3 Evaluation of six parents and six selected hybrids in a randomized block design with three replications in two seasons.

3.1 Inbred production

The following cultivars were selfed for one generation.

Name of cultivar	Source
1. Karingal local	Karingal, Kanyakumari district, Tamil Nadu.
2. Kilichundan	Vellayani, Trivandrum district.
3. Pilicode local	Pilicode, Cannanore district.
4. Pusa Sawani	A.R.S., Lam, Guntur, A.P.
5. Selection 2-2	A.R.S., Lam, Guntur, A.P.
6. Sevendhari	Pune, Maharashtra.

Technique of selfing

Bhindi flower being hermaphrodite with its own adaptation for self pollination, was selfed by protecting it with a butter paper cover. The flower buds which would open the next day were covered in the previous day evening. The covers were removed on the third day to facilitate growth of the fruits. The mature fruits were harvested after one month of fertilization and seeds extracted.

3.2 Crossing plot

The six single generation inbreds were raised in a crossing plot in pots during September-December, 1984. The inbreds were crossed in the following six selected combinations.

1.	Pusa Sawani	x	Sevendhari
2.	Selection 2-2	x	Kilichundan
3.	Selection 2-2	x	Sevendhari
4.	Sevendhari	x	Karingal local
5.	Sevendhari	x	Kilichundan
6.	Sevendhari	x	Pilicode local

Technique of crossing:

Crossing of bhindi flowers involved three principal steps namely emasculation of the flowers, protection and artificial pollination.

Emasculation

The flowers which would open the next day were selected. The staminal tube covering the ovary and style was removed in the previous day evening, following a slightly modified method of the 'Simple technique of crossing' suggested by Giriraj and Rao (1973).

Using a sharp razor blade a circular cut was made around the fused calyx of the selected flower at about 1 cm from its base and removed the calyx cup along with corolla and exposed the staminal tube bearing anthers. A needle tip was used to cut open the staminal column lengthwise and for its removal. Much care was taken to see that in the process no injury was imparted to either ovary or style. The calyx cone removed from the bud was used for protecting the emasculated flower bud. Mature flower buds of pollen parent were protected by butter-paper cover on the previous day of blooming. Pollination was done between 6 a.m. and 10 a.m. and pollinated flowers were protected again by butter paper covers. The paper covers were removed on the third day to facilitate growth of the fruits.

The mature pods were collected one month after pollination.

3.3 Evaluation of parents and hybrids

The six parents and six hybrids were assigned the following accession numbers.

1 Karingal local
2 Kilichundan
3 Pilicode local
4 Pusa Sawani
5 Selection 2-2
6 Sevendhari
7 Pusa Sawani x Sevendhari (4 x 6)
8 Selection 2-2 x Kilichundan (5 x 2)
9 Selection 2-2 x Sevendhari (5 x 6)
10 Sevendhari x Karingal local (6 x 1)
11 Sevendhari x Kilichundan (6 x 2)
12 Sevendhari x Pilicode local (6 x 3)

The six parent cultivars and their six hybrids were put under an evaluation trial with three replications during January-April and April- July 1985. Each treatment consisted of thirty plants. The inter and intra row distances were 60 cm and 45 cm respectively. Management practices were followed as per the Package of practices of Kerala Agricultural University (1984).

3.3.1 Observations recorded

From among thirty plants in each replication, ten plants were selected randomly for recording biometrical observations.

3.3.1.1 Biometrical observations

i Days to flower

Number of days taken for first blooming was recorded in all observational plants and averaged.

ii First fruiting node

The node in which the first fruit set was noted and recorded.

iii Mean leaf area

Two leaves were collected randomly from each of the fourth and eighth node of the observational plants. Leaf area was determined with a planimeter and averaged.

iv Number of fruits per plant

The total number of fruits produced by the observational plants were counted and averaged.

a. Number of fruits on main stem

The total number of fruits produced on the main stem of the observational plants were counted and averaged.

b. Number of fruits on branches

The total number of fruits produced on the branches of observational plants were counted and averaged.

v Length of fruit

Three fruits selected randomly from the third, sixth and nineth harvest of the observational plants were measured from base to tip, averaged, and expressed in centimetre.

vi. Girth of fruit

The fruits used for recording length were taken for measuring girth. The maximum girth of fruit was measured and expressed in centimetre.

vii Weight of single fruit

Weight of single fruit was calculated from total fruit yield and total number of fruits

viii Weight of fruits per plant

The total number of fruits produced by observationel plants at each harvest were weighed, averaged and expressed in gram.

ix Number of seeds per fruit

A random sample of three fruits each were taken from the third, sixth and nineth harvest, seeds extracted, counted and averaged.

x Number of ridges per fruit

Three fruits each were collected randomly from each of the third, sixth and nineth harvest of the observational

plants and number of ridges per fruit were counted and averaged.

xi Number of flowers per plant

The total number of flowers produced per plant were counted and recorded.

xii Fruiting phase

The duration between first harvest and final harvest in each treatment was recorded.

xiii Number of non-bearing nodes

Those nodes in which flowers failed to develop into fruits were counted and recorded.

xiv Height of plant

Height of plant from ground level to the tip was measured on the last harvest day, averaged and expressed in centimetre.

xv Number of branches

Total number of primary branches producing fruits were counted and averaged.

xvi Girth of stem

Girth of the main stem at the ground level was measured and averaged.

xvii Percentage of fruit set

Percentage of fruit set was calculated from number of flowers produced per plant and number of fruits set.

3.3.1.2 Yellow vein mosaic disease scoring

Yellow vein mosaic disease intensity was scored using the rating scale developed by Arumugam et al. (1975) which is given below.

Symptoms	Grade	Rating scale
i) No visible symptoms characteristic of the disease	Highly resistant	1
ii) Very mild symptoms, basal half of the primary veins green, mild yellowing of anterior half of primary veins, secondary veins and veinlets. Infection is also seen late in the season under field conditions.	Resistant	2
iii) Veins and veinlets, turn completely yellow	Moderately resistant	3
iv) Pronounced yellowing of veins and veinlets, 50% of the leaf lamina turned yellow, fruits exhibit slight yellowing	Susceptible	4
v) Petiole, veins, veinlets and interveinal area turn yellow in colour. Leaves start drying from the margin, fruits turn yellow in colour.	Highly susceptible	5

The disease rating for each treatment in a replication was calculated as follows.

$$\text{Mean disease rating} = \frac{\text{Sum of disease scores of plants observed}}{\text{Number of plants}}$$

3.3.1.3 Scoring of fruit and shoot borer infestation

a) Percentage of shoot infestation

The number of shoot infested plants in a plot were counted, averaged and expressed in percentage.

b) Percentage of fruit infestation

The total number of fruits damaged by fruit and shoot borer in a plot was counted, averaged and expressed in percentage

3.3.1.4 Chemical analysis

Crude fibre content

The crude fibre content was estimated as per the method suggested by Chopra and Kanwar (1976).

3.3.2 Statistical analysis

3.3.2.1 Estimation of Mean and Variance

i) Means were estimated for each character for all the 12 treatments.

ii) The significance of the variation between varieties with respect to each character was tested by applying the analysis of variance.

Source of variation	Degrees of freedom	Sum of squares	Mean squares	'F' ratio
Blocks	(b-1)	$\frac{\sum_j B_j^2}{v} - C = SS_B$	$SS_B/(b-1) = MS_B$	MS_B / MS_E
Varieties	(v-1)	$\frac{\sum_i V_i^2}{b} - C = SS_V$	$SS_V/(v-1) = MS_V$	MS_V / MS_E
Error	(b-1) (v-1)	$SS_T - (SS_B + SS_V) = SS_E$	$SS_E / (b-1)(v-1) = MS_E$	
Total	(bv-1)	$\sum_{ij} Y_{ij}^2 - C = SS_T$		

Where B_js' are the block totals,

$$j = 1, 2, \ldots\ldots\ldots\ldots b$$

V_is' are the treatment totals,

$$i = 1, 2, \ldots\ldots\ldots\ldots v$$

Y_{ij}s' are the individual observations.

The ratio $\frac{MS_B}{MS_E}$ follows an 'F' distribution with (b-1) and (b-1) (v-1) degrees of freedom and provides a test of significance for blocks. Similarly the ratio $\frac{MS_V}{MS_E}$ follows an 'F' distribution with (v-1) and (b-1) (v-1) degrees of freedom and provides a test of significance of varieties. MS_E is the estimate of error

variance and $\sqrt{\frac{MS_E}{b}}$ is the estimate of standard error of the mean. The varieties were compared by using the value of the critical difference given by

$$CD = t\ (b-1)(V-1)\ \sqrt{\frac{2MS_E}{b}}$$

The analysis of variance was done separately for both the trials.

Pooled analysis of variance was done to investigate the variety X season interaction for the various characters. Prior to pooling the estimates of error variance for the two trials were tested for homogenity by applying the 'F' test. Whenever the error variances were homogenous the following analysis was done:

Source of variation	Degree of freedom	Sum of squares	Mean squares	'F' ratio
Seasons	(l-1)	$\frac{\sum L_j^2}{vb} - C = SS_L$	$SS_L / (l-1) = MS_L$	
Varieties	(v-1)	$\frac{\sum V_i^2}{lb} - C = SS_V$	$SS_V / (v-1) = MS_V$	$\frac{MS_V}{MS_{VL}}$
Variety x season	(v-1) (l-1)	$SS_T - (SS_L + SS_V) = SS_{VL}$	$SS_{VL} / (v-1)(l-1) = MS_{VL}$	$\frac{MS_{VL}}{MS_E}$
Pooled error	$n_1+n_2 = n$	$SS_{E1} + SS_{E2} = SS_E$	$SS_E/n = MS_E$	

Where L_js' are the season totals, j = 1,2,.....1

V_is' are the treatment totals, i = 1,2,.....v

n_1 = error degrees of freedom for the first trial

n_2 = error degrees of freedom for the second trial

SS_T = sum of squares of variety totals

SS_{E1} = Error sum of squares for the first trial

SS_{E2} = Error sum of squares for the second trial

The ratio MS_{VL}/ MS_E follows an 'F' distribution with (v-1) (l-1) and n degrees of freedom and provides a test of significance for variety x season interaction. Similarly the ratio MS_V / MS_{VL} follows an 'F' distribution with (v-1) and (v-1) (l-1) degrees of freedom and provides a test of significance of varieties.

Wherever the error variances were found to be heterogenous, the procedure of weighted analysis of variance was done as follows:-

$$\text{Weight for each season} = W_i = \frac{r}{S_i^2}$$

Where r = number of replications

S_i^2 = error mean square of the corresponding character

$W_i P_i$ for each season, where P_i's are the season totals for the corresponding characters.

$W_i t_i$ for each variety, where t_i's are the means for each variety for each season.

S_i = The column wise sum of squares.

The various items in the analysis of variance were calculated as follows:

$$\text{Total sum of squares} = \Sigma W_i S_i - C = SS_T$$

$$\text{Where, } C = \frac{G^2}{t \Sigma W_i}, G = \Sigma(\Sigma W_i t_i) = \Sigma W_i P_i$$

t = number of varieties

$$\text{Season sum of squares} = \frac{1}{t} \Sigma(W_i P_i^2) - C = SS_L$$

$$\text{Variety sum of squares} = \frac{\Sigma(\Sigma W_i t_i)^2}{\Sigma W_i} - C = SS_V$$

Variety X Season sum of squares $= SS_T - (SS_L + SS_V)$

$= SS_{VL}$

Source of variation	Sum of squares
Seasons	SS_L
Varieties	SS_V
Variety X Season	SS_{VL}
Total	SS_T

For testing the significance of variety X Season interaction $\chi^2 = \frac{(n-4)\ (n-2)}{(n + t-3)} \times I$ was compared with the table value of χ^2 having

$\frac{(p-1)\ (t-1)\ (n-4)}{(n + t-3)}$ degrees of freedom where,

$I = SS_{VL}$

n = degrees of freedom for error

p = number of seasons

t = number of varieties

The significant χ^2 values indicated that the varieties differed from season to season with respect to the particular character. Hence the relevant varietal differences were tested by comparing the variety and interaction mean squares obtained from an unweighted analysis.

Source of variation	Degrees of freedom	Sum of squares	Mean squares	'F' ratio
Season	(l-1)	$\frac{\sum_j L_j^2}{v} - C = SS_L$	$SS_L / (l-1) = MS_L$	
Varieties	(v-1)	$\frac{\sum_i V_i^2}{l} - C = SS_V$	$SS_V / (v-1) = MS_V$	MS_V / MS_{VL}
Season X variety interaction	(v-1) (l-1)	$SS_T - (SS_L + SS_V) = SS_{VL}$	$SS_{VL} / (v-1)(l-1) = MS_{VL}$	
Total	(vl-1)	$\sum_{ij} Y_{ij}^2 - C = SS_T$		

Where

L_j's are the season totals, j = 1,2,.....l

V_i's are the varietal totals, i = 1,2,.....v

Y_{ij}'s are the individual observations

The ratio MS_V / MS_{VL} follows an 'F' distribution with (v-1) and (v-1) (l-1) degrees of freedom and provides a test of significance of varieties.

Non-significant χ^2 values indicated the absence of interaction. Under such a condition, no general test for overall treatment difference available. Hence the treatment means were tested individually as follows:

From each trial, we have to set down the responses corresponding to the degree of freedom in which we were interested for each trial and a weighted mean was calculated from it.

$$\bar{x}_w = \frac{\Sigma WX}{\Sigma W}$$

and thence calculated the quantity

$$Q = \Sigma WX^2 - \bar{x}_w \Sigma WX$$

and a χ^2 given by

$$\chi^2 = (P-1) + \sqrt{\frac{n-4}{n-1}} \left\{ \frac{n-2}{n} Q - \overline{p-1} \right\}$$

Where n is the number of degrees of freedom on which the error mean square is based in each experiment, p being the number of trials.

The weights W are the reciprocals of the estimates of error variance of the responses. The quantity χ^2 is approximately distributed as χ^2 with P-1 degrees of freedom and provides a test of interaction of response with seasons. If χ^2 is found to be non-significant we proceed to calculate t given by

$$t = \frac{\text{Response}}{\text{S.E. response}}$$

$$= \frac{\bar{x}_w}{\sqrt{1/\Sigma W}}$$

and refer the observed value to the 't' table with P(n-1) degrees of freedom.

iii Genetic parameters

The genetic parameters were worked out following Allard (1960) and Singh and Choudhary (1979).

1. Phenotypic coefficient of variation

$$= \frac{\sqrt{V_{(p)}}}{\text{Mean}} \times 100$$

Where $V_{(p)}$ = Phenotypic variance

2. Genotypic coefficient of variation

$$= \frac{\sqrt{V_{(g)}}}{\text{Mean}} \times 100$$

Where $V_{(g)}$ = Genotypic variance

3. Environmental coefficient of variation

$$= \frac{\sqrt{V_{(e)}}}{\text{Mean}} \times 100$$

Where $V_{(e)}$ = Environmental variance

4. Heritability in broad sense,

$$h^2 = \frac{V_{(g)}}{V_{(p)}} \times 100$$

Where h^2 = Heritability expressed in percentage

$V_{(g)}$ = Genotypic variance

and $V_{(p)}$ = Phenotypic variance

5. Expected genetic advance under selection

$$GA = K. h^2. \sqrt{V_{(p)}}$$

Where GA = Genetic advance

h^2 = Heritability in broad sense

$V_{(p)}$ = Phenotypic variance

K = Selection differential expressed in phenotypic standard deviation

= 2.06 in the case of 5 per cent of selection in large samples

iv Phenotypic and genotypic correlation coefficients

Phenotypic and genotypic correlation coefficients were estimated following Singh and Choudhary (1979).

1. Phenotypic correlation coefficient

$$r_{P_1 P_2} = \frac{COV\ (P_1 P_2)}{\sqrt{Var\ (P_1),\ V\ (P_2)}}$$

Where $COV(P_1 P_2)$ = Phenotypic covariance between the two traits

$V(P_1)$ = Phenotypic variance of first trait, and

$V(P_2)$ = Phenotypic variance of second trait

2. Genotypic correlation coefficient.

$$r_{g_1 g_2} = \frac{COV\ (g_1, g_2)}{\sqrt{V(g_1)\ ,\ V\ (g_2)}}$$

Where $COV\ (g_1 g_2)$ = Genotypic covariance between the two traits

$V(g_1)$ = Genotypic variance of first trait

and $V(g_2)$ = Genotypic variance of second trait

v Heterosis

The three types of heterosis, namely, relative heterosis heterobeltiosis and standard heterosis were estimated using the relation,

$$H = \frac{(\bar{X}\,F_1 - \bar{X}\,P)}{\bar{X}\,P} \times 100$$

Where $\bar{X}\,F_1$ = Mean value of F_1

$\bar{X}\,P$ = Mean value of mid parent, better parent or the standard cultivar as the case may be

For testing the significance between the mean value of the F_1 and those of the mid parent, better parent and standard cultivar, the critical values were calculated as given below.

1. C.D. I (For testing the significance over mid parental value)

$$C.D.I\ (0.05) = te\ (0.05)\ \sqrt{\frac{3\ MS_e}{2r}}$$

$$C.D.I\ (0.01) = te\ (0.01)\ \sqrt{\frac{3\ MS_e}{2r}}$$

2. C.D.II (For testing the significance over better parent and over standard cultivar)

$$C.D.II\ (0.05) = te\ (0.05) \cdot \sqrt{\frac{2\ MS_e}{r}}$$

$$C.D.II\ (0.01) = te\ (0.01) \cdot \sqrt{\frac{2\ MS_e}{r}}$$

Where CD = Critical difference

MS_e = Mean square for error

r = Number of replication

te (0.05) and te (0.01) are critical values of 't' corresponding to error degrees of freedom at 0.05 and 0.01 levels respectively.

RESULTS

4. RESULTS

The data on two trials with six parents and their six hybrids were subjected to analysis of variance. The various genetic parameters such as variances (phenotypic, genotypic and environmental), coefficients of variation (phenotypic and genotypic), heritability in broad sense, correlations (phenotypic and genotypic) and genetic advance were computed for the nineteen and twenty characters for the first (January - April '85) and second (April - June '85) trials respectively. The three estimates of heterosis namely relative heterosis, heterobeltiosis and standard heterosis were also computed. The results on the various aspects are presented below.

4.1 ANALYSIS OF VARIANCE

Analysis of variance was done separately for each character. Pooled analysis was done to test the influence of environment on these characters. The ANOVA of the two trials and the pooled ANOVA are provided in Appendix 1 to 23.

4.1.1 Days to flower

Significant variability was recorded among the treatments for this character in both the trials. Since the error variances were homogenous in nature unweighted pooled analysis was done to test the genotype x environmental interaction and found to be significant. Significant treatment differences were also observed when tested against this interaction.

The character ranged from 33.57 - 39.57 and 40.77 - 53.50 in the first and second trials respectively. Karingal local was found to be earliest in flowering in both the trials. The number of days taken for flowering was found to be maximum for Kilichundan. Among the hybrids 5 x 2 was found to be earliest in flowering. The prebearing and bearing periods of parents and hybrids are presented in Fig.1.

4.1.2 First fruiting node

ANOVA revealed significant variability for the character in both the trials. Since the error variances were heterogeneous, weighted analysis was performed to test the genotype x environmental interaction. A low Chi-square value of 2.31 indicated non-significant interaction. Hence the treatment means were tested individually.

The values for first fruiting node ranged from 6.5 (Kilichundan) to 4.43 (Sevendhari) and from 6.57 (Kilichundan) to 4.07 (Sevendhari) in the first and second trials respectively.

4.1.3 Mean leaf area

The treatment means differed significantly in both the trials. Since the error variances were found to be heterogeneous for the two trials, a weighted pooled analysis was done to test the interaction and found to be non-significant.

The mean leaf area ranged from 93.41 sq.cm to 172.87 sq.cm and 146.22 sq.cm to 249.09 sq.cm in the first and second trials respectively. In the first trial, the maximum leaf area was recorded by Kilichundan (172.87 sq.cm) and was on par with the hybrids 5 x 2, 6 x 2, 5 x 6 and 4 x 6. The leaf area was found to be minimum for Selection 2-2 (93.41 sq.cm). In the second trial maximum leaf area was recorded by the hybrid 5 x 2 (249.09 sq.cm) and was on par with 6 x 2 (241.07 sq.cm) and Kilichundan (229.61 sq.cm).

4.1.4 Number of fruits per plant

The abstract of ANOVA revealed significant differences among the treatments in both the trials. The error variances were homogeneous and hence unweighted pooled analysis was done to investigate the genotype x environmental interaction and found to be non-significant.

The mean values ranged from 11.10 (Karingal local) to 21.80 (5 x 2) and from 11.93 (Karingal local) to 22.7 (5x2) in the first and second trials respectively. In both the trials, the upper limit of the range among the parents was lesser than the lower limit of the range among hybrids.

The hybrid 5 x 2 produced maximum number of fruits in both the trials. Comparison of the pooled means indicated that the hybrid 5 x 2 had the maximum number of fruits (22.25) followed by the hybrid 6 x 2 (22.00).

The mean number of fruits per plant in parents and hybrids are illustrated in Fig.2.

4.1.4.1 Number of fruits on main stem

The abstract of ANOVA revealed that the treatments differed significantly in both the trials. Since the error variances were homogeneous, an unweighted analysis was done which revealed significant genotype x environmental interaction.

The mean values ranged from 9.93 (Karingal local) to 18.53 (5 x 2) and from 11.40 (Karingal local) to 18.60 (5 x 2) in the first and second trials respectively. In both the trials, the hybrid 5 x 2 recorded the maximum value for this character. Comparison of the pooled means also revealed the same result with the highest value for 5 x 2 (18.67) and the lowest for Karingal local (10.67).

4.1.4.2 Number of fruits on branches

Significant variability existed among the different genotypes only in the second trial. Since the error variances were heterogeneous, weighted analysis was done which indicated the presence of interaction. The genotypes differed significantly on testing against this interaction.

The mean values for this character ranged from 1.17 - 3.60 and 0.53 - 8.67 in the first and second trials respectively.

FIG.1 PRE-BEARING AND BEARING PERIODS IN PARENTS AND HYBRIDS

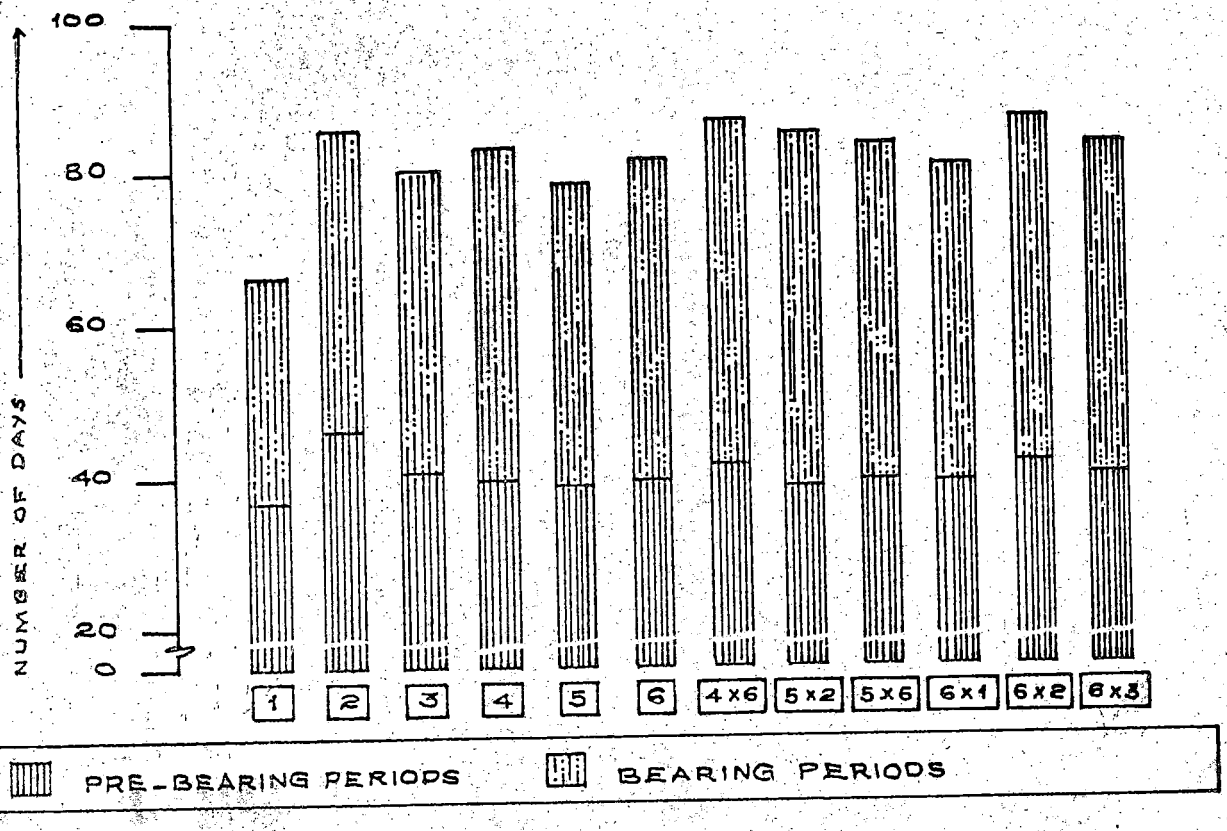
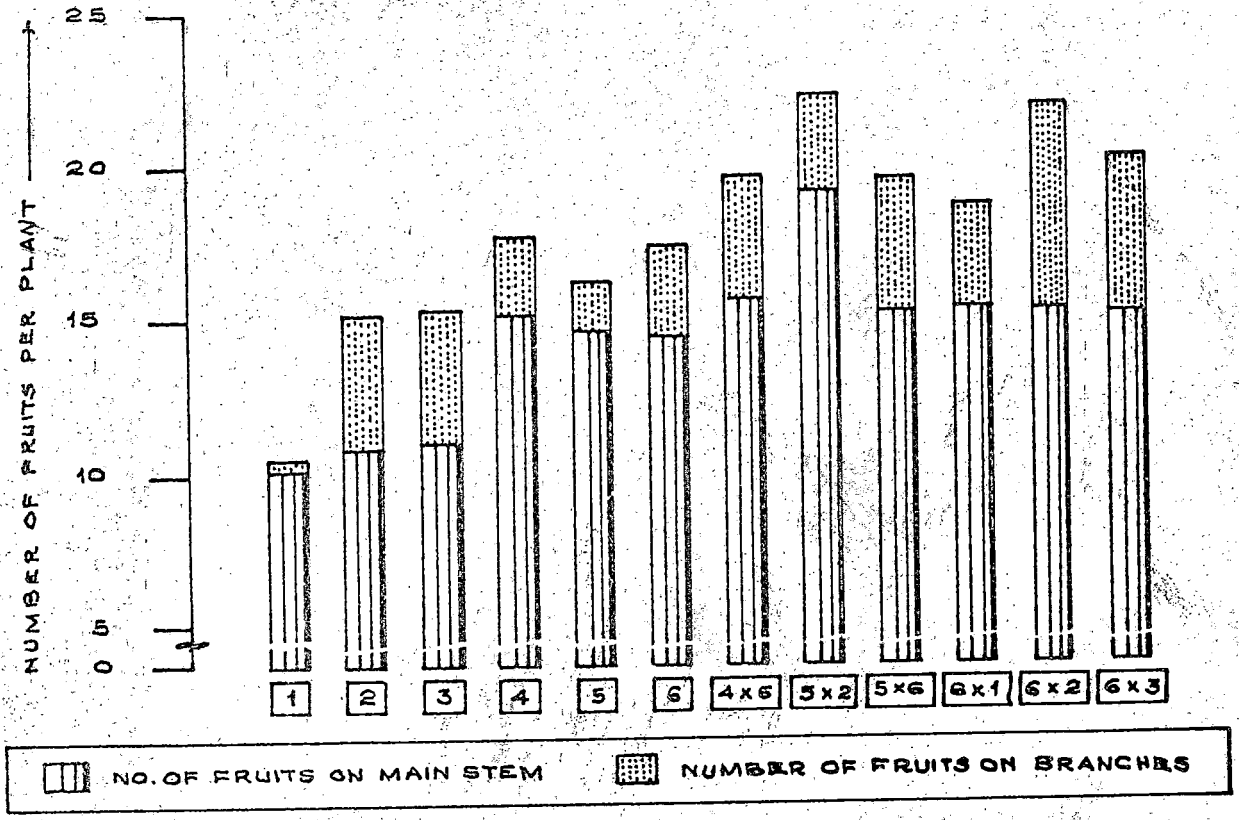


FIG. 2 NUMBER OF FRUITS PER PLANT IN PARENTS AND HYBRIDS



Comparison of the treatment means in the second trial indicated that the hybrid 6 x 2 had the maximum number of fruits on branches and was on par with 6 x 3. Comparison of the pooled means also revealed the same result.

4.1.5 Length of fruit

Significant treatment differences were seen in both the trials with respect to this character. The error variance were homogeneous and hence an unweighted pooled analysis was done to investigate the genotype x environmental interaction and found to be non-significant.

The mean values ranged from 13.18 (Sevendhari) to 17.91 (5 x 2) and from 16.02 (Sevendhari) to 22.75 (6 x 2) in the first and second trials respectively.

In the first trial 6 x 3, Pilicode local and 6 x 2 were found to be on par with 5 x 2 having the longest fruit (17.91 cm). Longest fruit was produced by 6 x 2 (22.75 cm) in the second trial and was on par with Kilichunde (21.93 cm) and 5 x 2 (20.65 cm). Comparison of the pooled means revealed that the hybrid 5 x 2 had the longest fruit (19.28 cm) followed by 6 x 2 (19.17 cm).

The mean length of fruit of parents and hybrids are diagrammatically represented in Fig.3.

4.1.6 Girth of fruit

Significant treatment differences were seen in second trial only with regard to this character. Weighted analysis was carried out to test the genotype x environmental interaction. There was significant interaction and the genotypes differed significantly.

The mean girth of fruit ranged from 5.54 cm (Selection 2-2) to 6.47 cm (Pilicode local) and from 5.79 cm (Selection 2-2) to 7.49 cm (6 x 2) in the first and second trials respectively.

Comparison of the pooled means showed that the fruit of the hybrid 6 x 2 had the maximum girth (6.93 cm) followed by 6 x 1 (6.75 cm) and 5 x 6 (6.74 cm).

4.1.7 Weight of single fruit

The results of ANOVA indicated that the treatments did not differ significantly with respect to this character.

The mean values ranged from 16.56 gm to 20.81 gm and from 19.82 gm to 29.62 gm in the first and second trials respectively. In both the trials, the hybrid 5 x 2 registered maximum value for this character.

4.1.8 Weight of fruits per plant

Significant treatment differences were seen in both the trials with regard to this character. Since the error variances were heterogeneous, weighted analysis was done to test the genotype X environmental interaction. A Chi-square value of 24.69 revealed significant genotype X environmental interaction.

The mean values ranged from 196.58 gm (Karingal local) to 457.80 gm (5 x 2) and from 236.57 gm (Karingal local) to 670.56 gm (5 x 2) in the first and second trials respectively. In the first trial, highest yield per plant was obtained from 5 x 2 followed by 6 x 3 (422.40 gm). In the second trial also highest yield was produced by the hybrid 5 x 2 and was on par with 6 x 2. Comparison of the pooled means revealed that 5 x 2 yielded maximum (564.18 gm) followed by 6 x 2 (513.86 gm). The mean weight of fruits per plant of parents and hybrids are diagrammatically illustrated in Fig. 4.

4.1.9 Number of seeds per fruit

Genotypes differed significantly in both the trials. Since the error variances were heterogeneous, weighted analysis was done to test the genotype X environmental

FIG. 3 LENGTH OF FRUIT IN PARENTS AND HYBRIDS

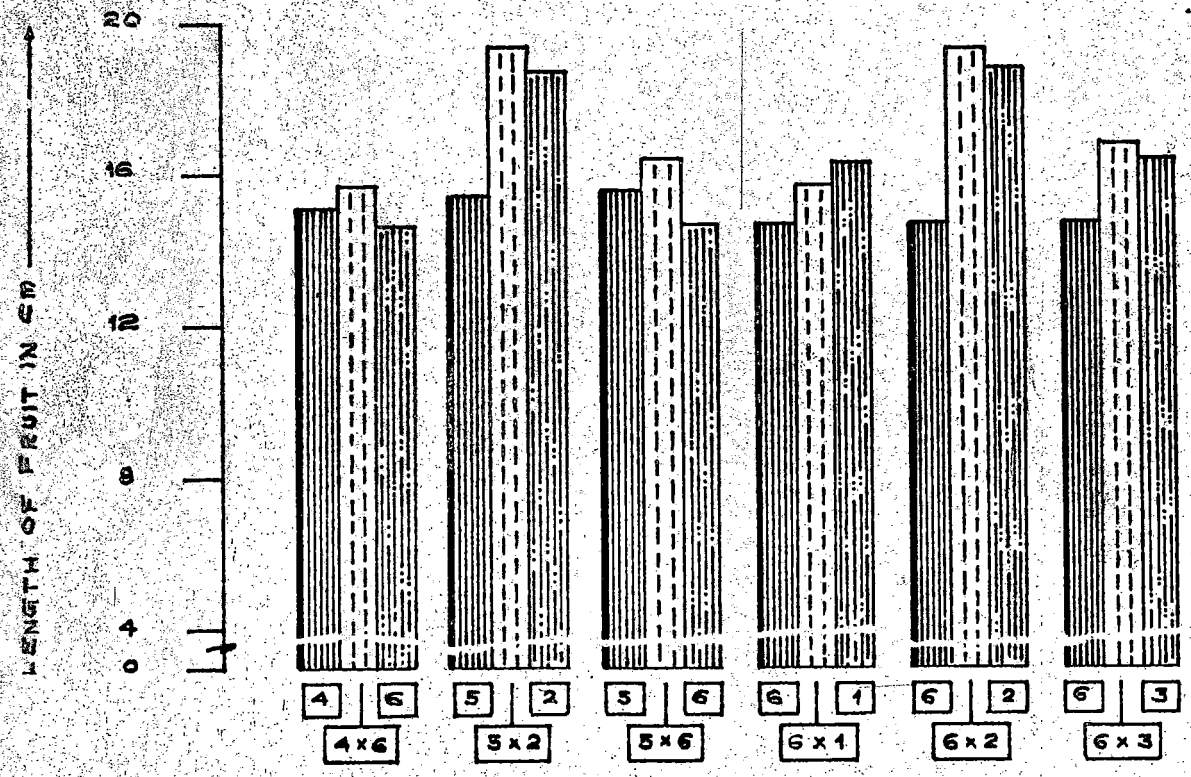
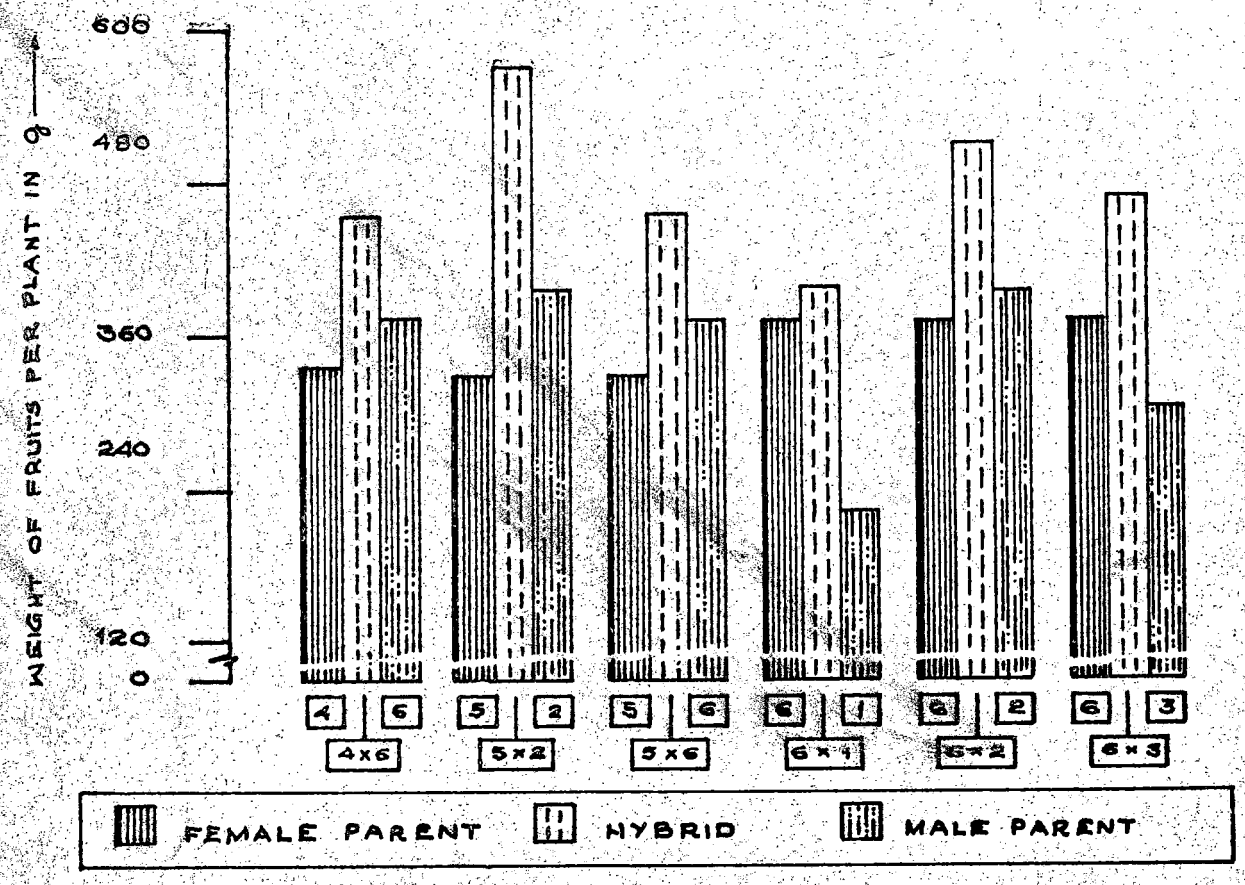


FIG. 4 WEIGHT OF FRUITS PER PLANT IN PARENTS AND HYBRIDS



interaction. A low Chi-square value of 3.52 indicated non-significant interaction. Hence the treatment means were tested individually.

The mean value for this character ranged from 56.65 (6 x 3) to 117.90 (Sevendhari) and from 61.08 (Karingal local) to 122.52 (5 x 6) in the first and second trials respectively.

Sevendhari which had maximum number of seeds per fruit was found to be on par with 5 x 6 (110.16), 6 x 1 (109.98) 6 x 2 (106.02), 6 x 3 (96.82), Kilichundan (96.70) and 5 x 2 (95.12). Selection 2-2 (74.83) was on par with Karingal local (56.65) which produced the lowest number of seeds. Other genotypes, were found to be intermediate. In the second trial 5 x 6 was found to have maximum number of seeds per fruit (122.52) and was on par with 6 x 1 and 6 x 2.

4.1.10 Number of ridges per fruit

ANOVA revealed significant differences among the genotypes with respect to this character in both the trials. Since the error variances were heterogeneous, a weighted pooled analysis was done which indicated non-significant interaction.

The mean number of riges per fruit ranged from 5.07 (Pusa Sawani) to 7.48 (Sevendhari) and from 5.00 (Selection 2-2) to 7.93 (Kilichundan) in the first and second trials respectively. The hybrids were found to be intermediate in this character.

4.1.11 Number of flowers per plant

The abstract of ANOVA indicated significant variability among the genotypes in both the trials. Since the error variances were homogenous an unweighted analysis was done which revealed non-significant interaction. Significant difference was noticed among pooled means.

The mean number of flowers per plant ranged from 13.87 (Karingal local) to 27.60 (5 x 2) and from 13.70 (Karingal local) to 28.07 (5 x 2) in the first and second trials respectively.

The hybrid 5 x 2 produced maximum number of flowers per plant in the first trial followed by 6 x 3 (25.37) and 4 x 6 (24.53). Kilichundan was found to be on par with Karingal local which had lowest number of flowers per plant.

In the second trial also the hybrid 5 x 2 ranked first and was on par with 6 x 2 (27.5), 5 x 6 (25.37) and 6 x 3 (25.23). In this trial also Karingal local produced the minimum number of flowers (13.70).

Comparison of the pooled means also revealed the same result. 5 x 2 ranked first (27.63) among the genotypes.

4.1.12 Fruiting phase

Significant difference noted among the different treatments in both the trials. The error variances were heterogeneous and weighted analysis was done. A Chi-square value of 34.15 revealed significant genotype x environmental interaction. The genotypes differed significantly.

The fruiting phase ranged from 32.73 (Karingal local) to 39.95 (5 x 2) and from 37.11 (Karingal local) to 50.68 (5 x 2) in the second and first trials respectively.

In the first trial, 5 x 2 had the maximum fruiting phase and was on par with 4 x 6 (39.40), Pusa Sawani (39.05) and 5 x 6 (38.33). In the second trial also 5 x 2 maintained the longest fruiting phase and was statistically on par with other hybrids namely 5 x 6 (50.33), 6 x 2(50.13), 6 x 3(49.67) and 4 x 6 (49.60). In both the trials, Karingal local recorded the shortest fruiting phase. Comparison of the pooled means also revealed that 5 x 2 had the longest fruiting phase (45.32) while Karingal local had the shortest fruiting phase (34.92).

4.1.13 Number of non-bearing nodes

Significant difference among treatments was present for the character in both the trials. Since the error variances

were homogeneous, an unweighted pooled analysis was done, which revealed non-significant interaction.

The mean values ranged from 4.2 (6 x 1) to 9.83 (Kilichundan) and from 4.03 (Sevendhari) to 11.27 (Kilichundan) in the first and second trials respectively.

Sevendhari recorded lowest number of non-bearing nodes in the second trial. Kilichundan recorded maximum number of non-bearing nodes in both the trials. The comparison of the pooled means showed that the hybrid 6 x 1 produced the lowest number of non-bearing nodes (4.28) while Kilichundan had highest number of non-bearing nodes (10.55).

4.1.14 Height of plant

The abstract of ANOVA revealed significant difference among the different genotypes in both the trials. Since the error variances were homogeneous, an unweighted pooled analysis was done which revealed non-significant genotype x environmental interaction. Hence the genotypes did not differ from season to season with respect to this character. The pooled treatment means differed significantly.

The mean height ranged from 37.43 cm (Sevendhari) to 77.07 cm (Pilicode local) and from 71.13 cm (Sevendhari) to 113.70 cm (6 x 1) in the first and second trials respectively

Except Pilicode local all other genotypes were on par with each other in the first trial with regard to this character. The hybrid 6 x 1 which recorded maximum height in the first trial was on par with all other genotypes except Selection 2-2 and Sevendhari.

Comparison of the pooled means showed Pilicode local as the tallest variety (94.63 cm) followed by the hybrid 6 x 1 (86.82 cm) and the shortest variety being Sevendhari with a height of 54.28 cm.

4.1.15 Number of branches

The results showed significant differences among treatments in both the trials. Pooled analysis was done and the genotype X environmental interaction was found to be significant. Hence the genotypes were tested against this interaction and found to be significant.

The mean number of branches per plant ranged from 0.43 (Karingal local) to 2.5 (6 x 2) and from 0.77 (Karingal local) to 4.40 (Kilichundan) in the first and second trials respectively.

The parents Kilichundan and Pilicode local and the hybrids 5 x 2 and 5 x 6 were on par with the hybrids 6 x 2 which had maximum number of branches in the first trial. Comparison of the treatment means in the second trial indicat

that Kilichundan had maximum number of branches which was followed by the hybrid 6 x 2 (3.40). The hybrid 6 x 1 and Pusa Sawani were on par with Karingal local, having the lowest number of branches.

Comparison of the pooled means indicated that Kilichundan was having the maximum number of branches (3.23) followed by 6 x 2 and Karingal local had the lowest number of branches.

4.1.16 Girth of stem

Significant differences among treatments were seen in the second trial only. Since the error variances were heterogeneous weighted analysis was done which indicated non-significant genotype x environmental interaction.

The mean girth of stem ranged from 4.09 cm (Karingal local) to 5.76 cm (Pilicode local) and from 5.73 (Karingal local) to 8.33 cm (6 x 2) in the first and second trials respectively.

The girth of stem was observed to be maximum for the hybrid 6 x 2 followed by the hybrid 6 x 3 (7.73 cm) in the second trial. All other genotypes were found to be on par to one another.

4.1.17 Percentage of fruit set

The abstract of ANOVA revealed that the genotypes did not differ significantly with respect to this character in

both the trials.

The mean values ranged from 62.76 per cent (Selection 2-2) to 70.16 per cent (6 x 2) and from 57.71 per cent (Selection 2-2) to 72.91 per cent (Pusa Sawani) in the first and second trials respectively.

4.1.18 Yellow vein mosaic disease scoring

Since there was little incidence of yellow vein mosaic disease, scoring was not done in the first trial. In the second trial, field incidence was noticed and intensity was scored using the rating scale. The hybrids 4 x 6 and 5 x 2 were found to be less susceptible with a mean disease rating of 1.21. Kilichundan was observed to be highly susceptible with a mean disease rating of 3.36.

The mean disease rating of parents and hybrids are diagrammatically presented in Fig.6.

4.1.19 Scoring of fruit and shoot borer infestation

a. Percentage of shoot infestation

The abstract of ANOVA revealed significant treatment differences only in the first trial. Since the error variances were heterogeneous, weighted analysis was done to test genotype x environmental interaction and found to be significant.

The character ranged from 27.76 per cent (Selection 2 to 33.67 per cent Pusa Sawani and from 27.03 per cent

(6 x 1) to 35.96 per cent (Kilichundan) in the first and second trials respectively.

Comparison of the treatment means revealed that 6 x 1 was less affected by shoot infestation followed by Selection 2-2, 6 x 3 and 5 x 2 which were on par with it. Kilichundan was found to have maximum damage by shoot infestation.

b. Percentage of fruit infestation

The abstract of ANOVA is presented in Table 22. Significant treatment differences were noticed only in the first trial. The error variances were homogeneous. Hence an unweighted pooled analysis was done to test the interaction and found to be non-significant. The treatment differences were tested against the pooled error and found to be significant.

The mean values ranged from 6.74 per cent (Selection 2-2) to 10.29 per cent (Pusa Sawani) and from 5.26 per cent (5 x 2) to 9.79 per cent (Pusa Sawani and Pilicode local) in the first and second trials respectively.

Comparison of the treatment means in the first trial revealed that the fruits of Pusa Sawani was found to be damaged maximum and was on par with Pilicode local, Karingal local and 6 x 1. The fruits of hybrid 5 x 2 was less damaged by fruit and shoot borer infestation.

4.1.20 Crude fibre content

The genotypes differed significantly in both the trials. Since the error variances were heterogeneous, weighted pooled analysis was done. A Chi-square value of 5.71 was low which revealed non-significant interaction. Hence the treatment differences were tested using unweighted analysis and found to be significant. The character ranged from 1.16 per cent to 1.46 per cent and 1.10 per cent to 1.46 per cent in the first and second trials respectively.

In the first trial, 5 x 2 was found to be superior in quality with low crude fibre content (1.16) and was on par with its parents.

In the second trial, Selection 2-2 recorded the lowest crude fibre content (1.10) and was on par with 5 x 2 (1.14), 5 x 6 (1.15), Kilichundan (1.16), 6 x 3 (1.19) and 6 x 2 (1.24). Maximum crude fibre content (1.46) was observed in the variety Pusa Sawani in the second trial.

Comparison of the pooled means revealed that 5 x 2 and 4 x 6 had the lowest and highest crude fibre content respectively. The mean crude fibre content of parents and hybrids are diagrammatically presented in Fig.6.

FIG. 5 YELLOW VEIN MOSAIC DISEASE SCORING IN PARENTS AND HYBRIDS

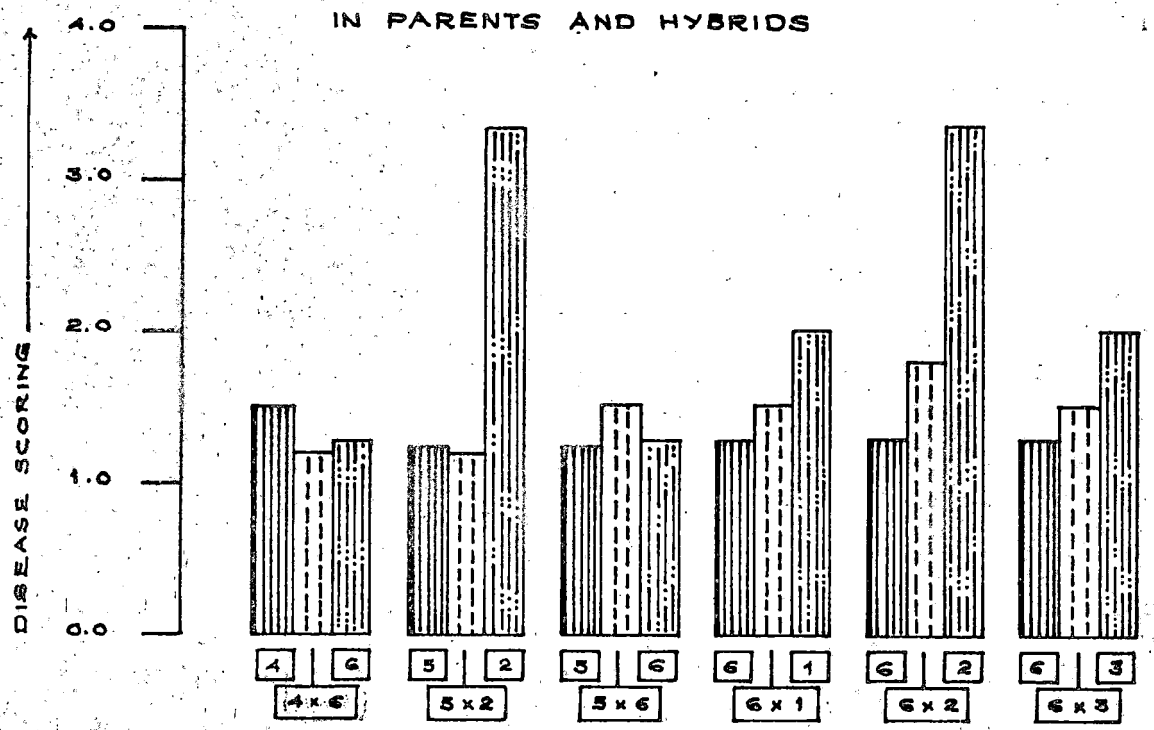
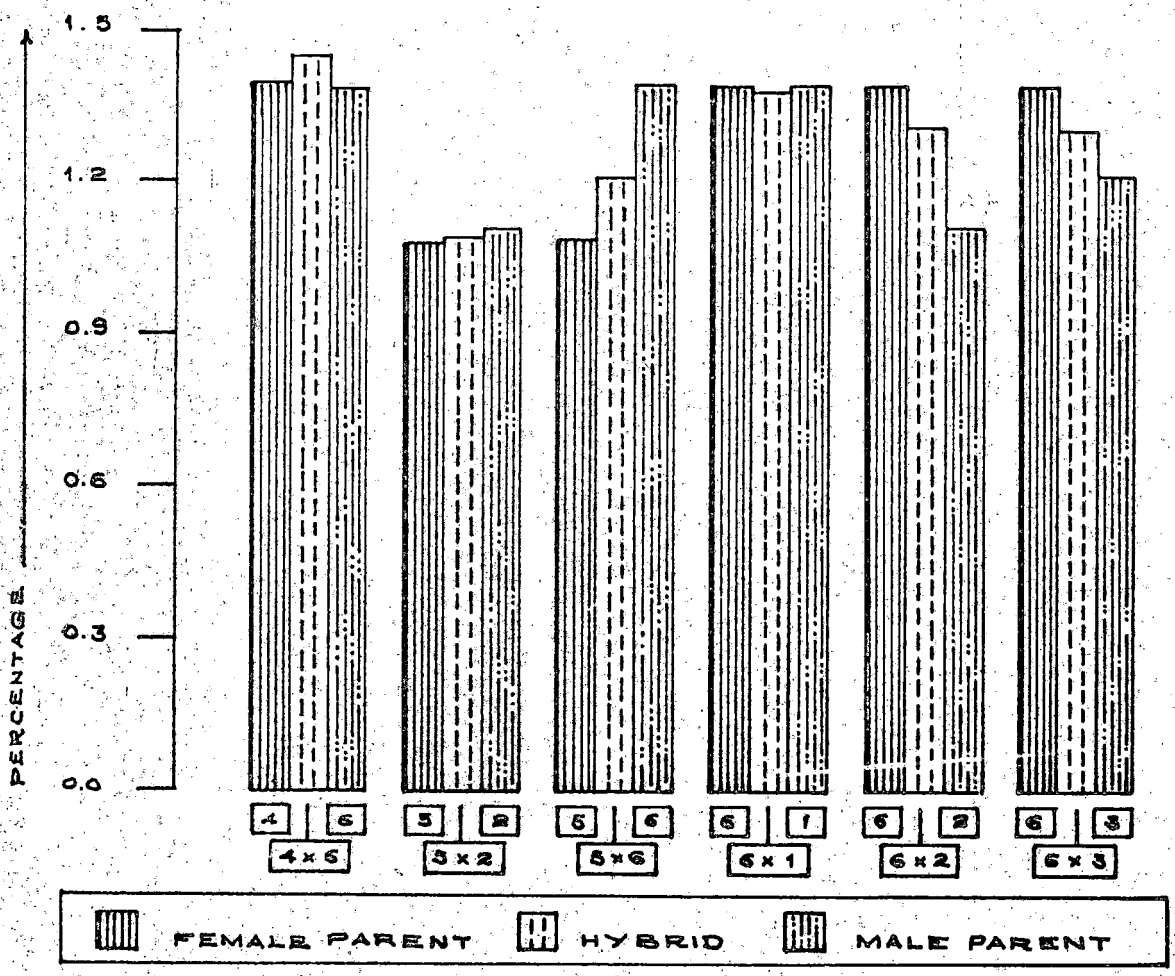


FIG. 6 CRUDE FIBRE CONTENT IN PARENTS AND HYBRIDS



4.2 PHENOTYPIC AND GENOTYPIC VARIABILITY AND GENETIC ADVANCE

The population mean, range, phenotypic, genotypic and environmental coefficient of variation, heritability and genetic advance of the different characters studied are presented in Table 1 and 2.

4.2.1 Yield and its components

The maximum amount of phenotypic coefficient of variation (41.17) was registered by number of fruits on branches in the first trial followed by number of branches (37.58) and number of non-bearing nodes (31.17). Days to flower recorded the minimum phenotypic coefficient of variation (6.11). In the second trial also number of fruits on branches registered the maximum phenotypic coefficient of variation of 67.61. The minimum phenotypic coefficient of variation was recorded by fruiting phase (7.05) followed by days to flower (7.21).

As regards genotypic coefficient of variation, the maximum (27.08) and minimum (2.58) figures were recorded by number of branches and girth of fruit respectively in the first trial. In the second trial, the maximum amount of genotypic coefficient of variation (53.32) was registered by number of fruits on branches and percentage of fruit set recorded the minimum genotypic coefficient of variation (5.

Table 1. Range, population means and genetic parameters of different characters - First trial

Character	Range		Mean	Coefficient of variation			Heritability in broad sense	Genetic advance in percentage of mean
	Parents	Hybrids		Phenotypic	Genotypic	Environmental		
Days to flower	33.57- 39.57	33.67- 37.63	35.31	6.11	4.08	4.55	44.63	5.66
First fruiting node	4.43- 6.50	4.47- 5.53	5.22	15.07	8.82	12.22	34.30	10.54
Mean leaf area	93.41-172.87	108.91-167.34	129.49	28.97	16.43	23.86	32.20	19.11
Number of fruits per plant	11.10- 19.20	19.70- 21.80	18.41	19.53	16.74	10.07	73.40	29.39
Number of fruits on main stem	9.93- 16.77	16.93- 18.53	15.68	2.59	18.30	11.46	71.80	31.82
Number of fruits on branches	1.17- 3.57	2.17- 3.60	2.66	41.17	18.35	36.83	19.90	16.92
Length of fruit	13.18- 15.68	13.67- 17.91	14.80	11.92	7.50	9.28	39.60	9.66
Girth of fruit	5.54- 6.47	6.10- 6.37	6.11	7.86	2.58	3.37	10.80	1.73
Weight of single fruit	16.56- 20.75	18.83- 20.81	17.63	13.12	3.68	14.76	7.90	2.27
Weight of fruits per plant	196.58-340.61	376.27-457.80	352.08	23.34	18.61	14.09	63.60	30.42
Number of seeds per fruit	56.65-117.50	90.22-110.16	93.60	21.98	16.07	15.00	53.40	24.07
Number of ridges per fruit	5.45 - 7.48	6.44 - 7.35	6.43	15.04	14.06	7.51	77.80	25.51

(contd...)

Table 1 (contd.)

Character	Range		Mean	Coefficient of variation			Heritability in broad sense	Genetic advance in percentage of mean
	Parents	Hybrids		Phenotypic	Genotypic	Environmental		
Number of flowers per plant	13.87 - 23.43	23.57 - 27.60	22.32	19.68	16.03	11.42	66.30	26.75
Fruiting phase	37.11 - 46.31	46.65 - 50.68	46.46	9.60	8.61	4.24	80.50	15.84
Number of non-bearing nodes	4.37 - 9.83	4.20 - 5.87	5.61	31.17	25.03	19.46	62.30	40.46
Height of plant	37.43 - 77.07	48.30 - 61.95	54.93	22.79	16.73	15.48	53.90	25.16
Number of branches	0.43 - 2.07	1.23 - 2.50	1.66	37.58	27.88	25.20	55.10	42.77
Girth of stem	4.09 - 5.76	4.54 - 5.38	4.78	12.38	6.65	10.44	28.90	7.32
Percentage of fruit set	61.67 - 69.09	62.76 - 70.16	65.85	11.05	10.09	6.61	18.54	2.85
Percentage of shoot infestation by Earias vitella (Fb)	27.6 - 33.67	30.92 - 32.86	31.47	8.79	1.71	8.95	3.79	68.60
Percentage of fruit infestation by Earias vitella (Fb.)	6.74 - 10.29	7.37 - 9.31	8.42	19.37	10.01	16.58	26.69	10.69
Crude fibre content	1.16 - 1.43	1.16 - 1.46	1.33	9.21	8.87	2.38	92.80	17.29

Table 2. Range, population means and genetic parameters of different characters- second trial

Character	Range		Mean	Coefficient of variation			Heritability in broad sense	Genetic advance in percentage of mean
	Parents	Hybrids		Phenotypic	Genotypic	Environmental		
Days to flower	40.77 - 53.5	43.1 - 47.77	45.34	7.21	6.58	2.95	83.27	12.37
First fruting node	4.07 - 6.57	4.20- 5.57	5.05	15.28	12.77	8.38	69.90	21.98
Mean leaf area	146.92 -229.61	190.26-244.09	199.18	16.24	13.78	8.60	72.00	23.96
Number of fruits per plant	11.93 - 16.77	17.70- 22.70	17.84	18.21	16.19	8.33	79.10	29.48
Number of fruits on main stem	11.40 - 15.17	13.03- 18.80	14.03	16.33	1.21	11.87	47.10	15.75
Number of fruits on branches	0.53 - 4.10	2.90- 8.67	5.81	67.61	53.22	41.74	62.00	86.09
Length of fruit	16.02 - 21.93	17.26- 22.75	18.36	13.81	10.96	8.40	63.00	17.86
Girth of fruit	5.79 - 6.88	6.90- 7.49	6.73	8.10	7.45	3.19	84.70	14.12
Weight of single fruit	19.82 - 25.82	24.45- 29.62	24.27	20.75	6.96	19.55	11.20	4.78
Weight of fruits per plant	236.57 -496.65	430.97-670.56	452.09	28.06	27.09	7.40	93.00	53.53
Number of seeds per fruit	61.08 -108.59	92.84-122.52	98.13	19.76	17.84	8.51	81.50	33.01
Number of ridges per fruit	5.00 - 7.93	6.33- 7.20	6.36	16.72	15.91	5.12	90.60	31.13
Number of flowers per plant	13.70 - 21.90	21.90- 28.07	22.17	20.14	17.47	10.02	75.20	31.08
Fruiting phase	32.73 - 39.05	35.28- 39.95	36.69	7.05	6.37	3.02	81.70	11.80

(contd..)

Table 2. (contd.)

Character	Range		Mean	Coefficient of variation			Heritability in broad sense	Genetic advance in percentage of mean
	Parents	Hybrids		Phenotypic	Genotypic	Environmental		
Number of non-bearing nodes	4.03- 11.27	4.33- 5.70	5.69	35.39	32.19	14.73	82.70	60.11
Height of plant	71.13-112.20	98.27-113.70	102.07	14.72	9.53	11.22	41.90	12.66
Number of branches	0.77- 4.40	1.47- 3.40	2.24	47.52	41.38	23.33	75.80	73.66
Girth of stem	5.73- 7.18	6.52- 8.33	6.93	14.24	8.70	11.27	37.30	10.97
Percentage of fruit set	57.71- 72.91	60.29- 68.90	61.71	10.34	5.44	9.26	27.68	6.21
Yellow vein mosaic disease scoring	1.24- 3.36	1.21- 1.76	1.68	61.57	57.09	23.05	85.98	108.93
Percentage of shoot infestation by *Earias vitella* (Fb.)	27.15- 35.96	27.03- 32.88	31.36	11.05	10.09	4.50	83.00	18.91
Percentage of fruit infestation by *Earias vitella* (Fb.)	5.53- 9.79	5.26- 7.91	7.33	25.63	18.20	18.05	50.42	26.60
Crude fibre content	1.10- 1.46	1.14- 1.45	1.27	11.35	8.78	7.04	59.80	14.17

In both the trials maximum environmental coefficient of variation was recorded for number of fruits on branches. Girth of stem and fruiting phase exhibited minimum value for this parameter in the first and second trials respectively.

In the first trial, maximum heritability (80.50) was displayed by fruiting phase followed by number of ridges per fruit (77.80) and number of fruits per plant (73.40). Among the yield components, lowest heritability (7.90) was observed for weight of single fruit in the first trial followed by girth of fruit (10.80). In the second trial, fruit yield per plant displayed maximum heritability (93.00) closely followed by number of ridges per fruit (90.60), girth of fruit (84.70), days to flower (83.27), number of non-bearing nodes (82.70) and fruiting phase (81.70). The minimum heritability of 11.20 was expressed by weight of single fruit in this trial also.

The expected genetic advance expressed as percentage of mean was maximum (42.77) for number of branches followed by number of non-bearing nodes (40.46) and number of fruits on main stem (31.82) in the first trial. All the remaining characters displayed low estimates for this parameter. In the second trial, the maximum genetic advance was recorded for number of fruits on branches (86.09) followed by number of branches (73.66) and number of non-bearing nodes (60.11). Weight of single fruit (4.78), percentage of fruit set (6.21)

and girth of stem (10.97) displayed lower estimates of this parameter in the second trial.

4.2.2 Yellow vein mosaic disease scoring

Resistance to yellow vein mosaic disease displayed fairly higher estimates of phenotypic (61.57) and genotypic (57.09) coefficients of variation. The environmental coefficient of variation was low (23.03). High heritability (85.98) and high genetic advance (108.93) were also observed for this character.

4.2.3 Scoring of fruit and shoot borer infestation

Both the percentages of fruit and shoot infestation displayed lower estimates of coefficient of variation in both the trials. Although high heritability (83.00) was recorded in the second trial for percentage of shoot infested plants, the figure was very low (3.79) for the first trial. The percentage of shoot infested plants registered higher estimates of genetic advance (68.60) in the first trial only. Lower estimates of heritability and genetic advance were noted for the percentage of fruit infested plants in both the trials.

4.2.4 Crude fibre content

Lower estimates of coefficient of variation for crude fibre content was observed in both the trials. High heritability (92.80) was observed for this character in the first

trial. Moderate heritability (59.80) was observed in the second trial. The expected genetic advance was low in both the trials for this attribute.

4.3 CORRELATION STUDIES

The association among fifteen important economic traits are presented in Table 3 and 4.

First fruiting node displayed significant positive genotypic correlation with mean leaf area, length of fruit, height, number of branches and number of non-bearing nodes in both the trials.

The association of first fruiting node with number of fruits per plant and number of flowers per plant were found to be significantly negative in the first trial whereas it was found to be positive and non-significant in the second trial. Weight of fruits per plant, number of seeds per fruit and fruiting phase had non-significant positive association with the first fruiting node in the first trial whereas it was negative and non-significant in the second trial. Positive correlation was observed between first fruiting node and girth of stem in both the trials, but was significant only in the second trial. Crude fibre content had negative correlation with first fruiting node in both the trials of which significant association was noticed only in the first trial.

Table 3. Correlation coefficient Trial I

Character		First fruiting node	Mean leaf area	No. of fruits per plant	Length of fruit	Girth of fruit	Weight of single fruit	Weight of fruits per plant	No. of seeds per fruit	No. of flowers per plant	Fruiting phase	Height of plant	No. of branches	Girth of stem	No. of non-bearing nodes	Crude fibre content
First fruiting nodes	P	1.000	0.235	-0.205	0.106	0.277	0.091	-0.158	0.054	-0.190	-0.132	0.209	0.194	0.122	0.658**	0.334
	G	1.000	1.217**	-0.358*	0.374*	0.145	0.410*	-0.279	-0.077	-0.414*	-0.249	0.546*	0.442*	0.355*	0.948**	-0.609**
Mean leaf area	P		1.000	0.125	0.492**	0.242	0.425*	0.349*	-0.026	0.051	0.225	0.388*	0.515**	0.476**	0.362*	-0.358*
	G		1.000	0.160	1.297**	1.591**	0.890**	0.302	0.516**	0.154	0.330	0.592**	0.964**	1.041**	0.931**	-0.728**
Number of fruits per plant	P			1.000	0.342*	0.226	-0.009	0.809**	0.547**	0.937**	0.825**	0.096	0.394*	0.135	-0.188	0.226
	G			1.000	0.356*	-0.128	0.779**	1.041**	0.811**	0.977**	1.026**	-0.044	0.558**	0.299	-0.367*	0.149
Length of fruit	P				1.000	0.379*	0.377*	0.535**	0.096	0.304	0.310	0.489**	0.376**	0.435*	0.205	-0.413*
	G				1.000	0.342	1.196**	0.559**	0.101	0.480**	0.604**	0.556**	0.926**	1.068**	0.513**	-0.604**
Girth of fruit	P					1.000	0.073	0.207	0.340	0.182	0.149	0.331	0.288	0.166	0.159	0.037
	G					1.000	3.224**	0.453**	0.789**	-0.583**	0.268	0.431*	0.712**	1.385**	-0.026	0.013
Weight of single fruit	P						1.000	0.558**	0.201	-0.130	0.166	0.008	0.232	0.230	0.075	-0.336
	G						1.000	0.442*	0.479**	1.023**	0.628**	0.978**	1.000**	1.121**	0.587**	-0.760**
Weight of fruits per plant	P							1.000	0.527**	0.703**	0.789**	0.083	0.468**	0.231	-0.146	-0.079
	G							1.000	0.770**	1.086**	1.022**	0.110	0.652**	0.469**	-0.220	-0.026
Number of seeds per fruit	P								1.000	0.387*	0.485**	-0.212	0.344	-0.006	0.068	0.092
	G								1.000	0.701**	0.684**	-0.136	0.686**	0.463**	0.101	0.225
Number of flowers per plant	P									1.000	0.807**	0.174	0.369**	0.174	-0.187	0.057
	G									1.000	1.027**	0.030	0.492**	0.346	-0.378*	0.020
Fruiting phase	P										1.000	0.199	0.449**	0.175	-0.241	0.004
	G										1.000	0.246	0.655**	0.655**	-0.310	0.031
Height of plant	P											1.000	0.088	0.427*	-0.039	-0.070
	G											1.000	0.175	0.809**	0.201	-0.182
Number of branches	P												1.000	0.522**	0.372*	-0.350*
	G												1.000	0.805**	0.481**	-0.561
Girth of stem	P													1.000	0.099	-0.321
	G													1.000	0.353*	-0.786**
Number of non-bearing nodes	P														1.000	-0.518**
	G														1.000	-0.701**
Crude fibre content	P															1.000
	G															1.000

Table 4. Correlation coefficient Trial II

Character		First fruiting node	Mean leaf area	Number of fruits per plant	Length of fruit	Girth of fruit	Weight of single fruit	Weight of fruits per plant	Number of seeds per fruit	Number of flowers per plant	Fruiting phase	Height of plant	Number of branches	Girth of stem	Number of non-bearing nodes	Crude fibre content
First fruiting node	P	1.000	0.354*	0.583**	0.315	-0.168	-0.120	0.096	0.168	0.048	0.171	0.343	0.377*	0.214	0.680**	-0.227
	G	1.000	0.426*	0.108	0.476**	-0.232	-0.565**	0.233	0.164	0.049	0.105	0.373*	0.510**	0.207	0.837**	-0.333
Mean leaf area	P		1.000	0.769**	0.635**	0.356*	0.223	0.603**	0.432*	0.696**	0.429*	0.157	0.594**	0.506**	0.271	-0.398*
	G		1.000	0.920**	0.960**	0.514**	1.374**	0.976**	0.477**	0.889**	0.558**	0.231	0.770**	1.114**	0.399*	-0.647**
Number of fruits /plant	P			1.000	0.484**	0.590**	0.478**	0.887**	0.553**	0.862**	0.583**	0.245	0.435*	0.531**	-0.055	-0.246
	G			1.000	0.675**	0.711**	1.677**	0.991**	0.558**	0.966**	0.745**	0.226	0.406*	1.080**	-0.123	-0.404*
Length of fruit	P				1.000	0.405*	0.169	0.593**	0.324	0.453**	0.125	0.160	0.525**	0.550**	0.314	-0.419*
	G				1.000	0.456*	0.628**	0.779**	0.383*	0.606**	0.265	0.233	0.832**	0.838**	0.580**	-0.588**
Girth of fruit	P					1.000	0.540**	0.673**	0.579**	0.574**	0.463*	0.088	0.285	0.428*	-0.288	-0.070
	G					1.000	1.395**	0.728**	0.744**	0.733**	0.579**	0.122	0.358*	0.655**	-0.347	-0.095
Weight of single fruit	P						1.000	0.538**	0.375*	0.514**	-0.441*	-0.025	0.140	0.376*	-0.202	-0.129
	G						1.000	1.595**	1.099**	1.681**	1.364**	-0.421*	0.393*	1.017**	-1.002**	-0.434*
Weight of fruits per plant	P							1.000	0.559**	0.792**	0.671**	0.060	0.510**	0.586**	0.036	-0.322
	G							1.000	0.643**	0.977**	0.760**	0.101	0.622**	0.961**	0.076	-0.470**
Number of seeds per fruit	P								1.000	0.631**	0.413*	0.044	0.464**	0.343	-0.039	-0.198
	G								1.000	0.743**	0.508**	-0.127	0.530**	0.608**	-0.101	-0.394*
Number of flowers per plant	P									1.000	0.476**	0.009	0.441*	0.532**	-0.141	-0.470**
	G									1.000	0.587**	0.090	0.462*	1.093**	-0.211	-0.659**
Fruiting phase	P										1.000	0.037	0.211	0.251	0.009	0.091
	G										1.000	0.087	0.328	0.448*	0.189	0.153
Height of plant	P											1.000	-0.091	0.441*	0.135	0.018
	G											1.000	-0.249	0.160	0.232	0.252
Number of branches	P												1.000	0.363*	0.530**	-0.291
	G												1.000	0.823**	0.618**	-0.599**
Girth of stem	P													1.000	0.023	-0.502**
	G													1.000	0.189	-0.649**
Number of non-bearing nodes	P														1.000	-0.112
	G														1.000	-0.219
Crude fibre content	P															1.000
	G															1.000

The genotypic correlation of mean leaf area with length of fruit, girth of fruit, weight of single fruit, number of seeds per fruit, number of branches, girth of stem and number of non-bearing nodes were found to be positive and significant in both the trials. Crude fibre content had significant negative association with mean leaf area in both the trials. Mean leaf area displayed positive correlation with weight of fruits per plant, number of flowers and fruiting phase in both the trials of which the correlations were found to be significant only in the second trial. Height of plant had significant positive correlation with mean leaf area in the first trial whereas it was found to be non-significant in the second trial.

In both the trials, significant positive correlation was observed for number of fruits per plant with length of fruit, weight of single fruit, weight of fruits per plant, number of seeds per fruit, number of flowers per plant, fruiting phase, number of branches and girth of stem. The correlation of number of fruits per plant with girth of fruit was found to be positive and significant in the first trial whereas negative and non-significant in the second trial. Non-significant negative and positive correlations were observed between number of fruits per plant and height of plant in the first and second trials respectively. In both the trials, negative correlation was observed between number

of fruits per plant and number of non-bearing nodes, but was significant only in the first trial. Crude fibre content had non-significant positive correlation with number of fruits per plant in the first trial whereas the association was found to be negative and significant in the second trial.

Length of fruit manifested significant positive correlation with weight of single fruit, weight of fruits per plant, number of flowers per plant, number of branches, girth of stem and number of non-bearing nodes in both the trials. Length of fruit also had positive correlation with girth of fruit and number of seeds per fruit in both the trials, but was significant only in the second trial. The genotypic correlation for length of fruit with fruiting phase and height of plant were also found to be positive in both the trials but were significant only in the first trial.

Girth of fruit was found to be positively correlated with weight of single fruit, weight of fruits per plant, number of seeds per fruit, number of branches and girth of stem and were significant in both the trials. Girth of fruit manifested negative and positive correlation with number of flowers per plant in the first and second trials respectively and were also significant. Further, the character was positively correlated with fruiting phase and height of plant in both the trials. Negative non-significant correlation was

observed between number of non-bearing nodes and girth of fruit in both the trials.

In both the trials, weight of single fruit was found to be positively correlated with weight of fruits per plant, number of seeds per fruit, number of flowers per plant, fruiting phase, number of branches and girth of stem and registered significant values. In the first trial, the correlation of weight of single fruit with height of plant and number of non-bearing nodes were found to be positive and significant. At the same time, significant negative correlation for weight of single fruit with these characters was observed in the second trial. Crude fibre content had negative significant correlation with weight of fruit in both the trials.

Significant positive correlation was observed for weight of fruits per plant with number of seeds per fruit, number of flowers per plant, fruiting phase, number of branches and girth of stem in both the trials. The correlation between height of plant and weight of fruits per plant was also found to be positive but non-significant in both the trials. Negative and positive correlations were observed between weight of fruits per plant and number of non-bearing nodes in the first and second trials respectively and the values were non-significant. Eventhough weight of fruits per

plant manifested negative correlation with crude fibre content in both the trials, it was significant only in the second trial.

As regards number of seeds per fruit, significant positive correlation was observed with number of flowers per plant, fruiting phase, number of branches and girth of stem in both the trials. At the same time, the correlation between number of seeds per fruit and height of plant was found to be negative and non-significant in both the trials. Positive and negative correlations were observed for number of seeds per fruit with number of non-bearing nodes and crude fibre content in the first and second trials respectively. The association of number ofseeds per fruit with crude fibre content was found to be significant only in the second trial.

In both the trials, number of flowers per plant manifested significant positive correlation with fruiting phase and number of branches. Number of flowers per plant showed non-significant positive correlation with height of plant, girth of stem and crude fibre content in the first trial. Significant positive correlation was observed between number of flowers per plant and girth of stem in the second trial. Number of non-bearing nodes was found to be negatively correlated with number of flowers per plant in both the trials.

but was significant only in the first trial. The negative correlation manifested by number of flowers per plant with crude fibre content in the second trial was also found to be significant.

Fruiting phase displayed significant positive correlation with girth of stem in both the trials. Significant positive correlation was also observed between number of branches and fruiting phase in the first trial. Positive but non-significant correlation was also observed for number of non-bearing nodes with height of plant and crude fibre content in the first trial. Further, the character was negatively associated with the number of non-bearing nodes and was also non-significant. In the second trial, the correlation of fruiting phase with height of plant, number of branches, number of non-bearing nodes and crude fibre content were found to be positive and non-significant.

The genotypic correlation of height of plant with girth of stem and number of non-bearing nodes were found to be positive in both the trials. The correlation of non-bearing nodes with girth of stem was significant in the second trial. Height of plant had non-significant positive and negative correlation with number of branches and crude fibre content respectively in the first trial, whereas the relation was reverse in the second trial.

Number of branches manifested significant positive correlation with crude fibre content in both the trials. Eventhough positive correlation was observed between girth of stem and number of non-bearing nodes, it was significant only in the first trial. In both the trials, significant negative correlation was observed between girth of stem and crude fibre content. Number of non-bearing nodes had negative association with crude fibre content in both the trials of which the value was significant only in the first trial.

The correlation of yield and its components is diagrammatically represented in Fig. 7a and Fig. 7b.

4.4 HETEROSIS

The mean values of the parents and hybrids, the relative heterosis, heterobeltiosis and standard heterosis relative to twenty characters studied are presented in Tables 5-27. Proportion of the desirable and undesirable heterosis displayed by the hybrids in various characters studied are diagrammatically illustrated in Fig.8.

4.4.1. Yield and its components

4.4.1.1 Days to flower

Table 5 shows the mean number of days taken for flowering by parents and hybrids and the three types of heterosis displayed by them. Except two, all other hybrids displayed

1 - First fruiting node

2 - Mean leaf area

3 - Number of fruits per plant

4 - Length of fruit

5 - Girth of fruit

6 - Weight of single fruit

7 - Weight of fruits per plant

8 - Number of seeds per fruit

9 - Number of flowers per plant

10 - Fruiting phase

11 - Height of plant

12 - Number of branches

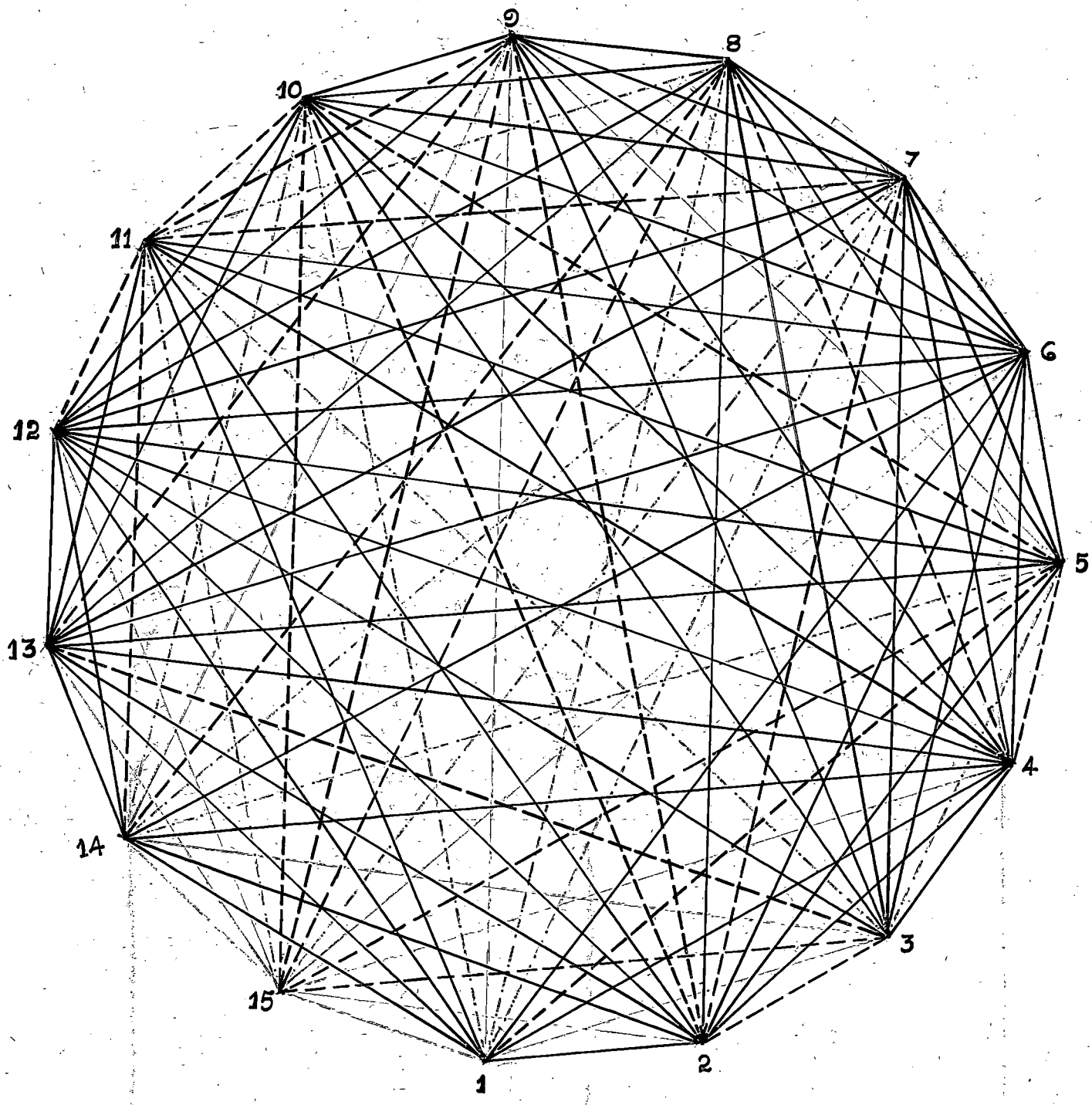
13 - Girth of stem

14 - Number of non-bearing nodes

15 - Crude fibre content

FIG. 7(a). DIAGRAM SHOWING CORRELATION AMONG IMPORTANT ATTRIBUTES IN BHIN

FIRST TRIAL



1 - First fruiting node

2 - Mean leaf area

3 - Number of fruits per plant

4 - Length of fruit

5 - Girth of fruit

6 - Weight of single fruit

7 - Weight of fruits per plant

8 - Number of seeds per fruit

9 - Number of flowers per plant

10 - Fruiting phase

11 - Height of plant

12 - Number of branches

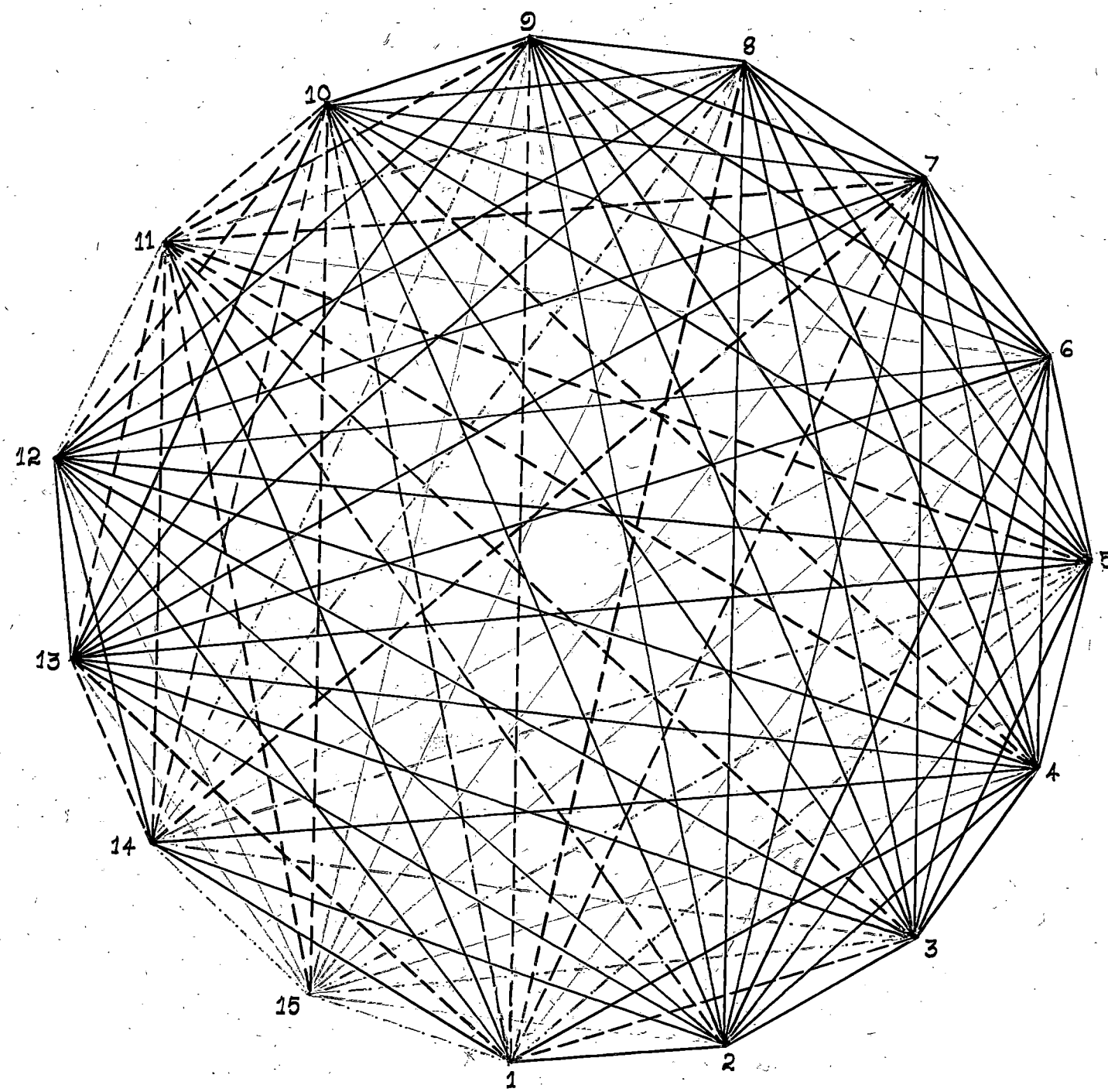
13 - Girth of stem

14 - Number of non-bearing nodes

15 - Crude fibre content

FIG. 7(6). DIAGRAM SHOWING CORRELATION AMONG IMPORTANT ATTRIBUTES IN BHINDI

SECOND TRIAL



Hybrids	Trial I				Trial II			
	Positive significant heterosis	Positive non-significant heterosis	Negative non-significant heterosis	Negative significant heterosis	Positive significant heterosis	Positive non-significant heterosis	Negative non-significant heterosis	Negative significant heterosis
	Percentage of characters (angle)				Percentage of characters (angle)			
4 x 6	15 (54°)	60 (216°)	25 (90°)	-	29 (104.4°)	57 (205.2°)	14 (50.4°)	-
5 x 2	30 (108°)	65 (234°)	5 (54°)	-	48 (172.8°)	38 (136.8°)	14 (50.4°)	-
5 x 6	20 (72°)	70 (252°)	10 (36°)	-	48 (172.8°)	29 (104.4°)	19 (68.4°)	4 (14.4°)
6 x 1	15 (57.6°)	55 (208.8°)	25 (93.6°)	-	33 (118.8°)	57 (205.2°)	-	10 (36°)
6 x 2	25 (90°)	60 (216°)	15 (54°)	-	62 (223.2°)	14 (50.4°)	24 (86.4°)	-
6 x 3	20 (72°)	60 (216°)	20 (72°)	-	57 (205.2°)	23 (82.8°)	10 (36°)	10 (36°)

FIG. 8 PROPORTION OF DESIRABLE AND UNDESIRABLE STANDARD HETEROSIS DISPLAYED BY THE HYBRIDS

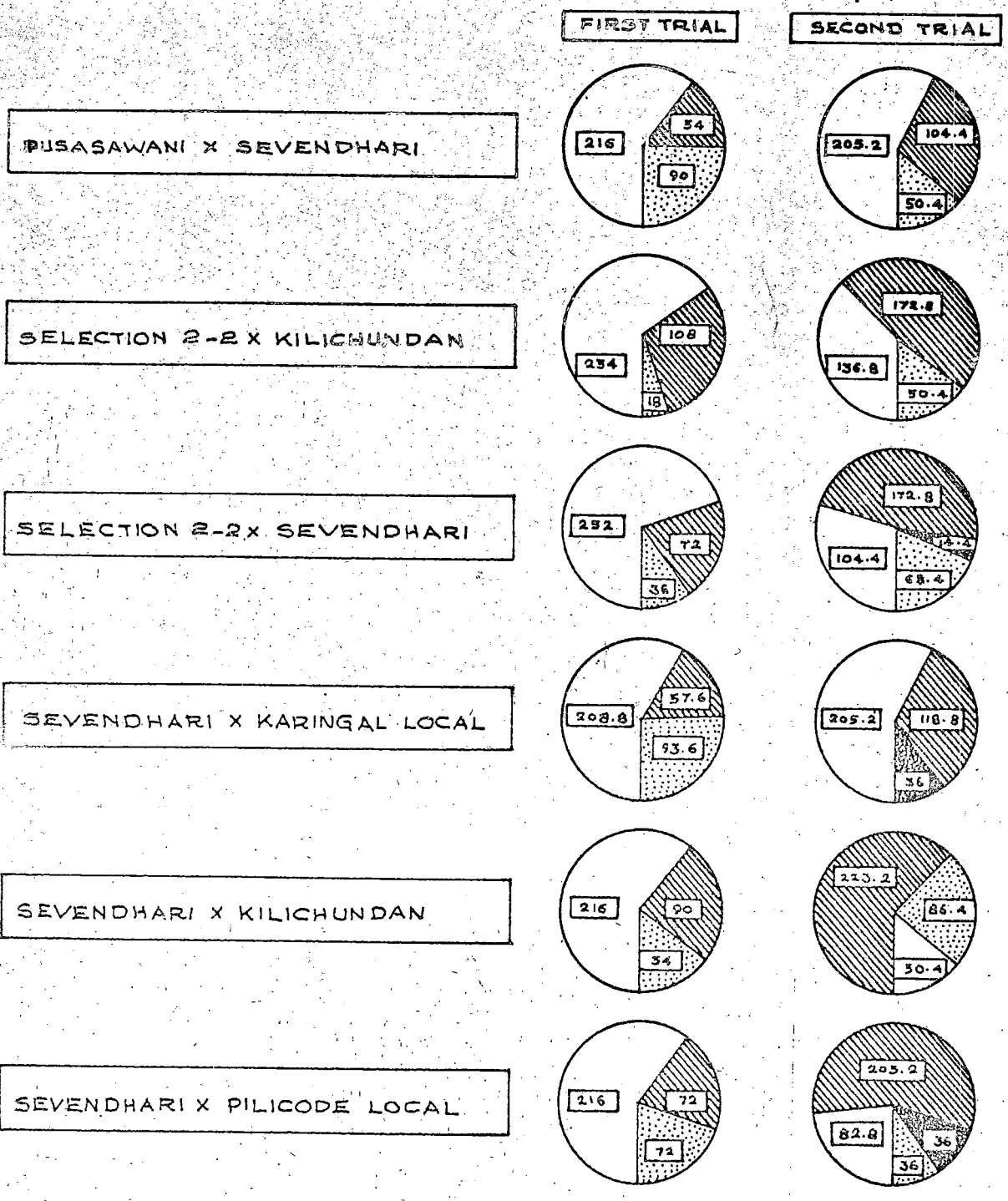


Table 5. The mean values of parents and hybrids and heterosis in percentage - Days to flower

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	33.57	40.77	37.17									
2 (Kilichundan)	39.57	53.50	46.55									
3 (Pilicode local)	34.67	46.50	40.59									
4 (Pusa sawani)	35.50	44.83	40.17									
5 (Selection 2-2)	34.63	44.50	39.57									
6 (Sevendhari)	34.83	44.43	39.63									
4 x 6	34.57	47.77	41.17	-1.69	7.04**	3.18	-2.62	6.56*	2.49	-2.62	6.56*	2.49
5 x 2	33.67	44.17	38.92	-9.25**	-9.86**	9.61	-14.91**	-17.44**	-16.39	-5.15	-1.47	-3.11
5 x 6	35.10	43.90	39.14	1.07	-1.27	-1.16	0.78	-1.35	-1.24	-1.13	-2.07	-2.56
6 x 1	34.20	43.10	39.05	0.00	1.17	1.69	-1.81	-2.99**	-1.46	-3.66	-3.86	-2.79
6 x 2	37.63	46.97	42.30	1.16	-4.07*	-1.83	-4.90	-12.21**	-9.13	6.00	4.77	5.30
6 x 3	35.83	43.60	39.72	3.11	-4.10	-0.97	2.87	-6.24*	-2.14	0.93	-2.74	-1.12

	Trial I	Trial II
C.D. I (0.05)	2.36	1.96
C.D.I (0.01)	3.20	2.67
C.D.II (0.05)	2.72	2.27
C.D.II (0.01)	3.70	3.08

* Significant at 5% level

** Significant at 1% level

negative relative heterosis of which two were significant in the second trial. Two hybrids displayed negative relative heterosis in the first trial of which one hybrid (5 x 2) registered significant value. As regards heterobeltiosis, five hybrids in the second trial and four hybrids in the first trial manifested significant heterosis. Three hybrids 5 x 2, 6 x 2 and 6 x 3 in the second trial and one hybrid 5 x 2 in the first trial had significant negative heterosis in comparison with the better parental values. One hybrid (4 x 6) manifested positive significant standard heterosis in the second trial. In the first trial two hybrids registered positive standard heterosis, but were non-significant.

4.4.1.2 First fruiting node

Table 6 presents the mean values of parents and hybrids and the three types of heterosis.

None of the hybrids displayed significant relative heterosis in the first trial while three hybrids manifested significant relative heterosis in the second trial. Three hybrids namely 5 x 2, 6 x 2 and 6 x 3 displayed negative relative heterosis and four hybrids had negative heterobeltiosis in both the trials. The hybrids 5 x 2, 6 x 2 and 6 x 3 displayed significant negative heterobeltiosis in both the trials. In comparison with the standard cultivar, positive heterosis was displayed by one hybrid in the first trial and

Table 6. The mean values of parents and hybrids and heterosis in percentage - First fruiting node

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	4.83	4.33	4.58									
2 (Kilichundan)	6.50	6.57	6.53									
3 (Pilicode local)	5.60	5.53	5.57									
4 (Pusa Sawani)	5.87	5.20	5.53									
5 (Selection 2-2)	4.83	5.00	4.92									
6 (Sevendhari)	4.43	4.07	4.25									
4 x 6	5.20	5.13	5.17	0.97	10.68	5.73	-11.41	-1.35	-6.51	-11.41	-1.35	-6.51
5 x 2	5.07	5.30	5.18	-10.58	- 8.46	-9.52	-22.00*	- 19.33**	-20.67	-13.63	1.92	-6.33
5 x 6	5.53	5.57	5.55	19.44	22.82**	21.05	14.49	11.40	12.80	5.79	7.12	0.36
6 x 1	5.20	4.97	5.08	12.31	18.33*	15.06	7.66	14.78	10.92	-11.41	-4.42	-8.14
6 x 2	5.10	4.70	4.90	-6.76	-11.65	-9.09	-21.54*	-28.46**	-24.96	-13.12	-9.62**	-11.39
6 x 3	4.47	4.20	4.33	-10.87	-12.50	-11.81	-20.18*	-24.05**	-22.26	-23.85*	-19.23**	-21.70

	Trial I	Trial II
C.D. I (0.05)	0.94	0.62
C.D. I (0.01)	1.28	0.85
C.D.II (0.05)	1.08	0.72
C.D.II (0.01)	1.47	0.98

* Significant at 5% level

** Significant at 1% level

by two hybrids in the second trial. The hybrid 6 x 3 was the only hybrid that displayed significant negative standard heterosis in both the trials.

4.4.1.3 Mean leaf area

Table 7 presents the mean values of parents and hybrids and the three types of heterosis.

In the first trial, none of the hybrids had significant heterosis in all the three types of comparisons. In the second trial, all the hybrids manifested positive heterosis in different types of comparisons. Five hybrids displayed significant relative heterosis, while one hybrid had significant heterobeltiosis and four hybrids manifested significant standard heterosis in the second trial.

4.4.1.4 Number of fruits per plant

The three types of heterosis computed are presented in Table 8.

All the six hybrids displayed positive relative heterosis in both the trials of which the heterosis expressed by the hybrids 4 x 6 and 5 x 6 in the first trial were only found to be non-significant. In both the trials, positive heterobeltiosis and standard heterosis were also displayed by all the hybrids. One hybrid in the first trial and four hybrids in the second trial displayed significant positive hetero-

Table 7. The mean values of parents and hybrids and heterosis in percentage - Mean leaf area

Parents and hybrids	Mean value			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	95.95	146.92	121.43									
2 (Kilichundan)	172.87	229.61	201.24									
3 (Pilicode local)	157.13	183.59	170.36									
4 (Pusa Sawani)	124.02	175.32	149.67									
5 (Selection 2-2)	93.41	193.36	143.39									
6 (Sevendhari)	100.89	171.69	136.29									
4 x 6	125.53	210.76	168.14	11.63	21.67**	17.60	1.22	20.21*	12.34	1.22	20.21*	12.34
5 x 2	167.34	244.09	205.72	25.69	15.42*	19.39	-3.20	6.31	2.23	34.93	39.23**	37.45
5 x 6	135.31	194.67	164.99	39.28	6.65	17.98	34.12	0.68	15.06	9.10	11.04	10.24
6 x 1	108.91	190.26	149.58	10.66	19.43*	16.08	7.95	10.82	9.75	-12.18	8.59	-0.06
6 x 2	153.25	241.07	197.16	11.96	20.14**	16.83	-11.35	4.99	-2.03	23.57	37.50**	31.73
6 x 3	119.79	208.77	164.28	-7.15	17.52*	7.14	-23.76	13.72	-3.57	-3.41	19.06*	9.76

	Trial I	Trial II
C.D. I (0.05)	46.32	25.11
C.D. I (0.01)	61.59	34.13
C.D.II (0.05)	52.33	28.99
C.D.II (0.01)	71.12	39.41

* Significant at 5% level

** Significant at 1% level

Table 8. The mean values of parents and hybrids and heterosis in percentage - Number of fruits per plant

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	11.10	11.93	11.52									
2 (Kilichundan)	14.40	16.73	15.57									
3 (Pillcode local)	15.30	16.60	15.95									
4 (Pusa Sawani)	18.67	16.77	17.72									
5 (Selection 2-2)	17.60	15.50	16.55									
6 (Sevendhari)	19.20	16.10	17.65									
4 x 6	20.70	19.03	19.87	9.32	15.79*	12.36	7.81	13.48	12.13	10.87	13.48	12.13
5 x 2	21.90	22.70	22.25	36.25**	40.86**	38.54	23.86**	35.68**	34.44	16.76	35.36**	25.56
5 x 6	20.30	18.77	19.53	10.33	18.80**	14.21	5.73	16.58*	10.65	8.73	11.93	10.21
6 x 1	19.70	17.70	18.70	30.03**	26.29**	28.21	2.60	9.94	5.95	5.52	5.55	5.53
6 x 2	21.30	22.70	22.00	26.79**	38.29**	32.45	10.94	35.68**	24.65	14.09	35.36**	24.15
6 x 3	20.90	19.60	20.25	21.15*	19.58**	20.34	8.85	18.07*	14.73	11.94	16.88*	14.29

	Trial I	Trial II
C.D. I (0.05)	2.72	2.18
C.D. I (0.01)	3.70	2.98
C.D.II (0.05)	3.14	2.52
C.D.II (0.01)	4.27	3.42

* Significant at 5% level

** Significant at 1% level

beltiosis.The only hybrid that displayed significant heterobeltiosis in both the trial was 5 x 2. Significant positive standard heterosis was manifested by three hybrids 5 x 2, 6 x 2 and 6 x 3 in the second trial while none had a significant value for standard heterosis in the first trial.

4.4.1.4.1 Number of fruits on main stem

The three heterosis comparisons along with the mean values of parents and hybrids are presented in Table 9.

The comparison with the mid-parental values revealed positive heterosis in all the hybrids in the first trial and in five hybrids in the second trial. In the second trial, negative relative heterosis was displayed by the hybrid 6 x 3 and found to be non-significant. In heterobeltiosis comparison, the hybrid 5 x 2 displayed significant hterosis in both the trials while other values were non-significant. The only hybrid that displayed negative heterosis was 6 x 3 in the second trial. In the first trial, all the hybrids displayed positive standard heterosis but the values were non-significant In the second trial, only one hybrid (5 x 2) displayed significant positive standard heterosis.

4.4.1.4.2 Number of fruits on branches

The three heterosis comparisons along with the mean values are presented in Table 10.

Table 9. The mean values of parents and hybrids and heterosis in percentage - Number of fruits on main stem

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	9.93	11.40	10.67									
2 (Kilichundan)	10.83	12.63	11.73									
3 (Pilicode local)	12.03	13.87	12.95									
4 (Pusa Sawani)	16.77	15.17	15.97									
5 (Selection 2-2)	15.30	13.73	14.52									
6 (Sevendhari)	16.13	12.43	14.28									
4 x 6	18.53	14.50	16.52	12.64	5.07	9.22	10.49	-4.42	3.44	10.49	-4.42	3.44
5 x 2	18.53	18.80	18.67	41.83**	42.64**	42.25	21.11*	36.93**	28.58	10.49	23.93*	16.91
5 x 6	17.20	13.97	15.58	9.45	6.80	8.19	6.63	1.75	7.30	2.56	-7.91	-2.44
6 x 1	16.93	14.80	15.87	29.93**	24.21*	27.21	4.96	19.07	11.13	0.95	-2.44	-0.63
6 x 2	17.70	14.03	15.87	31.31**	11.97	22.03	9.73	11.08	11.13	5.55	-7.51	-0.63
6 x 3	18.30	13.03	15.67	29.97**	-0.91	15.09	13.45	-6.06	9.73	9.12	-14.11	-1.88

	Trial I	Trial II
C.D. I (0.05)	2.64	2.44
C.D. I (0.01)	3.58	3.32
C.D. II (0.05)	3.04	2.82
C.D. II (0.01)	4.14	3.83

* Significant at 5% level

** Significant at 1% level

Table 10. The mean values of parents and hybrids and heterosis in percentage - Number of fruits on branches

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	1.17	0.53	0.85									
2 (Kilichundan)	3.57	4.10	3.83									
3 (Pilicode local)	3.10	2.73	2.92									
4 (Pusa sawani)	1.90	1.60	1.75									
5 (Selection 2-2)	2.17	1.77	1.97									
6 (Sevendhari)	3.07	3.67	3.37									
4 x 6	2.17	4.53	3.35	-12.68	71.92	30.86	-29.32	23.43	-0.59	14.21	163.13*	91.43
5 x 2	3.27	3.90	3.58	13.94	32.88	23.45	-8.40	-4.88	-6.53	72.11	143.75	104.57
5 x 6	3.10	4.80	3.95	18.32	76.47	47.94	0.98	30.79	17.21	63.16	200.00*	125.71
6 x 1	2.20	2.90	2.55	3.77	38.10	20.85	-28.34	-20.98	-24.33	15.79	81.25	45.71
6 x 2	3.60	8.67	6.13	8.43	123.17**	70.28	0.84	111.46**	60.05	89.47*	441.88**	250.29
6 x 3	2.60	6.57	4.58	-15.72	105.31*	45.63	-16.13	79.02*	35.91	36.84	310.63**	161.71

	Trial I	Trial II
C.D. I (0.05)	1.44	2.33
C.D. I (0.01)	1.95	3.17
C.D.II (0.05)	1.66	2.69
C.D.II (0.01)	2.26	3.66

* Significant at 5% level

** Significant at 1% level

In comparison with the mid-parental values, four hybrids displayed positive heterosis and two hybrids displayed negative heterosis in the first trial. All the hybrids manifested positive relative heterosis in the second trial of which two were significant. In comparison with the better parent, positive and negative heterosis were displayed by two and four hybrids respectively in the first trial. In the second trial, positive heterobeltiosis was exhibited by four hybrids of which two were significant. As regards standard heterosis, all the hybrids had positive heterosis in both the trials. One hybrid in the first trial and four hybrids in the second trial had significant values for standard heterosis. The hybrid 6 x 2 had significant positive standard heterosis in both the trials.

4.4.1.5 Length of fruit

Mean length of fruit in parents and hybrids and the extent of three types of heterosis are shown in Table 11.

All the hybrids manifested relative heterosis in both the trials of which the hybrid 5 x 2 in the first trial and 6 x 2 in the second trial had significant values. The hybrids 4 x 6 in the first trial and 5 x 2 in the second trial had negative values for heterobeltiosis but were found to be non-significant. All the hybrids except 4 x 6 and 5 x 6 showed positive relative heterosis in the first trial of which the values for 5 x 2 was found to be significant. In the second

Table 11. The mean values of parents and hybrids and heterosis in percentage - length of fruit

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	13.27	17.33	15.30									
2 (Kilichundan)	15.55	21.93	18.74									
3 (Pilicode local)	15.69	17.09	16.39									
4 (Pusa Sawani)	14.43	16.24	15.34									
5 (Selection 2-2)	13.77	17.04	15.41									
6 (Sevendhari)	13.18	16.02	14.60									
4 x 6	14.29	17.26	15.77	3.51	7.01	5.34	-0.97	6.28	2.80	-0.97	6.28*	2.80
5 x 2	17.91	20.65	19.28	22.17**	5.99	12.91	15.18**	-5.84	2.88	24.12**	27.16**	25.68
5 x 6	14.44	18.11	16.28	7.16	9.56	8.50	4.87	6.28	5.65	0.07	11.51	6.13
6 x 1	13.67	17.93	15.80	3.36	7.53	5.69	3.01	3.46	3.27	-5.27	10.41	3.00
6 x 2	15.59	22.75	19.17	8.53	19.89**	15.00	0.26	3.74	2.29	8.04	40.09**	24.97
6 x 3	15.77	17.95	16.86	9.29	8.43	8.81	0.57	5.03	2.87	9.29	10.53	9.91

	Trial I	Trial II
C.D. I (0.05)	2.01	2.26
C.D. I (0.01)	2.73	3.08
C.D. II (0.05)	2.32	2.61
C.D. II (0.01)	3.16	4.47

* Significant at 5% level

** Significant at 1% level

trial, all the hybrids showed positive standard heterosis with significant values for 5 x 2 and 6 x 2 only.

4.4.1.6 Girth of fruit

The three types of heterosis computed for this character are presented in Table 12.

Among the hybrids, one hybrid 6 x 3 manifested negative relative heterosis in the first trial and was found to be non-significant. In the second trial, all the hybrids manifested significant positive relative heterosis. Heterobeltiosis was found to be non-significant in all the hybrids in the first trial while two hybrids 5 x 6 and 6 x 2 showed significant values in the second trial. In comparison with the standar cultivar, positive heterosis was displayed by all the hybrids in both the trials. Two hybrids in the first trial and all the six hybrids in the second trial registered significant positive heterosis.

4.4.1.7 Weight of single fruit

Table 13 presents the three types of heterosis displayed by the hybrids. None of the hybrids exhibited significant relative heterosis in the first trial. The only hybrid that displayed significant positive relative heterosis in the second trial was 5 x 2. All the hybrids except 6 x 2 in the first trial displayed positive relative heterosis. As regards

Table 12. The mean values of parents and hybrids and heterosis in percentage - Girth of fruit

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	5.89	6.39	6.14									
2 (Kilichundan)	6.41	6.55	6.48									
3 (Vellicode local)	6.47	6.09	6.28									
4 (Pusa Sawani)	5.57	6.26	5.92									
5 (Selection 2-2)	5.54	5.79	5.67									
6 (Sevendhari)	6.07	6.88	6.47									
4 x 6	6.12	6.95	6.54	5.15	5.78*	5.57	0.82	1.02	1.08	9.87	11.02**	10.47
5 x 2	6.10	6.90	6.50	2.09	11.83**	7.00	-4.84	5.34	0.31	9.52	10.22**	9.80
5 x 6	6.21	7.26	6.74	6.98	14.69**	11.04	2.31	5.52*	4.17	11.49*	15.97**	13.05
6 x 1	6.37	7.12	6.75	6.52	7.30**	7.06	4.94	3.49	4.33	14.36	13.74	14.02
6 x 2	6.37	7.49	6.93	2.08	11.54**	7.03	-0.62	8.87**	6.94	14.36*	19.65**	17.06
6 x 3	6.18	7.12	6.65	-1.44	9.79**	4.31	-4.48	3.49	2.78	10.95	13.74**	12.33

	Trial I	Trial II
C.D. I (0.05)	0.67	0.33
C.D. I (0.01)	0.91	0.45
C.D. II (0.05)	0.78	0.38
C.D. II (0.01)	1.05	0.51

* Significant at 5% level

** Significant at 1% level

Table 13. The mean values of parents and hybrids and heterosis in percentage - Weight of single fruit

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	17.49	20.07	18.78									
2 (Kilichundan)	20.75	20.64	20.70									
3 (Pilicode local)	19.55	19.82	19.68									
4 (Pusa Sawani)	16.56	22.40	19.48									
5 (Selection 2-2)	18.71	21.98	20.35									
6 (Sevendhari)	17.71	25.82	21.77									
4 x 6	18.83	26.33	22.58	9.86	9.21	9.48	6.32	1.98	3.72	13.71	17.54	15.91
5 x 2	20.81	29.62	25.21	5.47	39.08*	22.83	0.29	34.76	21.79	25.66	32.23	29.41
5 x 6	19.74	26.62	23.18	8.40	11.38	10.07	5.51	3.10	6.48	19.20	18.84	18.99
6 x 1	19.92	24.45	22.19	13.18	6.56	9.45	12.48	-5.31	1.93	20.29	9.15	13.91
6 x 2	18.94	27.58	23.26	-1.51	18.73	9.54	-8.72	6.82	6.84	14.37	23.13	19.40
6 x 3	20.20	25.96	23.08	8.43	13.76	11.36	3.32	0.54	6.02	21.98	15.89	18.48

	Trial I	Trial II
C.D. I (0.05)	3.82	6.96
C.D. I (0.01)	5.19	9.46
C.D.II (0.05)	4.41	8.04
C.D.II (0.01)	5.99	10.92

* Significant at 5% level

** Significant at 1% level

this character all the six hybrids except 6 x 2 in the first trial and 6 x 1 in the second trial manifested positive heterosis in comparison with the respective better parental values. Non-significant positive standard heterosis was displayed by all the hybrids in both the trials.

4.4.1.8 Weight of fruits per plant

Relative heterosis, heterobeltiosis and standard heterosis computed are presented in Table 14.

In all the three types of heterosis assessed positive heterosis was obtained for all the hybrids in both the trials. Among the relative heterosis estimates four hybrids showed significance in the first trial with the values of heterosis ranging from 22.03 per cent (5 x 6) to 45.31 per cent (5 x 2) In the second trial, all the hybrids showed significant relative heterosis and the values ranged from 26.58 per cent (4 x 6) to 58.84 per cent (5 x 2). One hybrid (5 x 2) in the first trial and four hybrids in the second trial displayed significant heterobeltiosis. The positive heterobeltiosis ranged from 10.47 per cent (6 x 1) to 39.10 per cent (5 x 2) and from 3.98 per cent (6 x 1) to 35.02 per cent (5 x 2) in the first and second trials respectively. In comparison with the standard cultivar, all the hybrids except 5 x 6 manifested significant heterosis in both the trials. The maximum and minimum standard heterosis was displayed by 5 x 2 and 6 x 1 respectively in both the trials and the values

Table 14. The mean values of parents and hybrids and heterosis in percentage - Weight of fruits per plant

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1. (Karingal local)	196.58	236.57	216.58									
2. (Kilichundan)	300.96	496.65	398.81									
3. (Pilicode local)	295.29	325.43	310.36									
4. (Pusa Sawani)	307.28	376.31	341.80									
5. (Selection 2-2)	329.12	342.40	335.76									
6. (Sevendheri)	340.61	414.49	377.55									
4 x 6	392.05	500.48	446.27	21.02	26.58**	24.08	15.10	20.75**	18.20	27.59*	33.00**	30.56
5 x 2	457.80	670.56	564.18	45.31**	59.84**	53.61	39.10**	35.02**	41.47	48.98**	78.19**	65.06
5 x 6	401.94	499.67	450.81	20.03	32.03**	26.40	18.01	20.55**	19.40	30.81*	32.78**	31.89
6 x 1	396.27	430.97	403.62	40.09**	32.39**	35.87	10.47	3.98	6.91	22.45	14.53	18.09
6 x 2	404.70	623.01	513.86	26.16*	36.75**	32.38	18.82	25.44**	28.85	31.70*	65.56**	50.34
6 x 3	422.40	508.57	465.49	32.85**	37.47**	35.33	24.01	22.70**	23.29	37.46**	35.15**	36.19

	Trial I	Trial II
C.D. I (0.05)	72.74	49.09
C.D. I (0.01)	98.88	66.72
C.D. II (0.05)	84.00	56.68
C.D. II (0.01)	114.17	77.04

* Significant at 5% level

** Significant at 1% level

ranged from 22.45 per cent to 48.98 per cent and from 14.53 per cent to 78.19 per cent in first and second trial respectively.

4.4.1.9 Number of seeds per fruit

The three types of heterosis computed are presented in Table 15.

Three hybrids in the first trial and two hybrids in the second trial showed negative relative heterosis and were non-significant. One hybrid (6 x 1) in the first trial and two hybrids (5 x 6) and (6 x 1) in the second trial manifested significant positive heterosis in comparison with the mid-parental values. In both the trials, the negative heterobeltiosis displayed by the hybrid 4 x 6 was found to be significant. All the hybrids except 4 x 6 displayed positive standard heterosis in both the trials.

4.4.1.10 Number of ridges per fruit

The three comparisons of heterosis are presented in Table 16.

Only one hybrid (6x 2) displayed negative non-significant heterosis in both the trials. Two and three hybrids in first and second trials respectively registered significant values for relative heterosis. One hybrid each showed significant negative and positive heterobeltiosis respectively in the first trial. In the second trial, four hybrids manifested

Table 15. The mean values of parents and hybrids and heterosis in percentage - Number of seeds per fruit

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1. (Karingal local)	56.65	61.08	58.86									
2. (Kilichundan)	96.70	105.37	101.03									
3. (Pilicode local)	80.77	75.30	78.04									
4. (Pusa Sawani)	88.45	94.07	91.26									
5. (Selection 2-2)	76.83	89.46	82.14									
6. (Sevendhari)	117.50	108.59	113.05									
4 x 6	90.22	92.84	91.53	-12.39	-8.38	-10.40	-23.22	-14.50	-19.04	2.00	-1.31	0.30
5 x 2	95.12	96.89	96.00	10.91	-0.54	4.82	-1.16	-8.05	-4.98	7.54	3.00	5.19
5 x 6	110.16	122.52	116.34	14.55	23.38**	13.89	-6.25	12.83	2.91	24.54	30.24**	27.98
6 x 1	109.98	120.62	115.30	26.30*	42.13**	34.14	-6.40	11.08	1.99	24.34	28.22**	26.34
6 x 2	106.02	116.41	111.21	-1.01	8.81	3.90	-9.77	7.20	-1.63	19.86	23.75**	21.86
6 x 3	96.82	94.39	95.60	-2.34	2.65	0.06	-17.60	-13.09*	-15.44	9.46	0.33	4.76

	Trial I	Trial II
C.D. I (0.05)	20.59	12.25
C.D. I (0.01)	27.99	16.64
C.D. II (0.05)	23.78	14.14
C.D. II (0.01)	32.32	19.22

* Significant at 5% level

** Significant at 1% level

Table 16. The mean values of parents and hybrids and heterosis in percentage - Number of ridges per fruit

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	5.30	5.22	5.26									
2 (Kilichundan)	7.33	7.93	7.63									
3 (Pilicode local)	5.41	5.04	5.22									
4 (Pusa Sawani)	5.07	5.03	5.05									
5 (Selection 2-2)	5.15	5.00	5.07									
6 (Sevendhari)	7.48	7.09	7.28									
4 x 6	7.18	6.33	6.75	14.42*	4.46	9.65	-4.01	-10.72**	-7.14	41.62**	25.04**	33.86
5 x 2	7.15	6.96	7.05	14.58*	7.66*	11.02	-2.46	-12.23**	-7.60	41.03**	38.37**	39.60
5 x 6	6.85	7.20	7.03	8.47	19.10**	13.85	8.42	1.55	-3.43	35.11**	43.14**	39.21
6 x 1	6.44	6.48	6.46	0.78	5.28	3.03	13.90*	-8.60*	-11.26	27.82**	28.83**	27.92
6 x 2	7.35	7.04	7.19	-0.74	-6.26	-3.55	-1.74	-11.22**	-5.77	44.57**	39.96**	42.38
6 x 3	6.44	7.05	6.75	-0.08	16.24**	8.00	-13.98*	-0.56	-7.28	27.02**	40.16**	33.66

	Trial I	Trial II
C.D. I (0.05)	0.70	0.49
C.D. I (0.01)	0.96	0.66
C.D. II (0.05)	0.81	0.56
C.D. II (0.01)	1.10	0.76

* Significant at 5% level

** Significant at 1% level

significant negative heterobeltiosis. All the hybrids exhibite significant positive standard heterosis in both the trials.

4.4.1.11 Number of flowers per plant

The mean number of flowers produced per plant by the parents and hybrids and the three heterosis comparisons are presented in Table 17.

Positive heterosis was displayed by all the hybrids in all the three comparisons in both the trials. The hybrid 4 x 6 registered non-significant relative heterosis in both the trials, while the hybrid 5 x 6 had non-significant relative heterosis in the second trial only. All the other hybrids registered significant relative heterosis in both the trials. In the first trial, the heterobeltiosis values were significant only in the hybrid 5 x 2 . In the second trial, four hybrids displayed significant heterobeltiosis including 5 x 2. The values for standard heterosis was non-significant for all the hybrids in the first trial while the hybrid 4 x 6 alone recorded non-significant value in the second trial.

4.4.1.12 Fruiting phase

Table 18 depicts the mean duration of fruiting in parents and hybrids and the relative heterosis, heterobeltiosi and standard heterosis.

Table 17. The mean values of parents and hybrids and heterosis in percentage - Number of flowers per plant

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1. (Karingal local)	13.87	13.70	13.78									
2. (Kilichundan)	16.73	20.77	18.75									
3. (Pilicode local)	19.17	18.80	18.98									
4. (Pusa Sawani)	23.43	18.67	21.05									
5. (Selection 2-2)	22.87	21.70	22.28									
6. (Sevendhari)	22.37	21.00	21.68									
4 x 6	24.53	21.90	23.22	7.12	10.41	8.68	4.69	4.29	7.10	4.69	17.30	10.31
5 x 2	27.60	28.07	27.83	39.39**	32.18**	35.66	20.68**	29.35**	24.91	17.80	50.35**	32.21
5 x 6	24.20	25.37	24.78	6.98	18.83*	12.74	5.82	16.91*	11.22	3.29	35.89**	17.72
6 x 1	23.57	23.27	23.42	30.08**	34.12**	32.09	5.36	10.81	8.03	0.60	24.64*	11.26
6 x 2	24.13	27.50	25.82	23.43*	31.67**	27.73	7.87	30.95**	19.09	2.99	47.30**	22.66
6 x 3	25.37	25.23	25.30	22.15*	26.78**	24.45	13.41	20.14	16.70	8.28	35.14**	20.19

	Trial I	Trial II
C.D. I (0.05)	3.74	3.26
C.D. I (0.01)	5.08	4.43
C.D. II (0.05)	4.32	3.76
C.D. II (0.01)	5.87	5.11

* Significant at 5% level

** Significant at 1% level

Table 18. The mean values of parents and hybrids and heterosis in percentage - Fruiting phase

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	37.11	32.73	34.92									
2 (Kilichundan)	40.72	36.74	38.73									
3 (Pilicode local)	45.74	34.48	40.11									
4 (Pusa Sawani)	46.31	39.05	42.08									
5 (Selection 2-2)	45.31	32.82	39.06									
6 (Sevendhari)	45.25	37.45	41.35									
4 x 6	49.60	39.40	44.50	8.34*	3.01	5.91	7.10	0.90	4.26	7.10	0.90	4.26
5 x 2	50.68	39.95	45.32	17.81**	14.86**	16.52	11.85**	8.74**	16.03	9.44*	2.30	6.19
5 x 6	50.33	38.33	44.33	11.15**	9.09**	1.90	11.08**	2.35	7.21	8.68*	-1.84	3.87
6 x 1	46.65	35.28	40.97	13.28**	0.54	7.43	3.09	-5.79*	7.21	0.73	-9.65**	-4.01
6 x 2	50.13	37.19	43.65	16.61**	0.26	9.02	10.78**	-0.69	5.56	8.25*	-4.76	2.27
6 x 3	49.67	36.91	43.29	9.17**	2.63	6.29	8.59*	-1.44	4.69	7.26*	-5.48*	1.43

	Trial I	Trial II
C.D. I (0.05)	2.89	1.63
C.D.I (0.01	3.93	2.21
C.D.II (0.05)	3.34	1.88
C.D.II (0.01)	4.53	2.55

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

All the hybrids showed positive heterosis compared to the respective mid-parental values in both the trials of which all the six in the first and two in the second had significant values. In the first trial, all the hybrids registered positive heterobeltiosis of which four values were significant in each estimate. In the second trial, negative values for heterobeltiosis and standard heterosis were registered by the three and four hybrids respectively. The hybrids 5 x 2 and 6 x 1 recorded significant positive and negative heterobeltiosis in the second trial. The negative standard heterosis recorded by 6 x 1 and 6 x 3 in the second trial were also found to be significant.

4.4.1.13 Number of non-bearing nodes

Table 19 represents the mean number of non-bearing nodes per plant in parents and hybrids and the heterosis in comparison with mid-parental value, better parent and standard cultivar.

All the six hybrids in the first trial and five hybrids in the second trial displayed negative relative heterosis. The hybrids 5 x 2 and 6 x 2 manifested significant negative heterosis in both the trials in comparison with the mid-parental and better parental values. All the hybrids manifested negative standard heterosis of which 5 x 6, 6 x 1 and 6 x 3 registered negative values in both the trials.

Table 19. The mean values of parents and hybrids and heterosis in percentage - Number of nonbearing nodes

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	4.37	5.00	4.68									
2 (Kilichundan)	9.83	11.27	10.55									
3. (Pilicode local)	5.93	6.07	6.00									
4 (Pusa Sawani)	6.60	6.33	6.47									
5 (Selection 2-2)	5.93	5.67	5.80									
6 (Sevendhari)	4.57	4.03	4.30									
4 x 6	5.23	5.70	5.47	-6.36	10.04	1.58	-20.76	-9.95	-15.46	-20.76	-9.95	-15.4
5 x 2	5.67	5.47	5.67	-25.51*	-35.42**	-30.64	-40.28**	-51.46**	-46.26	-11.06	-13.59	-12.3
5 x 6	4.63	4.33	4.48	-11.81	-10.72	-11.29	-21.92	-23.63	-22.76	-29.85*	-31.60**	-30.7
6 x 1	4.20	4.37	4.28	-6.04	-3.21	-4.68	-8.10**	-12.60**	-8.55	-36.36*	-30.96**	-33.8
6 x 2	5.63	5.27	5.45	-21.81	-31.11	-26.60	-42.73	-53.24	-48.34	-14.70	-16.75	-15.7
6 x 3	4.50	4.80	4.65	-14.29	-4.95	-9.71	-24.11	-20.92	-22.50	-31.81*	-24.17*	-28.1

	Trial I	Trial II
C.D. I (0.05)	1.60	1.23
C.D. I (0.01)	2.17	1.67
C.D.II (0.05)	1.85	1.42
C.D.II (0.01)	2.51	1.93

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

4.4.1.14 Height of plant

The mean height of parents and hybrids, relative heterosis, heterobeltiosis and standard heterosis are presented in Table 20.

All the six hybrids exhibited positive relative heterosis in both the trials. Among the six hybrids positive significant relative heterosis was exhibited by two hybrids (5 x 2, 6 x 1) in the first trial while five hybrids displayed significant heterosis in the second trial. Three hybrids in each trial displayed negative heterobeltiosis of which 6 x 3 in the first trial registered significant value. As regards standard heterosis, four hybrids displayed negative heterosis in both the trials.

4.4.1.15 Number of branches

The three types of heterosis computed are given in Table 21.

The hybrid 6 x 2 in the first trial and 5 x 2 in the second trial displayed significant positive and negative relative heterosis respectively. In the second trial, the hybrid 6 x 3 did not display relative heterosis. Two hybrids (5 x 6, 6 x 2) displayed positive heterobeltiosis in the first trial while none expressed positive heterobeltiosis in the second trial. Comparison with the standard cultivar revealed significant positive heterosis for five hybrids in

Table 20. The mean values of parents and hybrids and heterosis in percentage - Height of plant

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Polled	Trial I	Trial II	Pooled
1 (Karingal local)	48.87	99.63	74.25									
2 (Kilichundan)	52.23	102.97	77.60									
3 (Pilicode local)	77.07	112.20	94.63									
4 (Pusa Sawani)	61.60	111.10	86.35									
5 (Selection 2-2)	42.95	90.90	66.93									
6 (Sevendhari)	37.43	71.13	54.28									
4 x 6	57.37	108.13	82.75	15.65	18.67*	17.68	-6.87	-2.67	-4.86	-6.87	-2.55	-4.86
5 x 2	61.95	98.27	80.11	30.17*	1.37	10.86	18.61	-4.56	3.23	0.57	-11.55	-7.23
5 x 6	51.27	102.17	76.72	27.57	26.10*	26.59	19.37	12.60	14.63	-16.77	-8.04	-11.15
6 x 1	59.93	113.70	86.82	38.85*	33.17**	35.10	22.63	14.12	16.93	-2.71	2.34	0.54
6 x 2	48.30	106.23	77.27	7.76	22.03*	17.18	-7.52	3.17	-0.43	-21.59	-4.38	-10.52
6 x 3	60.17	108.90	84.53	5.10	18.80*	13.53	-21.93*	-2.94	-10.67	-2.32	-1.98	-2.11

	Trial I	Trial II
C.D. I (0.05)	12.47	16.80
C.D. I (0.01)	16.90	22.83
C.D.II (0.05)	14.40	19.40
C.D.II (0.01)	19.57	26.37

* Significant at 5% level

** Significant at 1% level

Table 21. The mean values of parents and hybrids and heterosis in percentage - Number of branches

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	0.43	0.77	0.60									
2 (Kilichundan)	2.07	4.40	3.23									
3 (Pilicode local)	1.97	1.83	1.90									
4 (Pusa Sawani)	1.67	1.13	1.35									
5 (Selection 2-2)	1.67	2.03	1.85									
6 (Sevendhari)	1.53	2.63	2.08									
4 x 6	1.23	2.33	1.78	-20.65	23.94	3.79	-21.56	-11.41	-14.42	-21.66	106.19**	31.85
5 x 2	2.00	2.17	2.08	6.95	-32.50**	-18.11	-3.38	-50.68**	-35.60	27.39	92.04*	54.07
5 x 6	1.93	2.43	2.18	20.63	4.29	10.94	15.57	-7.60	4.81	22.93	115.04**	61.46
6 x 1	1.30	1.47	1.38	32.65	-13.53	2.99	-15.03	-44.11*	-33.65	-17.20	30.09	2.22
6 x 2	2.50	3.40	2.95	38.89*	-3.27	11.11	20.07	-22.73*	-9.67	59.24*	200.88**	118.52
6 x 3	1.73	2.23	1.98	-1.14	0.00	-0.50	-12.18	-15.21	-4.81	10.19	97.35*	46.67

	Trial I	Trial II
C.D.I (0.05)	0.62	0.76
C.D.I (0.01)	0.85	1.04
C.D.II (0.05)	0.72	0.88
C.D.II (0.01)	0.98	1.20

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

the second trial. The standard heterosis displayed by the hybrid 6 x 2 alone was found to be significant in the first trial.

4.4.1.16 Girth of stem

Table 22 presents the mean stem girth of parents and hybrids, relative heterosis, heterobeltiosis and standard heterosis.

In the first trial, none of the hybrids displayed significant heterosis in any of the three types of comparisons. In the second trial, all the hybrids manifested positive heterosis in their comparison with respective mid-parents, better parents and standard cultivar. Only two hybrids, 6 x 2 and 6 x 3 had significant relative heterosis and standard heterosis while none of the hybrids had significant heterobeltiosis.

4.4.1.17 Percentage of fruit set

The mean values of parents and hybrids and the three estimates of heterosis are presented in Table 23.

None of the hybrids exhibited significant heterosis in any of the three types of comparisons in the first trial while one hybrid (6 x 3) exhibited significant negative heterobeltiosis in the second trial. In comparison with the

Table 22. The mean values of parents and hybrids and heterosis in percentage - Girth of stem

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	4.09	5.73	4.91									
2 (Kilichundan)	4.78	7.18	5.98									
3 (Pilicode local)	5.76	6.58	6.17									
4 (Pusa Sawani)	4.54	6.30	5.42									
5 (Selection 2-2)	4.57	6.98	5.78									
6 (Sevendhari)	4.76	5.93	5.35									
4 x 6	4.57	7.13	5.85	-1.72	16.60	8.64	-3.99	13.17	7.93	0.66	13.17	7.93
5 x 2	5.38	7.23	6.31	15.08	2.12	7.31	12.55	0.70	5.52	18.50	14.76	16.42
5 x 6	4.83	7.48	6.16	3.54	15.88	10.69	1.47	7.16	6.57	6.39	18.73	13.65
6 x 1	4.54	6.52	5.53	2.60	11.84	7.80	-4.62	9.95	3.36	0.00	3.49	2.03
6 x 2	4.80	8.33	6.57	0.63	26.98**	15.98	0.42	16.02	9.87	5.73	32.22**	21.22
6 x 3	4.68	7.73	6.21	-11.03	23.48*	7.81	-18.75	17.48	0.65	3.08	22.70*	14.58

	Trial I	Trial II
C.D.I (0.05)	0.73	1.15
C.D.I (0.01)	1.00	1.56
C.D.II (0.05)	0.85	1.32
C.D.II (0.01)	1.15	1.80

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

Table 23. The mean values of parents and hybrids and heterosis in percentage - Percentage of fruit set

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1. (Karingal local)	63.66	68.85	66.26									
2. (Kilichundan)	67.96	63.65	65.81									
3. (Pilicode local)	63.44	72.36	67.90									
4. (Pusa Sawani)	63.26	72.91	68.09									
5. (Selection 2-2)	61.67	57.71	59.69									
6. (Sevendhari)	69.09	61.17	65.13									
4 x 6	67.83	68.90	68.37	2.50	2.77	2.64	-1.82	-5.50	0.41	7.22	-5.50	0.41
5 x 2	62.76	64.08	63.42	-3.17	5.60	1.07	-7.65	0.68	-3.63	-0.79	-12.11	-6.86
5 x 6	67.03	60.24	63.64	2.52	1.35	1.97	-2.98	-1.52	-2.29	5.96	-17.38*	-6.54
6 x 1	67.00	61.78	64.39	0.93	-4.97	1.99	-3.03	-10.27	-2.82	5.91	-15.27*	-5.43
6 x 2	70.16	65.70	67.93	2.39	5.27	3.76	1.55	3.22	3.22	10.91	- 9.89	-0.23
6 x 3	66.37	62.51	64.44	0.16	-6.37	3.12	-3.94	-13.61*	-5.10	4.92	-14.26*	-5.36

	Trial I	Trial II
C.D. I (0.05)	6.39	8.38
C.D. I (0.01)	8.68	11.39
C.D.II (0.05)	7.38	9.67
C.D.II (0.01)	10.02	13.15

* Significant at 5% level

mid-parental value. one hybrid in the first trial and two hybrids in the second trial displayed negative heterosis. Comparison with better parents revealed that only one hybrid (6 x 2) displayed positive heterosis in both the trials. Four hybrids manifested positive standard heterosis in the first trial while none of the hybrids registered positive heterosis in the second trial.

4.4.2 Yellow vein mosaic disease scoring

Table 24 depicts the mean scoring of yellow vein mosaic disease of parents and hybrids and relative heterosis, heterobeltiosis and standard heterosis.

All the hybrids had negative heterosis in comparison with the mid-parental value of which 5 x 2 registered significance. Of the six hybrids, only one hybrid registered positive heterosis in comparison with better parental value and was non-significant. Two hybrids showed significant negative heterobeltiosis with regard to this character. All the hybrids except 6 x 2 manifested negative standard heterosis and all the values were found to be non-significant.

4.4.3 Scoring of fruit and shoot borer infestation

4.4.3.1 Percentage of shoot infestation

The three types of heterosis computed are presented in Table 25.

Table 24. The mean values of parents and hybrids and heterosis in percentage - yellow vein mosaic disease scoring (Trial II)

Parents and hybrids	Mean values	Relative heterosis	Hetero-beltiosis	Standard heterosis
1 (Karingal local)	2.00			
2 (Kilichundan)	3.36			
3 (Pilicode local)	1.98			
4 (Pusa Sawani)	1.52			
5 (Selection 2-2)	1.24			
6 (Sevendhari)	1.28			
4 x 6	1.21	-13.57	-20.39	-20.39
5 x 2	1.21	-47.39**	-63.99**	-20.39
5 x 6	1.54	-22.22	20.31	1.32
6 x 1	1.51	-7.93	-24.50	-0.66
6 x 2	1.76	-24.14	-47.62**	15.79
6 x 3	1.50	-7.98	-24.24	-1.32

C.D. I (0.05) - 0.57
C.D. I (0.01) - 0.77
C.D.II (0.05) - 0.66
C.D.II (0.01) - 0.89

** Significant at 1% level

In comparison with the respective mid-parental values, three and four hybrids in the first and second trials respectively manifested negative relative heterosis. Of the four hybrids which displayed negative relative heterosis in the second trial three were significant. Non-significant negative heterobeltiosis was manifested by all the hybirids except 5 x 2 in the first trial. All the hybrids except 4 x 6 displayed significant negative heterobeltiosis in the second trial. All the hybrids displayed negative standard heterosis in both the trials. Four hybrids had significant standard heterosis in the second trial.

4.4.3.2 Percentage of fruit infestation

Table 26 presents the mean values of parents and hybrids and the three types of hterosis displayed by the hybrids.

In comparison with the mid-parental values, non-significant negative heterosis was displayed by three hybrids in each trial. Significant negative heterobeltiosis was manifested by one and two hybrids in the first and second trials respectively. The hybrid 5 x 2 displayed significant negative heterobeltiosis in both the trials. All the hybrids displayed negative standard heterosis of which one had significant value in the first trial while five hybrids recorded significant values in the second trial.

Table 25. The mean values of parents and hybrids and heterosis in percentage - Percentage of shoot infestation by Earias vitella (Fb.)

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trail II	Pooled
1 (Karingal local)	30.76	34.15	32.46									
2 (Kilichundan)	30.97	35.96	33.47									
3 (Pilicode local)	32.09	35.15	33.62									
4 (Pusa Sawani)	33.67	34.01	33.84									
5 (Selection 2-2)	27.76	27.15	27.46									
6 (Sevendhari)	32.91	30.99	31.95									
4 x 6	31.53	33.10	32.32	-5.29	1.85	-1.75	-6.36	-2.68	-4.49	-6.36	2.66	-4.4
5 x 2	32.56	32.88	32.87	11.30	4.20	7.89	6.10	-0.57*	-1.79	-2.41	-3.32**	-2.3
5 x 6	30.92	28.43	29.68	1.93	-2.18	-0.08	-6.05	-9.33*	-7.11	-8.17	-16.41**	-12.2
6 x 1	32.67	27.03	29.85	2.62	-17.01**	-7.31	-0.73	-20.85**	-8.04	-2.97	-20.52**	-11.7
6 x 2	30.90	30.11	30.55	-3.01	-10.04**	-6.60	-5.86	-16.27**	-8.72	-7.99	-11.47**	-9.7
6 x 3	30.97	27.39	29.18	-4.71	-17.16**	-11.00	-5.89	-22.08**	-13.21	-8.02	-19.46**	13.7

	Trial I	Trial II
C.D. I (0.05)	4.13	2.07
C.D. I (0.01)	5.62	2.81
C.D. II (0.05)	4.77	2.39
C.D. II (0.01)	6.49	3.25

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

Table 26 The mean values of parents and hybrids and heterosis in percentage - Percentage of fruit infestation by Earias vitella (Fb)

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Poole
1 (Karingal local)	9.63	9.24	9.44									
2 (Kilichundan)	7.97	6.62	7.30									
3 (Pilicode local)	10.08	9.71	9.90									
4 (Pusa Sawani)	10.29	9.79	10.04									
5 (Selection 2-2)	6.74	6.21	6.48									
6 (Sevendhari)	7.11	5.53	6.32									
4 x 6	7.37	6.99	7.18	-15.29	-8.75	-12.22	-28.38*	-28.50*	-28.49	-28.38*	-28.60*	-28.4
5 x 2	7.77	5.26	6.52	5.64	-18.00	-5.37	-2.51	-20.54	-10.68	-24.49*	-46.27**	-35.0
5 x 6	8.47	7.39	7.93	22.22	25.89	23.90	19.13	19.00	22.38	-17.69	-24.51*	-21.0
6 x 1	8.25	7.91	8.08	-1.43	7.04	2.54	-14.33	-14.39	-14.41	-19.83	-19.20	-19.5
6 x 2	9.31	6.65	7.98	23.47	9.47	17.18	16.81	0.45	9.32	-9.52	-32.07**	-20.5
6 x 3	8.03	6.70	7.35	-6.57	-12.07	-9.37	-20.34	-31.00*	-25.76	-21.96	-31.56**	-26.7

	Trial I	Trial II
C.D. I (0.05)	2.05	1.94
C.D. I (0.01)	2.78	2.64
C.D.II (0.05)	2.36	2.24
C.D.II (0.01)	3.21	3.04

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

4.4.4 Crude fibre content

Table 27 presents the three estimates of heterosis displayed by the hybrids.

In the first trial, only one hybrid (5 x 6) displayed negative relative heterosis. Four hybrids displayed negative relative heterosis in the second trial of which the value for 6 x 3 alone was significant. Of the four hybrids that displayed negative heterobeltiosis in the first trial, one hybrid (5 x 6) had significant heterosis. All the hybrids manifested negative heterobeltiosis in the second trial of which two were significant. In comparison with the standard cultivar, only one hybrid (5 x 2) displayed significant negative heterosis in the first trial. All the hybrids except 4 x 6 manifested significant negative standard heterosis in the second trial.

Table 27. The mean values of parents and hybrids and heterosis in percentage – Crude fibre content

Parents and hybrids	Mean values			Relative heterosis			Heterobeltiosis			Standard heterosis		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
1 (Karingal local)	1.43	1.38	1.40									
2 (Kilichundan)	1.16	1.16	1.16									
3 (Pilicode local)	1.24	1.32	1.28									
4 (Pusa Sawani)	1.38	1.46	1.42									
5 (Selection 2-2)	1.17	1.10	1.14									
6 (Sevendhari)	1.43	1.36	1.39									
4 x 6	1.42	1.45	1.46	1.07	2.84	3.91	-0.70	-0.68	2.82	2.90	-0.68	2.82
5 x 2	1.16	1.14	1.15	0.43	0.88	0.00	0.85	-1.72	-0.86	-15.94**	-21.92**	-19.01
5 x 6	1.26	1.15	1.21	-3.08	-6.50	-4.35	-11.85**	-15.44*	-12.95	-8.70	-21.23**	-14.79
6 x 1	1.46	1.30	1.38	2.10	-5.11	-1.08	2.10	-5.80	-1.43	5.80	-10.96*	-2.82
6 x 2	1.41	1.24	1.32	8.46**	-1.59	3.52	-1.40	-8.82	-5.04	2.17	-15.07*	-7.04
6 x 3	1.42	1.19	1.31	6.37*	-11.20*	1.87	-0.70	-12.50	-5.76	2.90	-18.49*	-7.75

	Trial I	Trial II
C.D.I (0.05)	0.05	0.15
C.D.I (0.01)	0.06	0.20
C.D.II (0.05)	0.05	0.17
C.D.II (0.01)	0.07	0.23

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

DISCUSSION

5 DISCUSSION

Bhindi (Abelmoschus esculentus (L.)Moench) is extensively cultivated in all parts of the country round the year. Inspite of its popularity, research on this crop is meagre compared to the study made in other common vegetable crops. Bhindi was reported to respond well to breeding efforts (Martin and Ruberte, 1978). A wide spectrum of variation exists in this crop, as such the scope for genetic improvement is immense.

Improvement in yield is generally dependent on many component characters which are simple in inheritance. A study of the correlation provides an idea of the simple characters that could effectively be used in selection of ideal plant types. Yield being a complex quantitative character is controlled by polygenic system. The basic genetic information on paramount genetic parameters like coefficient of variation, heritability and genetic advance are essential prerequisites in any breeding programme. In the present work, efforts were made to elucidate these genetic aspects for future breeding programmes in okra.

The cross pollination in bhindi is reported to vary from 40.0 to 31.7 per cent (Venkataramani, 1953) while Martin (1983) reported an outcrossing range of 11.80-60.00 per cent and as such the cultivated varieties are expected

to be somewhat heterozygous inspite of observed uniformity. Hence there is ample scope for the exploitation of heterosis. Evidences on the manifestation of hybrid vigour with respect to the various economic characters have been advocated by many earlier workers. The floral biology enhances easy emasculation and pollination, besides being able to produce large number of seeds in single pollination. This enables the commercial utilization of hybrid vigour in bhindi.

Research in vegetable crops is directed towards the production of not only high yielding types but also those of the best quality. Crude fibre determines the edibility of bhindi fruits and the consumers preference largely depends on it. But crop improvement works on this aspect is meagre.

Yellow vein mosaic of okra is the most destructive virus disease infecting at all the stages of growth of this crop. Fruit and shoot borer is the major insect pests of bhindi that causes serious damage to the crop. A genotype with lesser incidence of these dreadful disease and pest would be more welcome in enhancing the production as well as the quality of fruits.

With these objectives in view the present work was undertaken to identify bhindi hybrids which will go a long way in enhancing the yield potential of this crop.

Six top ranking F_1 combinations were selected based on the works of Balachandran (1984). The parents of these hybrids were selfed for one generation and crossed. The six hybrids and their six parents were evaluated in an RBD with three replications in two trials. First and second trials were conducted during January - April (1985) and April- July (1985) respectively. Observations on yield and its components were recorded. Chemical assay was conducted to evaluate the quality of the hybrids. Scoring of yellow vein mosaic disease was done in the second trial only since there was no field incidence of the disease in the first trial. The damage caused by fruit and shoot borer was recorded in both the trials. The data were statistically analysed for the estimation of genetic parameters, association between characters and different types of heterosis with respect to the important economic attributes.

The results of the investigation are discussed in the succeeding pages.

5.1 ANALYSIS OF VARIANCE

The data for individual trials and pooled performance were analysed with respect to the twenty characters studied.

The analysis of variance with respect to days to flower revealed significant differences among the genotypes. There was significant influence of environment on this

character as indicated by pooled analysis and was in conformity with the findings of Rao and Kulkarni (1977). The variability with respect to this character was also reported by many earlier workers (Lal et al., 1977; Singh and Singh, 1978b and Singh and Singh, 1979a).

Significant treatment difference was noticed with respect to first fruiting node in both the trials as earlier recorded by Singh and Singh (1978b). Since the genotype X environment interaction was not found to be significant, it can be presumed that the environment has no influence on the first fruiting node. Mean leaf area also recorded the same trend.

Significant variability was noticed for number of fruits per plant as recorded by many earlier workers (Singh and Singh, 1978a; Kaul et al., 1979; Singh and Singh, 1979a and Murthy and Bavaji, 1980). The hybrid Selection 2-2 X Kilichundan produced maximum number of fruits and was observed to be stable in performance in the two trials while Sevendhari X Pilicode local and Sevendhari X Kilichundan ranked second in the first and second trials respectively. In the first trial, eventhough Sevendhari X Pilicode local had second position. Sevendhari X Kilichundan was on par with the former.

Significant treatment differences were recorded in the analysis of variance for the number of fruits on the main stem in both the trials and for the number of fruits on branches in the second trial. Although total number of fruits displayed consistency in performance in both the trials, the number of fruits on the main stem and branches showed environmental influence. The decrease in the number of fruits on the main stem was compensated by more number of fruits on the branches keeping the total number of fruits constant. The hybrids Selection 2-2 X Kilichundan and Sevendhari X Kilichundan possessed maximum number of fruits on main stem and branches respectively which accounted for their superiority in yield.

The analysis of variance revealed significant variability for length of fruit. Variability in fruit length was also reported by many earlier workers (Trivedi and Prakash, 1969; Lal et al., 1977; Singh and Singh, 1978b; Murthy and Bavaji, 1980; Parthap et al., 1980 and Balachandran, 1984). Pooled analysis indicated non-significant genotype X environment interaction denoting absence of environmental influence on the length of fruits, contrary to the findings of Rao (1972 The high yielding hybrids Selection 2-2 X Kilichundan and Sevendhari X Kilichundan ranked first and second respectively with respect to this character.

Girth of fruit showed significant variability in the second trial only. Pooled analysis revealed the absence of stability for this character. The fruits of the second best hybrid of the study ie., Sevendhari X Kilichundan possessed maximum girth.

Regarding the weight of single fruit, significant variability was not observed among the genotypes in contrary to the findings of Balachandran (1984). But the weight of fruits per plant registered significant variability in both the trials. This supports the views of many earlier workers (Singh and Singh, 1978b; Kaul et al., 1979; Murthy and Bavaji, 1980 and Balachandran, 1984). Pooled analysis indicated significant influence of environment on this character. This may be attributed to the complex polygenic system operating on the inheritance of this character. The present study could identify two high yielding hybrids namely Selection 2-2 Kilichundan and Sevendhari X Kilichundan. The hybrid Selection 2-2 X Kilichundan ranked first in both the trials while Sevendhari X Pilicode local and Sevendhari X Kilichundan stood second in the first and second trials respectively. Pooled analysis unveiled Sevendhari X Kilichundan as the secon high yielding hybrid.

As regards the number of seeds per fruit, significant variability was displayed in both the trials and the character was found to be less influenced by the environment.

The same result was obtained for number of ridges per fruit also. This finding differs from the views of Vashistha et al. (1982). The hybrids were found to be intermediate with regard to this character.

Significant variability was noticed for number of flowers per plant in both the trials in conformity with the findings of Balachandran (1984). The genotype x environment interaction was found to be non-significant and hence the genotypes were stable in performance with respect to this character. The hybrid Selection 2-2 x Kilichundan had maximum number of flowers in both the trials indicating its marked superiority over other genotypes.

Fruiting phase also displayed significant variation. The pooled analysis indicated significant environmental influence on this character. The hybrid Selection 2-2 x Kilichundan recorded maximum fruiting phase in both the trials.

Marked variability was noticed among the genotypes in both the trials with respect to height of plant. Singh and Singh (1978b) and Balachandran (1984) also recorded significant variability for this character. The pooled analysis indicated that the varieties were stable in performance with regard to this character. Number of branches also displayed marked varietal diversity in both the trials. Singh and Singh (1978a), Singh and Singh (1978b) and Balachandran (1984)

also reported the same results. But there was little stability in performance as the genotype X environmental interaction was found to be significant.

Significant variability along with stability was observed for number of non-bearing nodes per plant and girth of stem. But opposite result was obtained for percentage of fruitset in contrary to the findings of Balachandran (1984). Hence it can be presumed that percentage of fruitset vary from season to season.

The genotypes differed significantly in the intensity of yellow vein mosaic disease. The hybrids Selection 2-2 X Kilichundan and Pusa Sawani X Sevendhari were found to be less affected by the disease.

The analysis of variance revealed significant variability in the percentage of shoot and fruit infested plants only in the first trial. The genotype X environment influence was found to be significant. Hence the genotypes responded differentially to the incidence of this pest in the two trials

Crude fibre content exhibited significant variability among the genotypes in both the trials as reported by Maurya et al. (1978). But it differs from the findings of Kakar (1976) and Balachandran (1984). The range of variation was narrow for this important quality attribute in agreement with the findings of Elangovan et al. (1983). Environmental

influence was found to be significant. The comparison of the pooled means revealed that the hybrid Selection 2-2 X Kilichundan ranked first which produced quality pods with low fibre content.

5.2 GENETIC PARAMETERS

5.2.1 Yield and its components

The genotypic coefficient of variation was slightly higher than the environmental coefficient of variation for yield in both the trials indicating that environment influenced the inheritance of the character to a lesser degree. This gave moderate to high heritability for yield. The relatively high genotypic coefficient of variation observed for yield was in conformity with the reports of Majumdar et al (1974), Kaul et al. (1979), Mishra and Chhonkar (1979) and Thaker et al. (1981). Moderately high heritability and genetic advance was also reported by Rao et al. (1977) and Murthy and Bavaji (1980). But the present finding differ from the views of Lal et al. (1977) and Balachandran (1984) who reported low estimates of heritability for yield.

The genotypic coefficient of variation was low but slightly higher than the environmental coefficient of variation for number of fruits which accounts for the high heritability and moderate genetic advance of the character. This

indicates additive gene action and was in agreement with the findings of Majumdar et al. (1974), Rao and Kulkarni (1977), Rao and Sathyavathy (1977), Rao et al.(1977), Mahajan and Sharma (1979), Mishra and Chhonkar (1979) and Vashistha(1982) whereas Parthap et al. (1982) and Balachandran (1984) reported low heritability for this character.

Moderate to high heritability was observed for days to flower and fruiting phase in both the trials. But the valu for genetic advance was low. High heritability associated with low genetic advance may be attributed to the predominance of non-additive gene action which includes epistasis and dominance as suggested by Liang et al.(1972). Rao (1972), Lal et al.(1977), Rao and Sathyavathy (1977) Rao et al.(1977) Parthap et al. (1980); Rao (1980) Parthap et al.(1982) and Balachandran (1984) also reported high heritability for days to flower. Rao (1972) and Rao (1980) reported high genetic advance for days to flower while Rao and Sathyavathy (1977) ; Murthy and Bavaji (1980) and Balachandran (1984) reported low estimates of genetic advance for this character in conformity with the present finding indicating non-additive gene action. Balachandran (1984) observed low genetic advance for fruiting phase also. Hence heterosis breeding is the ideal method for the improvement of these characters.

The genotypic coefficients of variation of length and girth of fruits were higher than the respective environmental coefficients of variation in the second trial. The environmental variation was found to be much pronounced in the first trial which has resulted in low heritability. However high heritability was observed for these characters in the second trial. The genetic advance was low in both the trials. These results indicate that the length and girth of fru of bhindi were governed by non-additive gene action. Trivedi and Prakash (1969), Singh et al. (1974), Mahajan and Sharma (1979) and Parthap et al. (1980) reported high heritability and genetic advance for these two characters. Balachandran (1984) observed moderate heritability and low genetic advance for length and girth of fruit. Low genetic advance for girth of fruit was also reported by Lal et al. (1977) in agreement with the present finding.

The environmental coefficient of variation was much higher than the genotypic coefficient of variation for weight of single fruit in both the trials indicating pronounced influence of environment on this character. This gave a low heritability and genetic advance for this character. Hence non-additive gene action governs the inheritance of this character. Low heritability for weight of single fruit was reported by Padda et al. (1970), Mishra and Chhonkar (1979),

Murthy and Bavaji (1980), Thaker et al., (1981) and Balachandran (1984) in agreement with the present finding. Singh et al., (1974) also reported low genetic advance for weight of single fruit. However high genetic advance for this character was reported by Thaker et al. (1981).

Height of plant registered moderate heritability and low genetic advance in the present study in conformity with the findings of Thaker et al. (1981) and Balachandran (1984). Trivedi and Prakash (1969), Rao (1972), Ngah and Graham (1973) Rao et al. (1977), Mishra and Chhonkar (1979), Murthy and Bavaji (1980), Rao (1980), Palaniveluchamy (1982) and Vashistha (1982) reported high heritability whereas Rao and Sathyavathy (1977) observed low heritability for this character.

Moderate to low heritability was observed for leaf area in the present study in agreement with the findings of Thaker et al. (1981). Moderate to high heritability and genetic advance were observed for number of branches per plant in the present study in conformity with the findings of Mishra and Chhonkar (1979) and Balachandran (1984) indicating additive gene action. Low heritability and genetic advance were observed for girth of stem and percentage of fruit set indicating non-additive gene action. Hence there is greater possibility of heterosis breeding in enhancing the production potential of the crop.

5.2.2 Yellow vein mosaic disease

High values of both phenotypic and genotypic coefficient of variation indicated broad spectrum of variation for the character. Further high heritability and genetic advance indicated additive gene action. Environmental influence was found to be less. Hence susceptible plants could be identified in subsequent generations and resistant types isolated. This was in agreement with the reports of Padda et al. (1970), Kaul et al. (1979) and Mishra and Chhonkar (1979). The observations differed from the views of Parthap et al. (1982) who observed non-additive inheritance for resistance to yellow vein mosaic disease.

5.2.3 Fruit and shoot borer infestation

Fruit and shoot infestation displayed lower estimates of coefficients of variation indicating very little variability of the trait. Heritability for percentage of shoot infested plants was low in first trial whereas the same was high in the second trial which may be attributed to the difference in the intensity of pest population. Lower estimates of heritability and genetic advance were recorded for percentage of fruit infested plants stressing its non-additive inheritance.

5.2.4 Crude fibre content

The genotypic coefficient of variation was higher than the environmental coefficients of variation indicating lesser

influence of environment on this trait. This character registered moderate to high heritability and low genetic advance. High heritability for this attribute was also reported by Singh et al. (1974). However, Parthap et al.(1982) and Balachandran (1984) reported contrary views. Low genetic advance was also observed by Balachandran (1984) in conformity with the present finding.

5.3. Correlation studies

Yield was found to have significant positive correlation with number of fruits per plant, number of branches, length, weight and girth of single fruit, total number of flowers, fruiting phase, number of seeds per fruit and girth of stem. This association was supported by the results of many earlier workers.

The direct association of yield with number of fruits per plant was in conformity with the findings of Kohle and Chavan (1967), Martha Mary (1969); Singh et al.(1974), Roy and Chhonkar (1976), Rao et al. (1977), Korla and Rastogi (1978), Singh and Singh (1978a), Singh and Singh (1978b), Ajimal et al. (1979), Mahajan and Sharma (1979); Parthap et al (1979), Singh and Singh (1979b); Elangovan et al. (1980); Murthy and Bavaji (1980); Arumugham and Muthukrishnan (1981) and Balachandran (1984).

Positive association of number of branches to total yield was in agreement with the views of Singh et al.(1974), Roy and Chhonkar (1976) and Elangovan et al.(1980) and was contrary to the findings of Balachandran (1984). The number of branches per plant also have significant positive correlation with other important yield components such as number of fruits per plant, total number of flowers per plant, length of fruit, girth of stem and fruiting phase. Eventhough branched types had more number of non-bearing nodes the increase in the total number of fruits compensated the total yield.

Yield was found to be positively associated with weight of single fruit in agreement with the findings of Thamburaj and Kamalanathan (1973), Singh et al. (1974) and Parthap et al. (1979). Length of fruit had direct positive correlation with weight of fruit. As such long fruits with increased weight have a direct bearing in augmenting total yield. Kohle and Chavan (1967); Martha Mary (1969); Singh and Singh (1979b), Mahajan and Sharma (1979), Parthap et al. (1979), Singh and Singh (1979b), Elangovan and Muthukrishnan (1981) and Balachandran (1984) have also reported significant positive correlation between yield and length of fruit in agreement with the present finding. Length was also directly correlated with the major yield components such as total number of flowers per plant, number of fruits per plant, girth and weight of single fruit and girth of stem. Tall genotypes were observed to produce long fruits.

Yield was also found to be enhanced by the increase in the girth of fruit, which was in conformity with the observations of Kohle and Chavan (1967), Martha Mary (1969) and Elangovan et al. (1980) while Balachandran (1984) observed negative correlation between yield and girth of fruit. Tall plants were found to produce fruits with reasonable thickness. Increase in girth also influenced the length of fruit and number of seeds per fruit.

Significant positive correlation was observed between total number of flowers and yield in accordance with the results of Singh et al.(1974) and Parthap et al. (1979). Increase in the number of flowers was also associated with increase in the number of branches, length of fruit and fruiting phase. Negative association was observed for total number of flowers with first fruiting node and number of non-bearing nodes. The plants with less number of non-bearing nodes and fruiting on the lowest node were found to produce more number of flowers. An increase in the total number of flowers was associated with decrease in the girth and weight of single fruit. Increase in the duration of fruiting was positively associated with increase in the weight of fruits per plant, number of fruits per plant, number of branches, total number of flowers and number of seeds per fruit. Branching types were found to have longer fruiting phase. This may be attributed to the production of fruits on the

branches even after the completion of fruiting on the main stem.

Girth of stem was also identified as a major yield component confirmed by the observations of Parthap et al. (1979). This differed from the findings of Balachandran (1984) who reported a negative association of girth of stem and yield. Increase in the girth of stem may be an indication of the vigour of plant. Tall and branching types were found to have thicker stem. Increase in stem thickness was associated with increase in leaf area and length of fruits.

Non-significant positive correlation was observed between yield and height of plant as reported by Elangovan et al (1980) and Arumugham and Muthukrishnan (1981). But significant positive correlation between height and yield of plant was reported by many earlier workers (Martha Mary, 1969; Rao and Ramu, 1975; Kewthalker and Kunte, 1978; Rao and Kulkarni, 1978; Singh and Singh, 1978b; Mahajan and Sharma, 1979 and Singh and Singh 1979b). This differs from the results recorded by Balachandran (1984).

The present study indicated that branching types produce fruits with less fibre content. Long heavy fruits had good quality with less fibre content in conformity with the findings of Balachandran (1984). Moreover increase in the girth of stem and mean leaf area were also associated with

decrease in fibre content. Non-significant negative correlation was observed between yield and crude fibre content.

Correlation studies revealed that medium tall branching types having increased stem girth producing large number of long thick and heavy fruits constitute the ideal plant type of bhindi for enhancing the yield and quality of fruits.

5.4 HETEROSIS

The term heterosis, as is now widely used, refers to the phenomenon in which the F_1 population obtained by crossing of the two genetically dissimilar gametes or individuals show increased or decreased vigour over the better parent or over the standard cultivar or over the mid-parental value. Heterosis in major vegetable crops has been advocated by many earlier workers. The superiority of the hybrids of judiciously selected parents is expressed in higher, early and total yield, uniformity, environmental adaptation, resistance to disease and insect pests, nutritional and processing qualities and organo-leptic preference. Although heterosis has been reported as early as 1938 in bhindi, the hybrids have not yet become popular in this crop.

In the present investigation of evaluation of hybrids in bhindi all the hybrids displayed desirable heterosis in the three types of comparisons for the major economic characters. Majority of the hybrids had desirable heterosis in most of the characters studied. Negative heterosis was exhibited by the hybrids for the characters such as fruit and shoot borer infestations and yellow vein mosaic incidence indicating the magnitude of resistance of the hybrids to these two constraints of yield. Majority of the hybrids had negative heterosis for crude fibre content.

5.4.1 Yield and its components

Majority of the hybrids had negative heterosis for days to flower revealing that the hybrids were earlier in flowering. Raman (1965), Mathews (1966), Jalani and Graham (1973), Kulkarni and Virupakashappa (1977), Rao and Kulkarni (1977), Rao (1978), Sharma and Mahajan (1978), and Elmaksoud et al. (1984) also reported the earliness in bhindi hybrids. This differs from the views of Isack (1965) who opined that the hybrids do not possess significant heterosis for this character. The highest yielding hybrid Selection 2-2 X Kilichundan was found to be the earliest in flowering in the present study.

All the hybrids except Selection 2-2 X Sevendhari possessed desirable standard heterosis for first fruiting node in conformity with the findings of Singh et al.(1975), Singh and Singh (1978b) and Elangovan et al. (1981). The hybrid Sevendhari X Pilicode local was found to be fruiting at the lowest node.

All the six hybrids displayed desirable heterosis in the three types of comparisons for number of fruits per plant, the most important yield component. Maximum heterosis for this attribute was displayed by the hybrid Selection 2-2 X Kilichundan followed by Sevendhari X Kilichundan. The hybrid Selection 2-2 X Kilichundan exhibited significant heterobeltiosis and relative heterosis for the character in both the trials. The highest yielding hybrids Selection 2-2 X Kilichundan and Sevendhari X Kilichundan had registered a standard heterosis as high as 35.36 per cent in the second trial. This was in agreement with the views of many earlier workers (Joshi et al., 1958; Rao and Giriraj, 1974; Lal et al., 1975; Kulkarni and Virupakshappa, 1977; Rao and Kulkarni, 1977; Singh and Singh, 1979c; Parthap and Dhankar, 1980; Thaker et al., 1982; and Balachandran, 1984).

Positive heterosis was manifested by all the six hybrids in the three types of comparisons for yield per plant. The extent of standard heterosis was as high as

65.06 per cent (Selection 2-2 X Kilichundan) followed by 50.34 per cent (Sevendhari X Kilichundan). The hybrid Selection 2-2 X Kilichundan was found to be top-ranking which displayed significant heterosis in the three types of comparisons in both the trials. Except Sevendhari X Karingal local, all the other hybrids recorded significant standard heterosis in both the trials. The higher yield of hybrids may be asserted to the increased number of fruits produced by the hybrids over their parents. These findings support the views of Venkataramani (1952), Joshy et al. (1958), Jalani and Graham (1973), Lal and Srivastava (1973), Rao and Giriraj (1974), Lal et al.(1975), Singh et al (1977), Sharma and Mahajan (1978), Singh and Singh (1979c), Parthap and Dhankar (1980), Elangovan et al. (1981), Thaker et al. (1982) and Balachandran (1984).

Majority of the hybrids displayed positive heterosis for the important fruit characters such as length, girth and weight. The maximum amount of standard heterosis was manifested by the hybrid Selection 2-2 X Kilichundan for weight and length whereas for girth of fruit, maximum standard heterosis was recorded by Sevendhari X Kilichundan. The enhancement in the weight of single fruit due to hybrid vigour was also observed by Joshy et al. (1958), Raman (1965) Sharma and Mahajan (1978) and Elmaksoud et al. (1984). Positive heterosis was manifested by the hybrids for length of fruit as recorded by Joshy et al. (1953), Lal and

Srivastava (1978), Parthap and Dhankar (1980), Thaker et al. (1982), Balachandran (1984) and Elmakeoud et al. (1984). Selection 2-2 X Kilichundan had maximum standard heterosis (25.6 per cent) followed by Sevendhari X Kilichundan (24.97 per cent), both had one common parent namely Kilichundan which had the longest fruit among the parent cultivars. With respect to girth of fruit two hybrids registered significant standard heterosis in both the trials. This was in conformity with the findings of Isack (1965), Lal et al. (1975), Singh et al. (1975) and Elangovan et al. (1981). The length and girth had direct bearing on weight of fruit. Majority of the hybrids registered an enhancement in length and girth of fruit which consequently contributed an increase in individual fruit weight and total yield.

All the six hybrids had positive relative heterosis for height while fifty per cent of the hybrids displayed negative heterobeltiosis in both the trials. All the hybrids except Sevendhari X Karingal local had negative standard heterosis. This revealed that most of the hybrids were shorter in stature than the taller parent and the standard cultivar, Pusa Sawani. This finding was in conformity with the views of Venkataramani (1952) and Isack (1965). But this differs from the findings of Joshy et al. (1958), Jalani and Graham (1973), Lal and Srivastava (1973), Lal et al. (1975), Singh et al. (1975), Kulkarni and

Virupakeshappa (1977), Rao and Kulkarni (1977), Singh et al. (1977), Singh and Singh (1978), Elangovan et al. (1981) and Elmeksoud et al. (1984) who recorded significant increase in the height of the hybrids over their parents.

Positive heterosis for the hybrids over the standard cultivar was observed in both the trials for the number of branches per plant. Majority of the hybrids registered positive relative heterosis where as all the hybrids except Selection 2-2 X Sevendhari had negative heterobeltiosis. This indicated that the hybrids were almost intermediate in branching character. The magnitude and direction of heterosi varied from season to season. Hence this character was presumed to be highly influenced by the environment. The hybrid Sevendhari X Kilichundan had significant heterosis in both the trials. The magnitude of standard heterosis manifested by the Sevendhari X Kilichundan was as high as 200.88 per cent and the parents of this hybrid were highly branching when compared to other parent cultivars. The hybrids Selection 2-2 X Kilichundan and Selection 2-2 x Sevendhari were also found to be branching types. Joshi et a (1958), Lal and Srivastava (1973) and Elangovan et al. (1981) also reported increase in the number of branches of the hybrids in agreement with the present finding.

The hybrids had very little non-bearing nodes than th parents. Positive heterosis was displayed by the hybrids for

number of flowers per plant in conformity with the reports of Isack (1965). This increased number of flowers produced by the hybrids had led to increased fruit yield in the hybrids. However, the hybrids displayed low heterosis for percentage of fruit set. By better management practices the percentage of fruit set of the hybrids can be enhanced. This points towards the possibility of augmenting the yield potential by adopting better manurial and irrigation practices.

As regards the fruting phase, positive heterosis was manifested by all the hybrids in the first trial where as all the hybrids except two had negative heterobeltiosis and standard heterosis in the second trial. This revealed the influence of environment on the magnitude of heterosis of this character. Among the hybrids Selection 2-2 X Kilichundan recorded maximum positive heterosis revealing its marked superiority over other hybrids.

In general the hybrids were found to possess increased leaf area over their parents. This may be due to the vegetative vigour expressed by the hybrids resulting from their heterozygous nature. The hybrid Selection 2-2 X Kilichundan displayed 37.45 per cent heterosis over the standard cultivar. Since yield was positively correlated with mean leaf area this was obviously an important attribute of the hybrid.

Majority of the hybrids manifested positive heterosis for girth of stem, an important yield component, which was also an indication of the vigour of the hybrid.

5.4.2 Resistance to yellow vein mosaic disease

All the hybrids possessed negative heterosis for yellow vein mosaic disease scoring of which the value registered for Selection 2-2 X Kilichundan was found to be significant. Majority of the hybrids also registered negative heterobeltiosis and standard heterosis which revealed the decreased susceptability of the hybrids to this dreadful disease when compared to the better parents and standard cultivar, Pusa Sawani. This was in conformity with the report of Parthap et al. (1961).

5.4.3 Resistance to fruit and shoot borer (Earias vitella (Fb.

Majority of the hybrids displayed negative heterosis in the three types of comparisons in both the trials which indicated the decreased susceptibility of hybrids to this major pest of okra when compared to the parent cultivars. The negative heterobeltiosis and standard heterosis registered by the hybrids Selection 2-2 X Kilichundan and Pusa Sawani X Sevendhari were found to be significant suggesting their marked superiority.

5.4.4 Crude fibre content

Majority of the hybrids manifested negative heterosis for this character. Marked decrease was observed in the crude fibre content of Selection 2-2 X Kilichundan over the standard cultivar, Pusa Sawani, in both the trials. The present findings indicate that the hybrids are not only high yielding but also produce fruits with high quality. The findings were in conformity with the views of Parthap et al. (1983), Elangovan et al.(1983) and Balachandran (1984).

The present study could identify two hybrids with high yield potential coupled with other desirable attributes. Among the twenty characters studied the hybrid Selection 2-2 X Kilichundan ranked first in ten characters. The hybrids Selection 2-2 X Kilichundan and Sevendheri X Kilichundan had outyielded the standard cultivar by 65.06 per cent and 50.34 per cent respectively.

The hybrid Selection 2-2 X Kilichundan had large number (22) of long (19.28 cm) fruits with good thickness (6.50 cm) and weight (25.21 gm). It is a branching type with large leaves (205.72 cm^2) and medium stature (80.10 cm). It was earlier in fruiting with long fruiting phase (45 days) and produced an average yield of 564.18 gm/plant. The fruits are of good quality with less fibre content (1.15 per cent). The hybrid was also found to be less susceptible to yellow vein mosaic disease under the field

conditions. This hybrid ranked first in both the trials indicating stability in performance.

Sevendhari x Kilichundan was identified as the second ranking hybrid in the present study which had an average yield of 513.86 gm/plant. It is a highly branching type with large lobed leaves and medium height. This hybrid also produced large number (22) of long (19.17 cm) heavy (23.2 gm) fruit with reasonable thickness (6.93 cm) and low crude fibre content (1.32 per cent).

A better management practice with a manure schedule in maximum frequencies with less intervals may further enhance the yield potential of these hybrids.

The performance of the hybrids would be better in the kitchen gardens where better management could be given. The reproductive potential of the crop being much higher, is an added advantage, which along with the above mentioned attributes of the hybrids make them suitable for commercial cultivation.

SUMMARY

6 SUMMARY

Lack of production potential of the indigenous varieties is one of the major constraints in vegetable production. With a view to evolve high yielding hybrids of Bhindi having enhanced production coupled with quality attributes, a study was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani during 1983-1985.

Six top-ranking F_1 combinations were selected based on the works of Balachandran (1984). The parents of these hybrids were selfed for one generation and crossed. The six hybrids and their six parents were evaluated in an RBD with three replications in two trials. First and second trials were conducted during January - April (1985) and April- July (1985) respectively. Ten plants from a treatment in replication were randomly selected for recording observations on yield and its component characters. Scoring of yellow vein mosaic disease and fruit and shoot borer incidence were recorded. Chemical assay was done to estimate the crude fibre content of the genotypes. The data were statistically analysed for the estimation of genetic parameters, associations between different pairs of characters and different types of heterosis with respect to the various characters studied. Pusa Sawani, the most popular bhindi

cultivar was taken as the standard. The salient results of the study are summarised below.

6.1 Analysis of variance

The data relating to individual trials were analysed with respect to the twenty characters studied. Pooled analysis was done to test the genotype x environment interaction. Significant variability was observed in both the trials for majority of the characters including fruit yield per plant. In both the trials, the treatment differences were non-significant for two characters namely weight of single fruit and percentage of fruit set. Error variances were found to be heterogeneous with respect to eleven characters studied including fruit yield per plant and weighted analysis was done in such cases to study the combined performance of the genotypes. Significant genotype x environment interaction was observed in case of ten characters studied.

Comparison of the treatment means revealed that the hybrid Selection 2-2 x Kilichundan (5 x 2) ranked first in majority of the characters studied including yield and number of fruits per plant. Sevendhari x Kilichundan (6 x 2) was observed to be the second best hybrid under study.

6.2 Genetic parameters

The genotypic coefficient of variation was slightly higher than the environmental coefficient of variation for yield and its major component number of fruits per plant in both the trials. This gave higher heritability for these characters. The phenotypic coefficient of variation was minimum for days to flower and fruiting phase in the first and second trials respectively. High heritability associated with low genetic advance of these characters may be because of non-additive gene action which includes dominance and epistasis. Relatively high environmental coefficient of variation was recorded for number of fruits on branches, weight of single fruit, girth of stem and percentage of fruit set which resulted in low heritability and genetic advance indicating non-additive gene action. High heritability was recorded for yellow vein mosaic disease incidence and crude fibre content. However genetic advance was low for crude fibre content in both the trials.

These observations provide ample testimony to the fact that heterosis breeding could be successfully employed to augment the production potential of this crop.

6.3 Correlation

Yield was found to have significant positive correlation with number of fruits per plant, number of branches,

length girth and weight of single fruit, total number of flowers, fruiting phase, number of seeds per fruit and girth of stem. Branching types produced long and heavy fruits with less fibre content. Correlation studies revealed that medium tall branching types with increased stem girth and producing large number of long thick and heavy fruits constitute the ideal plant type of bhindi for enhancing the yield and quality of fruits.

6.4 Heterosis

All the hybrids displayed desirable heterosis in the three types of comparisons for the major economic characters such as yield, number of fruits per plant etc. in both the trials. Negative heterosis was exhibited by the hybrids for the characters such as crude fibre content, fruit and shoot borer infestation and yellow vein mosaic disease incidence.

The present study could identify two hybrids Selection 2-2 X Kilichundan (5 x 2) and Sevendhari X Kilichundan (6 x 2) with high yield potential coupled with other desirable attributes. The hybrids Selection 2-2 x Kilichundan and Sevendhari X Kilichundan have outyielded the standard cultivar, Pusa Sawani, by 65.05 per cent and 50.34 per cent respectively. These hybrids produced large number of long heavy fruits with good thickness and low

crude fibre content in both the trials.

Maximum extent of desirable heterosis was displayed by Selection 2-2 X Kilichundan in both the trials and was given the first rank among the hybrids. This hybrid had an average yield of 564.18 gm/plant and was also found to be less susceptible to yellow vein mosaic disease under field conditions when compared to its highly susceptible male parent, Kilichundan. The hybrid Sevendhari X Kilichundan recorded an average yield of 513.86 gm/plant and was given the second rank among the hybrids.

The studies indicated the scope of heterosis breeding programme in augmenting the yield potential of bhindi, one of the most important vegetable crops of Kerala. Further, the easy technique of emasculation and the high reproductive potential of the crop enables the farmer to produce the required amount of seed easily.

The new hybrids (Selection 2-2 X Kilichundan and Sevendhari X Kilichundan) could be grown in kitchen gardens with good management practices for the maximum exploitation of their yield potential. These hybrids were ideal for homestead cultivation and commercial cultivation, as well.

REFERENCES

REFERENCES

Ajimal, M.R., Rattan, R.S. and Saini, S.S. 1979. Correlation and path coefficient analysis in okra. (*Abelmoschus esculentus* (L.) Moench). *Haryana J. Hortic. Sci.* 8: 58-63.

*Akram, M., Shafi, M. and Khan, D.A. 1973. Heterosis in okra (*Hibiscus esculentus* L.) *Journal of Agricultural Research, Pakistan* 11: 84-95.

Allard, R.W. 1960. *Principles of Plant Breeding*. John Wiley & Sons, New York, London.

Anonymous. 1984. *Package of Practices Recommendations*. Kerala Agricultural University, Mannuthy, pp.173.

Arumugam, R., Chelliah, S. and Muthukrishnan, C.R. 1975. *Abelmoschus manihot* - a source of resistance to bhindi yellow vein mosaic. *Madras Agric. J.* 62: 312.

Arumugam, R. and Muthukrishnan, C.R. 1979. Association of resistance to yellow vein mosaic with economic characters in okra. *Indian J. agri. Sci.* 49: 605-608.

Arumugam, R. and Muthukrishnan, C.R. 1981. Association of metric traits in bhindi. *South Indian Hort.* 29: 1-3.

Balachandran, P.V. 1984. Estimation of Heterosis in bhindi (*Abelmoschus esculentus* (L.) Moench) Unpublished thesis of KAU.

Chauhan, K.S. and Bhandari, Y.M. 1971. Pod development and germination studies in okra (*Abelmoschus esculentus* (L.) Moench). *Indian J. agric. Sci.* 41: 852-856.

Chopra, S.L. and Kanwar, J.S. 1976. *Analytical Agricultural Chemistry*. Kalyani Publishers, Ludhiana. pp. 341.

Choudhary, B. and AnothaiChoomsai, M.L. 1970. Natural cross Pollination in some vegetable crops. *Indian J. agric. Sci.* 40: 805-812.

Dhawan, A.K. and Sidhu, A.S. 1984. Incidence and relative abundance of different species of spotted boll worms on okra at Ludhiana. *Punjab J. Res.* 21: 533-542.

*Durantia, 1964. Osservazionisulla biologia Florale di Hibiscus esculentus L. (A.esculentus May) (observations on the floral biology of H. esculentus, L. (A. esculentus, May)). Ann. Fac. Sci. agr. Portici. 30: 393-406.

Elangovan, M., Muthukrishnan, C.R. and Irulappan, I.1980. A study of correlation analysis in bhindi. South Indian Hort. 28: 28-30.

Elangovan, M., Muthukrishnan, C.R. and Irulappan, I. 1981. Hybrid vigour in bhindi (Abelmoschus esculentus (L) Moench) for some economic characters. South Indian Hort. 29: 4-14.

Elangovan, M., Muthukrishnan, C.R. and Irulappan, I. 1983. Evaluation of bhindi hybrids and their parents for crude fibre content. South Indian Hort. 31:241-243.

*Elmaksoud, M.A., Helal, R.M. and Mohamed, M.H. 1984. Studies on an intervarietal cross and hybrid vigour in okra. Annals. Agri. Sci. 29: 431-438.

Giriraj, K. and Rao, T.S. 1973. Note on simple crossing technique in okra. Indian J. agric. Sci.43: 1089.

Isack, M. 1965. Investigation on hybrid vigour in bhindi (Abelmoschus esculentus (L.)Moench). Thesis submitted to the University of Kerala.

*Jalani, B.S. and Graham, K.M. 1973. A study of heterosis in crosses among local and American varieties of okra (Hibiscus esculentus L.) Malayasian Agricultural Research 2: 7-14.

*Joshi, A.B., and Hardas, M.W.1956. Alloploid nature of okra: Abelmoschus esculentus (L.) Moench. Nature 13: 178-190.

Joshi, B.S., Singh, H.B. and Gupta, P.S. 1958. Studies in hybrid vigour - III Bhindi. Indian J. Genet. Pl.Breed. 18: 57-68.

Kakar, R.S. 1976. Influence of cultivar, pod maturity and fertilization on quality of okra (Abelmoschus esculentus (L.) Moench). Dissertation Abstracts. 36: 3149 B

Kaul, T., Lal, G. and Peter, K.V. 1979. Correlation and path coefficient analysis of components of earliness, pod yield and seed yield in okra. Indian J. agric. Sci. 48: 459-463.

*Kawthalkar, M.P. and Kunte, Y.N. 1978. Correlation studies in bhindi. College of Agriculture, Nagpur Magazine 50: 48.

Kohle, A.K. and Chavan, V.M. 1967. Development of fruit, yielding capacity and influence of fruit maturity on the reproductive and vegetative behaviour in okra (Abelmoschus esculentus (L.) Moench) Indian J. agric. Sci. 37: 155-166.

Korla, B.N. and Rastogi, K.B. 1978. Correlation and path coefficient analysis and their implications in selection of high fruit yield in bhindi (Abelmoschus esculentus (L.) Moench). Haryana J. Hortic. Sci. 7: 82-85.

Korla, B.N., Sharma, P.P., Rastogi, K.B. and Sharma, J.K. 1984. Regression studies in bhindi (Abelmoschus esculentus (L.) Moench). South Indian Hort. 32: 270-274.

Kulkarni, R.S. and Virupakshappa, K. 1977. Heterosis and inbreeding depression in okra. Indian J. agric. Sci. 47: 552-555.

Lal, S., Shekhar, C. and Srivastava, J.P. 1975. Genetical studies in bhindi. (Abelmoschus esculentus (L.) Moench) - Gene effects and heterosis. Indian J. Hort. 32: 175-178.

Lal, S., Shekhar, C. and Srivastava, J.P. 1977. A note on genetical studies in bhindi (Abelmoschus esculentus (L.) Moench) - Heritability and genetic advance. Indian J. Hort. 34: 49-50.

Lal, S. and Srivastava, J.P. 1973. Hybrid vigour in bhindi. Indian J. Hort. 30: 542-545.

*Liang, G.H., Reddy, C.R. and Dayton, A.D. (1972). Heterosis, inbreeding depression and heritability estimates in a systematic series of grain sorghum genotypes. Crop Sci. 12: 409-411.

Mahajan, Y.P. and Sharma, B.R. 1979. Parent-offspring correlation and heritability of some characters in okra. Sci. Hortic. 10: 135-139.

Majumdar, M.K., Chatterjee, S.D., Bose, P. and Bhattacharya, G. 1974. Variability, inter-relationship and path coefficient analysis for some quantitative characters in okra (Abelmoschus esculentus (L.) Moench). Indian Agric. 18: 13-20.

Marthamary, K.T. (1969). Studies on correlation in Bhindi (Abelmoschus esculentus (L.) Moench) Thesis submitted to the University of Kerala.

*Martin, F.W. 1983. Natural outcrossing of okra in Puerto Rico. J. Agric. Univ. Puerto Rico. 67: 50-52.

Martin, F.W. and Ruberte, R. 1978. Vegetables for the hot, humid tropics. Part II - Okra. Science and Education Administration. U.S.Department of Agriculture.

Mathews, M. 1966. Investigations on hybrid vigour in F_2 and F_3 generations in bhindi. Thesis submitted to the University of Kerala.

Maurya, A.N., Singh, B. and Singh, R.L. 1978. Studies on the growth, performance, fruit characters and yield of bhindi (Abelmoschus esculentus (L.) Moench) cultivars. Plant Sci. 10: 153-154.

Mishra, R.S. and Chhonkar, V.S. 1979. Genetic divergence in okra. Indian J. Agric. Sci. 49: 247-249.

*Mitidieri, J. and Vencovsky, R. 1974. Polinizacao cruzadao do quiabeiro emcondicrss de campo. Rev. Agric. 49 (1): 3-6.

Murthy, N.S. and Bavaji, J.N. 1980. Correlation and path coefficient analysis in bhindi (Abelmoschus esculentus). South Indian Hort. 28: 35-38.

*Ngah, A.W. and Graham, K.M. 1973. Heritability of four characters in okra (Hibiscus esculentus L.). Malayasian Agricultural Research. 2: 15-21.

Oyolu, C. 1983. Patterns of chemical composition in vegetable species with special reference to okra (A. esculentus), egusi (Citrullus colocynthis) and fluted pumpkin (Telfairia occidentalis). Acta Horticulturae. 123: 105-115.

Padda, D.S., Saimbhi, M.S. and Singh, D. 1970. Genetic evaluation and correlation studies in okra. Indian J. Hort. 27: 39-41.

Pal, B.P., Singh, H.B. and Swarup, V. 1952. Taxonomic relationships and breeding possibilities of species of Abelmoschus related to okra (A.esculentus). Bot. Gaz. 113: 455-464.

Palaniveluchamy, K., Muthukrishnan, C.R. and Irulappan, J. 1982. Studies on heritability and genetic advance in bhindi (Abelmoschus esculentus (L.) Moench). Madras agric. J. 69: 597-599.

Parthap, P.S. and Dhankar, B.S. 1980. Heterosis studies in okra (Abelmoschus esculentus (L.) Moench). Haryana Agric. Univ. J.Res. 12: 433-437.

Parthap, P.S., Dhankar, B.S. and Gautam, R.R. 1982. Genetics of earliness and quality in okra. (Abelmoschus esculentus (L.) Moench). Haryana Agric. Univ. J. Res. 12: 433-437.

Parthap, P.S., Dhankar, B.S. and Pandita, M.L. 1979. Interrelationship and path analysis studies in okra (Abelmoschus esculentus (L.) Moench). Haryana Agric. Univ. J.Res. 9: 317-321.

Parthap, P.S., Dhankar, B.S. and Pandita, M.L. 1980a. Genetics of yield and its components in okra. Indian J. agric. Sci. 50: 320-323.

Parthap, P.S., Dhankar, B.S. and Pandita, M.L. 1981. Heterosis and combining ability in okra (Abelmoschus esculentus (L.)Moench). Haryana J. Hort. Sci. 10: 122-127.

Parthap, P.S., Dhankar, B.S., Pandita, M.L. and Dubi, B.S. 1980b. Genetic divergence in parents and their hybrids in okra. (Abelmoschus esculentus (L.) Moench). Genetica Agraria. 34: 323-330.

Parthasarathy, V.A. and Sambandam, C.N. 1979. Studies on pod development in bhindi (Abelmoschus esculentus (L.) Moench). Annamalai University Agricultural Research Annual 7 & 8: 20-28.

Peter, K.V. 1984. Vegetable research - a review. Kalpadhenu 12: 3-6.

Purewal, S.S. and Randhawa, G.S. 1947. Studies on Hibiscus esculentus (Lay's finger) 1. Chromosomes and Pollination studies. Indian agric. Sci. 17: 129-136.

Raman, K.R. 1965. Studies in intervarietal cross and hybrid vigour in bhindi (Abelmoschus esculentus (L) Moench). Madras agric. J. 52: 365.

Ramu, P.M. 1976. Breeding investigations in Bhindi (Abelmoschus esculentus (L.)Moench). Mysore J. Agric. Sci. 10: 146.

Rao, K.P.G. and Sulladmath, V.V. 1977. Changes in certain chemical constituents associated with maturation of okra (Abelmoschus esculentus) Pod. Veg. Sci. 4: 37-42.

Rao, T.S. 1972. Note on the natural variability for some quantitative and qualitative characters in bhindi. Indian J. agric. Sci. 42: 437-438.

Rao, T.S. 1978. Heterosis and inbreeding depression for some yield components in bhindi. Agric. Res. J. Kerala 16: 95-96.

Rao, T.S. 1979. Genotype X environmental interactions in bhindi. Agric. Res. J. Kerala 17: 169-172.

Rao, T.S. 1980. Genetics of yield components in bhindi. Prog. Hortic. 11: 5-14.

Rao, T.S. and Giriraj, K. 1974. Hybrid variety in bhindi. Current Research 3: 97-98.

Rao, T.S. and Kulkarni, R.S. 1977. Genetic variation in bhindi. Haryana Agric. Univ. J.Res. 7: 58-59.

Rao, T.S. and Kulkarni, R.S. 1978. Interrelationship of yield components in bhindi. Agric. Res. J. Kerala. 16: 76-78.

Rao, T.S. and Ramu, P.M. 1975a A study of correlation and regression coefficients in bhindi (Abelmoschus esculentus (L.) Moench). Current Research 4: 135-137.

Rao, T.S. and Ramu, P.M. 1975b Genetic analysis of three pod characters in bhindi (Abelmoschus esculentus (L.) Moench). Madras Agri. J. 62: 331-337.

Rao, T.S. and Ramu, P.M. 1981. Genetic parameters and heterosis in 6 x 6 diallel cross of bhindi (Abelmoschus esculentus). J. Res. Andra Pradesh Agric. Univ. 3: 78-82.

Rao, T.S., Ramu, P.M. and Kulkarni, R.S. 1977. Genetic variability and path coefficient analysis in bhindi. Punjab Horticultural Journal 18: 76-83.

Rao, T.S. and Sethyavathi, C.P. 1977. Genetic and environmental variability in okra. Indian J. agric. Sci. 47: 80-81.

Raut, U.M. and Sonone, H.N. 1979. A preliminary observation on resistance in okra to shoot and fruit borer. Earias vitella (Fabricias) (Arctiidae: Lepidoptera). J.Maharashtra Agri. Universities 4: 101-103.

Ravindra, K. 1964. Studies on growth and bearing habits of certain varieties of bhindi (A. esculentus (L.) Moench with special reference to fruit maturity and quality. Thesis submitted to the Agricultural University of Tamil Nadu.

Roy, S. and Chhonkar, V.S. 1976. Relationship of yield with different growth characters in okra (Abelmoschus esculentus (L.) Moench). Proc. Bihar Acad. Agric.Sci. 24: 170-172.

Sastry, K.S.M. and Singh, S.I. 1974. Effect of yellow vein mosaic virus infection on growth and yield of okra crop. Indian Phytopathology 27: 294-297.

Shalaby, G.I. 1972. Natural cross pollination in okra. Assuit. J. Agric. Sci. 3: 381-386.

Sharma, B.R. and Mahajan, Y.P. 1978. Line X Tester analysis for combining ability and heterosis for some economic characters in okra. Sci. Hortic. 9: 111-118.

Sharman, B.R. and Sharma, O.P. 1984. Breeding for resistance to yellow vein mosaic virus in okra. Indian J. agric. Sci. 54: 917-920.

Singh, B.N., Chakravarthi, S.C. and Kapoor, G.P. 1938. An interspecific Hibiscus hybrid between H. ficulneus L. and H. esculentus L. J. Heredity 29: 37-41.

Singh, K., Malik, Y.S., Kalloor and Mehrotra, N. 1974. Genetic variability and correlation studies in bhindi (Abelmoschus esculentus (L) Moench). Veg. Sci. 1: 47-54.

Singh, R.K. and Choudhary, B.D. 1979. Biometrical methods in quantitative genetic analysis. Kalyani Publishers, Ludhiana pp.296.

Singh, S.P. and Singh, H.N. 1978a. Discriminant function technique for the improvement of fruit yield in okra (Abelmoschus esculentus (L.) Moench). Prog. Hortic. 10: 27-35.

Singh, S.P. and Singh, H.N. 1978b. Combining ability in okra (Abelmoschus esculentus (L.) Moench). Indian J. agric. Sci. 48: 455-458.

Singh, S.P. and Singh, H.N. 1978c. Study of genetic variability and inheritance of certain characters in okra (Abelmoschus esculentus (L.) Moench). Haryana J. Hortic. Sci. 7: 68-73.

Singh, S.P. and Singh, H.N. 1979a. Genetic divergence in okra. (Hibiscus esculentus (L.) Moench). Indian J. Hort. 36: 156-170.

Singh, S.P. and Singh, H.N. 1979b. Path coefficient analysis for yield components in okra. Indian J. agric. Sci. 49: 244-246.

Singh, S.P. and Singh, H.N. 1979c. Hybrid vigour for yield and its components in okra. Indian J. agric. Sci. 49: 596-601.

*Singh, S.P., Singh, H.N. and Raj, J.N. 1980. Multivariate analysis in relation to breeding systems in okra (Abelmoschus esculentus L.). Pflanzenzuecht. 84: 57-62.

Singh, S.P., Srivastava, J.P. and Singh, H.N. 1975. Heterosis in bhindi (Abelmoschus esculentus (L.) Moench). Prog. Hort. 7: 5-15.

Singh, S.P., Srivastava, J.P., Singh, H.N. and Singh, N.P. 1977. Genetic divergence and nature of heterosis in okra. Indian J. agric. Sci. 47: 546-555.

Singh, P., Tripathi, R.S. and Singh, H.N. 1974. Effect of age of picking on the chemical composition of fruits in okra. Indian J. agric. Sci. 41: 22-26.

Sistrunk, W.A., Jones, L.G. and Miller, J.C. 1960. Okra pod growth habits. Proc. American Soci. Hort. 76: 486-491.

Teli, V.S. and Dalaya, V.P. 1981. Studies on varietal resistance of okra (A. esculentus (Linn) Moench) to the shoot and fruit borer, Earias vitella, (Fabricius). South Indian Hort. 29: 24-60.

Thaker, D.N., Tikka, S.B.S. and Patel, K.K. 1982. Hybrid vigour and inbreeding depression for fruit yield and its components in okra. (Abelmoschus esculentus (L.) Moench). Gujarat Agric. Univ. Res. J. 8: 1-4.

Thaker, D.N., Tikka, S.B.S., Patel, K.K. and Ukani, S.J. 1981. Analysis of parameters of variability in okra. (Abelmoschus esculentus (L.) Moench). Indian J. Hort. 38: 232-235.

Thamburaj, S. and Kamalanathan, S. 1973. Studies on growth and productivity in bhindi. Madras agric. J. 60: 1659-1666.

Trivedi, H.B. and Prakash, R. 1969. Heritability of fruit size in bhindi (Abelmoschus esculentus (L.) Moench). Sci. Culti. 35: 318-319.

Vashistha, R.N., Pandita, M.L. and Bhutani, A.D. 1982. Variability studies in okra (Abelmoschus esculentus (L. Moench) under dry farming conditions. Haryana J. Hort. Sci. 11: 117-121.

Venkataramani, K.S. 1952. A preliminary study on some interverietal crosses and hybrid vigour in Hibiscus esculentus (L.). J. Madras Univ. 22: 183-200.

Venkataramani, K.S. 1953. Some observations on blossom biology and fruit formation in H. esculentus (L.). J. Madras Univ. 23: 1-14.

Vijayaraghavan, C. and Warrier, U.A. 1946. Evaluation of high yielding hybrid "Bhindi" (Hibiscus esculentus). Proc. 33rd Indian Sci. Congress 33: 165.

* Original not seen.

APPENDICES

Appendix 1

Days to Flower

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.15	0.08	0.03
Treatments (Genotypes)	11.00	97.16	8.83	3.42**
Error	22.00	56.72	2.58	

ii) Trial II - ANOVA

Source	df	SS	MS	F- value
Blocks	2.00	10.06	5.03	2.81*
Treatments (Genotypes)	11.00	313.82	28.53	15.94**
Error	22.00	39.44	1.79	

iii) Pooled Analysis

Source	df	SS	MS	F-value
Environment	1.000	1810.214		
Genotypes (Treatments)	11.000	358.046	32.550	5.083**
G x E	11.000	70.445	6.404	2.193*
Pooled error	44.000	96.140	2.185	

* Significant at 5% level

** Significant at 1% level

Appendix 2

First Fruiting node

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.10	0.05	0.12
Treatments (Genotypes)	11.00	11.47	1.04	2.56 *
Error	22.00	8.95	0.41	

ii) Trial II - ANOVA

Source	dF	SS	MS	F- value
Blocks	2.00	0.64	0.32	1.80
Treatments (Genotypes)	11.00	15.68	1.43	7.96 **
Error	22.00	3.94	0.18	

iii) Pooled Analysis

Weighted Analysis

Source	SS
Environment	1.821289
Genotypes	111.3242
G x E	4.379395

* Significant at 5% level

** Significant at 1% level

Appendix 3

Mean leaf area

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	13675.94	6837.97	7.16**
Treatments (Genotypes)	11.00	25453.56	2313.96	2.42*
Error	22.00	21005.06	954.78	

ii) Trial II - ANOVA

Source	df	SS	MS	F- value
Blocks	2.00	2234.38	1117.19	3.81*
Treatments (Genotypes)	11.00	28071.88	2551.99	8.71**
Error	22.00	6448.63	293.12	

iii) Pooled Analysis

Weighted Analysis

Source	Ss
Environment	139.919
Genotypes	110.7075
G x E	11.72266

* Significant at 5% level

** Significant at 1% level

Appendix 4

Number of fruits per plant

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	28.50	14.25	4.15*
Treatments (Genotypes)	11.00	351.18	31.93	9.29**
Error	22.00	75.62	3.44	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	54.35	27.17	12.30**
Treatments (Genotypes)	11.00	299.84	27.26	12.34**
Error	22.00	48.60	2.21	

iii) Pooled Analysis

Unweighted Analysis - ANOVA

Source	df	SS	MS	F- value
Environment	1.000	5.833		
Genotypes	11.000	598.276	54.389	19.264**
G X E	11.000	52.737	4.794	1.698
Pooled error	44.000	124.228	2.823	

* Significant at 5% level

** Significant at 1% level

Appendix 5

Number of fruits on main stem

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	23.18	11.59	3.59*
Treatments (Genotypes)	11.00	307.36	27.94	8.65**
Error	22.00	71.03	3.23	

ii) Trial II - ANOVA

Source	df	SS	MS	F- value
Blocks	2.00	5.07	2.53	0.91
Treatments (Genotypes)	11.00	112.16	10.20	3.67**
Error	22.00	61.04	2.77	

iii) Pooled Analysis

Unweighted Analysis - ANOVA

Source	df	SS	MS	F-value
Environment	1.000	49.168		
Genotypes	11.000	318.715	28.974	8.161*
G x E	11.000	100.809	9.164	3.053*
Pooled error	44.000	132.074	3.002	

* Significant at 5% level

** Significant at 1% level

Appendix 6

Number of fruits on branches

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.80	0.40	0.42
Treatments (Genotypes)	11.00	18.41	1.67	1.74
Error	22.00	21.12	0.96	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	26.30	13.15	5.20*
Treatments (Genotypes)	11.00	163.76	14.89	5.89**
Error	22.00	55.63	2.53	

iii) Pooled Analysis

a) Weighted Analysis

Source	SS
Environment	16.38037
Genotypes	102.0366
G x E	33.5835*

b) Unweighted Analysis - ANOVA

Source	df	SS	MS	F-Value
Environment	1.000	24.036		
Genotypes	11.000	127.873	11.625	2.355*
G X E	11.000	54.291	4.936	

* Significant at 5% level

** Significant at 1% level

Appendix 7

Length of fruit

i) Trial I- ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	9.34	4.67	2.49
Treatments (Genotypes)	11.00	61.32	5.57	2.97*
Error	22.00	41.30	1.88	

ii) Trial II ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	11.58	5.79	2.43
Treatments (Genotypes)	11.00	159.85	14.53	6.11**
Error	22.00	52.32	2.38	

iii) Pooled Analysis

Unweighted Analysis-ANOVA

Source	df	SS	MS	F-value
Environment	1.000	228.232		
Genotypes	11.000	171.833	15.621	3.480*
G X E	11.000	49.337	4.485	2.108*
Pooled Error	44.000	93.620	2.128	

* Significant at 5% level

** Significant at 1% level

Appendix 8

Girth of fruit

1) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	1.44	0.72	3.51*
Treatments (Genotypes)	11.00	3.08	0.28	1.36
Error	22.00	4.53	0.21	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.84	0.42	9.24**
Treatments (Genotypes)	11.00	8.80	0.80	17.55**
Error	22.00	1.00	0.05	

iii) Pooled Analysis

a) Weighted Analysis

Source	SS
Environment	55.9961
Genotypes	183.2852
G X E	24.7461*

b) Unweighted Analysis - ANOVA

Source	df	SS	MS	F-value
Environment	1.000	7.038		
Genotypes	11.000	8.777	0.798	2.82**
G X E	11.000	5.529	0.283	

* Significant at 5% Level

** Significant at 1% level

Appendix 9

Weight of single fruit

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	140.34	70.17	10.37**
Treatments (Genotypes)	11.00	58.19	5.29	0.78
Error	22.00	148.92	6.77	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	87.30	43.65	1.94
Treatments (Genotypes)	11.00	341.62	31.07	1.38
Error	22.00	495.52	22.52	

Appendix 10

Weight of fruits per plant

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	112329.50	56164.75	22.83**
Treatments (Genotypes)	11.00	168731.50	15339.23	6.23**
Error	22.00	54130.00	2460.45	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	14863.00	7431.50	6.63**
Treatments (Genotypes)	11.00	506553.50	46050.32	41.10**
Error	22.00	24648.50	1120.39	

iii) Pooled Analysis

a) Weighted Analysis

Source	SS
Environment	100.5508
Genotypes	473.9238
G X E	46.7783*

b) Unweighted Analysis - ANOVA

Source	df	SS	MS	F-value
Environment	1.000	180033.300		
Genotypes	11.000	591536.000	53776.000	7.063**
G X E	11.000	83749.340	7613.576	

** Significant at 1% level

Appendix 11

Number of seeds per fruit

i) Trial I - ANOVA

Source	df	SS	MS	F-Value
Blocks	2.00	269.03	134.52	0.68
Treatments (Genotypes)	11.00	9632.41	875.67	4.44**
Error	22.00	4337.94	197.18	

ii) Trial II -ANOVA

Source	df	SS	MS	F-Value
Blocks	2.00	372.41	186.20	2.67
Treatments (Genotypes)	11.00	10876.94	988.81	14.18**
Error	22.00	1533.94	69.72	

iii) Pooled Analysis

Weighted Analysis

Source	SS
Environment	2.763184
Genotypes	198.1797
G X E	6.67041

** Significant at 1% level

Appendix 12

Number of ridges per fruit

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.91	0.46	1.95
Treatments (Genotypes)	11.00	29.53	2.68	11.52**
Error	22.00	5.13	0.23	

ii) Trial II -ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.09	0.04	0.42
Treatments (Genotypes)	11.00	35.01	3.18	30.02**
Error	22.00	2.33	0.11	

iii) Pooled Analysis

Weighted Analysis

Source	SS
Environment	0.46875
Genotypes	439.4746
G X E	17.40234

** Significant at 1% level

Appendix 13

Number of flowers per plant

i) Trial I -ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	87.95	43.97	6.77**
Treatments (Genotypes)	11.00	493.77	44.89	6.91**
Error	22.00	142.98	6.50	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	83.34	41.67	8.45**
Treatments (Genotypes)	11.00	548.96	49.91	10.12**
Error	22.00	108.52	4.93	

iii) Pooled Analysis

Unweighted Analysis - ANOVA

Source	df	SS	MS	F-value
Environment	1.00	0.438		
Genotypes	11.00	949.664	86.333	15.104*
G X E	11.00	93.068	8.461	1.480
Pooled Error	44.00	251.502	5.716	

* Significant at 5% level

** Significant at 1% level

Appendix 14

Fruiting phase

i) Trial I -ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	8.55	4.27	1.10
Treatments (Genotypes)	11.00	570.56	51.87	13.38**
Error	22.00	85.30	3.88	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.84	0.42	0.34
Treatments (Genotypes)	11.00	194.00	17.64	14.36**
Error	22.00	27.03	1.23	

iii) Pooled Analysis

a) Weighted Analysis

Source	SS
Environment	672.1797
Genotypes	240.375
G X E	64.15208*

b) Unweighted Analysis - ANOVA

Source	df	SS	MS	F-value
Environment	1.000	1716.115		
Genotypes	11.000	599.417	54.492	3.630*
G X E	11.000	112.332	15.012	

* Significant at 5% level

** Significant at 1% level

Appendix 15

Number of non bearing nodes

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	8.08	4.04	3.39
Treatments (Genotypes)	11.00	78.13	7.10	5.96**
Error	22.00	26.22	1.19	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.82	0.41	0.58
Treatments (Genotypes)	11.00	118.47	10.77	15.34**
Error	22.00	15.44	0.70	

iii) Pooled Analysis

Unweighted Analysis -ANOVA

Source	df	SS	MS	F-value
Environment	1.000	0.125		
Genotypes	11.000	121.298	17.390	18.366**
G X E	11.000	5.305	0.482	0.509
Pooled error	44.000	41.663	0.947	

* Significant at 5% level

** Significant at 1% level

Appendix 16

Height of plant

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	695.33	347.66	4.81*
Treatments (Genotypes)	11.00	3580.48	325.50	4.50**
Error	22.00	1590.96	72.32	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	2413.19	1206.59	9.20**
Treatments (Genotypes)	11.00	4569.56	415.41	3.17**
Error	22.00	2886.88	131.22	

iii) Pooled Analysis

Unweighted Analysis -ANOVA

Source	df	SS	MS	F-value
Environment	1.000	40073.250	40073.250	
Genotypes	11.000	7153.709	650.337	6.390**
G X E	11.000	996.333	90.576	0.890
Pooled Error	44.000	4477.636	101.769	

* Significant at 5% level

** Significant at 1% level

Appendix 17

Number of branches

i) Trial I -ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	2.07	1.03	5.90**
Treatments (Genotypes)	11.00	9.01	0.82	4.67**
Error	22.00	3.65	0.18	

ii) Trial II -ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	2.24	1.12	4.10*
Treatments (Genotypes)	11.00	31.26	2.84	10.41**
Error	22.00	6.01	0.27	

iii) Pooled Analysis

Unweighted Analysis - ANOVA

Source	df	SS	MS	F-value
Environment	1.000	5.951		
Genotypes	11.000	31.692	2.881	3.698*
G X E	11.000	8.570	0.779	3.477**
Pooled error	44.000	9.859	0.224	

* Significant at 5% level

** Significant at 1% level

Appendix 18

Girth of stem

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.84	0.42	1.69
Treatments (Genotypes)	11.00	6.07	0.55	2.22
Error	22.00	5.47	0.25	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	1.06	0.53	0.87
Treatments (Genotypes)	11.00	18.69	1.70	2.79*
Error	22.00	13.43	0.61	

III) Pooled Analysis

Weighted Analysis

Source	SS
Environment	194.3496
Genotypes	32.2085
G X E	22.83008

* Significant at 5% level

Appendix 19

Percentage of fruitset

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	133.71	66.86	3.52*
Treatment (Genotypes)	11.00	256.17	23.29	1.23
Error	22.00	417.35	18.97	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	39.27	19.64	0.60
Treatments (Genotypes)	11.00	771.02	70.09	2.15
Error	22.00	717.85	32.63	

* Significant at 5% level

Appendix 20

Yellow vein Mosaic disease scoring

Trial II-ANOVA

Source	df	SS	MS	F-Value
Blocks	2.00	0.02	0.01	0.07
Treatments (Genotypes)	11.00	11.77	1.07	7.13**
Error	22.00	3.24	0.15	

** Significant at 1 % level

Appendix 21

Percentage of shoot infestation by fruit and shoot borer

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.34	0.17	0.09
Treatments (Genotypes)	11.00	352.50	32.05	16.11**
Error	22.00	43.74	1.99	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	353.34	176.67	22.25**
Treatments (Genotypes)	11.00	77.84	7.08	0.89
Error	22.00	174.59	7.94	

iii) Pooled Analysis

a) Weighted Analysis

Source	SS
Environment	0.0771
Genotypes	156.646
G X E	31.348*

b) Unweighted Analysis - ANOVA

Source	df	SS	MS	F-value
Environment	1.000	0.383		
Genotypes	11.000	276.844	25.168	1.778
G X E	11.000	155.642	14.149	

* Significant at 5% level

** Significant at 1% level

Appendix 22

Percentage of fruit infestation by fruit and shoot borer

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.13	0.07	0.04
Treatments (Genotypes)	11.00	77.90	7.08	4.05**
Error	22.00	38.52	1.75	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	5.35	2.68	1.37
Treatments (Genotypes)	11.00	44.81	4.07	2.09
Error	22.00	42.81	1.95	

iii) Pooled Analysis

Unweighted Analysis

Source	df	SS	MS	F-value
Environment	1.000	21.190		
Genotypes	11.000	111.387	10.126	5.474**
G X E	11.000	11.375	1.034	0.559
Pooled error	44.000	81.400	1.850	

** Significant at 1% level

Appendix 23

Crude fibre content

i) Trial I - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.00	0.00	α
Treatments (Genotype)	11.00	0.47	0.04	39.48**
Error	22.00	0.02	0.00	

ii) Trial II - ANOVA

Source	df	SS	MS	F-value
Blocks	2.00	0.00	0.00	α
Treatments (Genotypes)	11.00	0.50	0.05	5.46**
Error	22.00	0.18	0.01	

iii) Pooled Analysis

a) Weighted Analysis

Source	SS
Environment	12.859
Genotypes	459.789
G X E	34.531*

b) Unweighted Analysis - ANOVA

Source	df	SS	MS	F-value
Environment	1.000	0.061		
Genotypes	11.000	0.809	0.074	4.930*
G X E	11.000	0.163	0.015	

* Significant at 5% level

** Significant at 1% level

Plate 1 View of the experimental field

Plate 2 Selection 2-2 - Female parent of the first ranking hybrid (60th day after planting)

Plate 3 Kilichundan - Male parent of the first ranking hybrid (60th day after planting)

Plate 4 Selection 2-2 X Kilichundan - the first ranking hybrid showing maximum heterosis (60th day after planting)

Plate 2.

Plate 3

Plate 4

Plate 5 Sevendhari X Kilichundan - Second ranking hybrid of the study (60th day after planting)

Plate 6 Comparison of fruit characters of Pusa Sawani X Sevendhari (4 x 6) and its parents.

Plate 7 Comparison of fruit characters of Selection 2-2 X Kilichundan (5 x 2) and its parents

Plate 8 Comparison of fruit characters of Selection 2-2 X Sevendhari (5 x 6) and its parents.

Plate 9 Comparison of fruit characters of Sevendhari X Karingal local (6 x 1) and its parents.

Plate 10 Comparison of fruit characters of Sevendhari X Kilichundan (6 x 2) and its parents.

Plate 11 Comparison of fruit characters of Sevendhari X Pilicode local (6 x 3) and its parents.

ABSTRACT

A study was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani during 1983-'84 and 1984-'85 with six intervarietal hybrids of bhindi and their six parents aimed at estimation of heterosis for the different economic characters manifested by the hybrids and selecting the best hybrid with high yield potential and allied attributes. The hybrids were selected based on the results of a diallel cross study by Balachandran (1984) at the College of Agriculture, Vellayani. The six parents and their six hybrids were evaluated during January-April and April- July, 1985 in an RBD with three replications. The characters studied included seventeen yield components and one fruit quality attribute. Field incidence of yellow vein mosaic disease and fruit and shoot borer infestation were scored during the study inorder to assess the comparative resistance of the parents and the hybrids.

The data for individual trials were analysed with respect to the various characters studied. Pooled analysis was done to study the genotype X environment interaction. In both the trials, significant variability was noticed among the genotypes for most of the economic characters including weight of fruits per plant.

Moderate to high heritability was recorded for the important characters such as weight of fruits per plant, number of fruits per plant, crude fibre content and yellow vein mosaic disease incidence. However, the estimates of genetic advance were low for these characters indicating predominance of non-additive gene action. Hence heterosis breeding can be effectively employed as a potent tool for the improvement of these characters.

Correlation studies revealed that number of fruits per plant, number of branches, length girth and weight of single fruit, total number of flowers, fruiting phase, number of seeds per fruit and girth of stem were the important contributing characters of yield. Long and heavy fruits were found to be of good quality with less crude fibre content.

All the hybrids displayed desirable heterosis for the major economic characters such as weight of fruits per plant, number of fruits per plant etc. in both the trials. Negative heterosis was exhibited by the hybrids for the characters such as crude fibre content, fruit and shoot borer infestation and yellow vein mosaic disease incidence. The results suggested that heterosis breeding could be effectively employed in augmenting the yield potential and allied attributes in bhindi.

The present study could identify two hybrids "Selection 2 X Kilichundan" (5 x 2) and "Sevendhari X Kilichundan" (6 x 2)

with high yield potential coupled with other desirable attributes. The hybrids Selection 2-2 X Kilichundan and Sevendhari X Kilichundan have outyielded the standard cultivar, Pusa Sawani, by 65.06 per cent and 50.34 per cent respectively. The hybrid Selection 2-2 X Kilichundan produced the highest average yield (564.18 gm/plant) closely followed by Sevendhari X Kilichundan (513.86 gm/plant). Both the hybrids produced large number of long heavy fruits with good thickness and low crude fibre content. The hybrid Selection 2-2 X Kilichundan was also found to be less susceptible to yellow vein mosaic disease under field conditions.

These hybrids will go a long way in boosting up the production potential of bhindi in homestead and commercial cultivations.