GENETIC DIVERGENCE IN BHINDI
(*Abelmoschus esculentus* (L.) Moench)

By

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THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

Department of Plant Breeding
COLLEGE OF AGRICULTURE
Vellayani – Trivandrum
1993

Dedicated

to my loving parents

DECLARATION

I hereby declare that this thesis entitled "Genetic divergence in bhindi (*Abelmoschus esculentus* L. Moench)", 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.

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CERTIFICATE

Certified that this thesis entitled Genetic divergence in bhindi (*Abelmoschus esculentus* L. Moench)", is a record of research work done independently by Kum. K. K. BINDU, 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.

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ACKNOWLEDGMENT

I owe deep sense of gratitude and fervent indebtedness to Dr. Manju, P. Associate Professor of Plant Breeding and Chairman Advisory Committee for suggesting the research problem, valuable and untiring guidance, constructive criticism, persisting encouragement and patience through out the course of this investigation and in the preparation of this thesis.

I extend my heartfelt thanks and indebtedness to Dr. V. Gopinathan Nair, Professor and Head of the Department of Plant Breeding for his unstinted help, valuable suggestion and for providing the necessary facilities for carrying out the research work.

I place on record my deep sense of gratitude to Dr. (Mrs) P. Saraswathy, Head, Department of Agricultural Statistics for her valuable help and timely advice in the statistical analysis of the data and subsequent interpretation and Dr. S.G. Sreekumar, Associate Professor, Department of Agricultural Botany, College of Horticulture, Vellanikkara for critically going through the manuscript and offering constructive suggestions.

I profusely thank the Kerala Agricultural University for awarding me the University fellowship.

My sincere thanks are due to Shri. C.E. Ajithkumar, Junior Programmer, Agricultural Statistics, for his help in the computer analysis of the data and M/s Athira Computers, Kesavadasapuram, Thiruvananthapuram, for the careful, sincere computer works and neat typing.

I extend my thanks to the staff of the Department of Plant Breeding for the sincere help extended to me throughout the research programme.

I am grateful to Shri Sulaiman, Photographer, NARP for his help in taking photographs.

I sincerely thank my class mates, Sreekumar, S., Sudha, Reeja and friends especially Rashmi, Fathima, Sheela Chithra, Rajashree for their help and whole hearted co-operation extended to me throughout these two years.

I am deeply indebted to my parents, sister and uncle without whose unstinted moral support, prayers, sacrifices this endeovour would not have ever seen the light.

Above all, I thank God for all his blessings which enabled me to undertake this endeavour successfully.

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INTRODUCTION

1. INTRODUCTION

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 fruit. Further more, the production potential per unit area of this crop surpasses many folds of all other crops. Bhindi is an annual vegetable crop grown extensively throughout India. The ease with which it can be cultivated and its adaptability to a wide range of growing conditions make it popular among vegetable growers. Bhindi is also a crop of significant nutritional as well as medicinal value. Bhindi is rich in vitamins, Calcium, Potassium and minerals. It is a self pollinated crop with natural cross pollination ranging from 4 to 19.0 per cent. However, Mitideri and Vencovsky (1974) reported maximum of 42.2 per cent cross pollination in bhindi, which is one of the reasons for genetic variability.

The primary aim of a Plant Breeder is to evolve superior genotypes with high yield, superior quality and resistance to pest and disease. The preliminary step in any crop improvement programme is the search for variability in the germplasm. Selection of genotypes showing high heritability and genetic advance for desirable characters that contribute to yield is a prerequisite in the development of high yielding varieties.

Yield, an extremely complex character is the result of many growth functions of the plant. An estimation of inter-relationship of yield with other traits is of immense help in any crop improvement programme. Correlation studies would facilitate effective selection for simultaneous improvement of one or many yield contributing components.

An assessment of the merit of each character by analysing the direct and indirect effects of individual component towards yield is of immense value in selecting the character for crop improvement as correlation coefficient will not provide a true picture of merits and demerits of each of the component which contributes to yield.

Heterosis is exploited in bhindi for many characters like earliness, dwarfness and high yield. As a preliminary step of heterosis breeding, it is desirable to investigate the nature and degree of divergence in a population of the different groups. Multivariate analysis has been successfully used in several crops for the estimation of genetic divergence. It helps in choosing parents in the hybridization programme for achieving specific breeding objectives.

With this view is mind, the present investigation was undertaken with the objectives of estimating the variability in the important economic characters and the genetic divergence among the genotypes and to group them into clusters according to the magnitude of genetic distance using Mahalanobis D^2 statistic.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

A review of literature on the subject is attempted in this chapter. Details of information available have been pooled and brief review made covering genetic variability, correlation of variables, heritability, genetic advance, path coefficient and genetic diversity.

2.1. Genetic parameters in bhindi

Dahatonde (1970) screened 24 varieties of okra against fruit and shoot borer and concluded that varieties with more hair density on fruits showed more fruit infestation.

Padda et al. (1970) observed high heritability and moderate to high genetic advance as percentage of mean for resistance to yellow vein mosaic. Negative correlation was found to be existing between yellow vein mosaic incidence and yield.

Rao (1972) reported that plant height and days to flower showed high genotypic coefficient of variation coupled with both high values of heritability and genetic advance.

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

Shastry and Singh (1974) reported that the average loss in yield due to yellow vein mosaic disease was as high as 93.80 per cent.

Singh _et al_. (1974) reported high heritability values and estimates of genetic advance for fruit diameter and fruit length.

Patil (1975) while conducting screening trials of okra varieties under AICVIP at Rahuri revealed that there was no shoot and fruit borer incidence in a wild species _Abelmoschus manihot_.

Ramu (1976) reported high narrow sense heritability for number of fruits per plant and yield per plant. High additive and non additive components of genetic variation were also observed for number of fruits per plant and yield per plant.

Lal _et al_. (1977) reported high phenotypic and genotypic variability and also high heritability for all characters studied except for yield per plant, highest estimates being for days to flowering, internodal length and fruit length.

Rao and Kulkarni (1977) reported that the estimates of heritability and genetic advance were highest for number of fruits per plant and that this character was under the control of additive genes.

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) reported that broad sense heritability estimates and expected genetic advance were greater for days to flowering, yield per plant and number of fruits per plant.

Kaul et al. (1979) observed considerable genetic variation for number of plants at stage IV of infection with yellow vein mosaic virus.

Mahajan and Sharma (1979) observed high heritability estimates for number of fruits, fruit length and fruit diameter.

Meshra and Chhonkar (1979) reported high heritability genetic advance and genotypic coefficient of variation for number of branches per plant, fruits per plant, seeds per fruits, fruit length and plant height.

Murthy and Bavaji (1980) noticed highest heritability and genetic advance for pod length (99.6 per cent and 61.86 per cent respectively).

Pratap *et al.* (1980) observed high heritability for all characters except yield per plant (19.09 per cent), number of fruits per plant (32.56 per cent) and plant height (39.45 per cent).

Teli and Dahalaya (1981) screened 20 okra varieties and $7F_1$s for resistance to fruit and shoot borer. It was observed that the larval entry was easier in soft-skinned, smooth surfaced varieties.

Thaker *et al.* (1981) observed high genotypic coefficient of variation for plant height, leaf area, number of fruits per plant, weight of single fruit and weight of fruits per plant.

Mote (1982) evaluated 10 *Hibiscus esculentus* varieties for resistance to *Earias vitella*. The varieties with long and dense hair had the lowest infestation in the field.

Palaniveluchamy *et al* (1982) observed that heritability and genetic advance were of lower magnitude for all the characters studied. High heritability was recorded for plant height (25.03 per cent).

Pratap et al. (1982) reported non additive inheritance for resistance to yellow vein mosaic disease.

Vashistha et al. (1982) reported significant difference for yield per plant and other characters except for number of ridges per fruit. Heritability and genetic advance were high for the fruits per plant, plant height and root length.

Balachandran (1984) reported high phenotypic and environmental coefficient of variation for fruit yield and number of fruits per plant indicating greater influence of environment on these characters. Genotypic coefficient of variation was maximum for percentage of fruit set, number of non bearing nodes, number of branches per plant, number of fruits per plant and fruit yield

Korla and Sharma (1984) reported that plant height exhibited the greatest variability and node of first fruit set, the least. All the traits studied viz., plant height, node of first fruit set, number of fruits per plant and yield per plant had a low to moderate heritability and genetic advance.

Maksaud et al. (1984) noted high and narrow sense heritability values for earliness of flowering, fruits per plant and fruit weight.

Sharma and Sharma (1984) reported that tolerance to yellow vein mosaic was probably controlled by two dominant complementary genes or under polygenic control.

Paive *et al*. (1985) recorded high magnitude of heritability and high genetic advance for yield, number of fruits per plant, fruit length and days to flower. High heritability and genetic advance was observed for fruit length (98 per cent and 52.18 respectively) and lowest for days to flower. (43 per cent and 5.97 respectively)

Reddy *et al*. (1985) reported high heritability for plant height and number of branches.

Khan and Mukhopadhyay (1986) reported that out of 5 varieties of *A esculentus* screened under field conditions, S1-1 showed the lowest incidence of infection (24.36) and the same had the highest yield.

Mathews (1986) observ igh heritability and genetic advance for weignt of fruits per plant, days to flowering and number of leaves per plant.

Sheela (1986) recorded maximum genotypic coefficient of variation for number of branches and minimum value for girth of fruit.

Singh (1986) reported that in the F_1 and F_2 hybrids dominance effects of yield and its component were greater than additive effects. Heritability estimates were higher in F_2 than in F_1 except for number of days to flowering.

Yadav (1986) reported that plant height registered the highest value of genotypic coefficient of variation (48.08) and pod length the lowest value (14.21). Highest heritability was recorded for number of seeds per pod and highest genetic advance for yield per plant.

Balakrishnan and Balakrishnan (1988) reported that the phenotypic and genotypic variances were high for yield per plant, plant height and number of fruits per plant. The traits number of ridges per fruit and fruit girth showed low variability. The heritability and genetic advance as percentage of means were high for number of fruits per plant, fruit weight and yield per plant.

Renie (1988) reported that GCV was maximum for number of branches per plant and minimum for first fruting node. The heritability and genetic advance as percentage of means were high for plant height, days to flowering and fruiting phase.

Kale et al. (1989) reported that variability studies conducted on 36 varieties of okra indicated that the estimates of GCV, PVC and heritability were moderate to high for the characters number of branches, number of nodes per plant, internodal length, leaf area, plant height, fruit length and number of fruits per plant.

Ariyo (1990) reported that relatively large genotypic coefficient of variation and heritability estimates were recorded for height at flowering, pod length, final plant height, number of seeds per fruit and length of mature pods.

2.2. Correlation studies in bhindi

Majumdar et al. (1974) reported that yield was positively correlated with number of fruits per plant, weight of single fruit, length/girth ratio of fruit, plant height and negatively correlated with days to flowering. Path coefficient analysis revealed that the weight of the fruit had maximum direct contribution to yield. The plant height also had a positive direct effect.

Ramu (1976) opined that yield per plant was significantly correlated with number of fruits per plant, node number and height of the plant. He observed that number of fruits per plant had the greatest maximum direct effect on yield.

Roy and Chhonkar (1976) reported that yield was significantly and positively correlated with number of fruits, number of branches, height of the main shoot, fruit length and weight of the fruit.

Rao and Kulkarni (1978) reported that yield was significantly and positively correlated with height of the plant and number of fruits per plant. Similarly he observed that height of the plant followed by days to flowering made the greatest direct contribution to yield.

Singh and Singh (1978) reported that yield was positively correlated with fruits per plant, number of branches per plant and height of the plant. Fruit length followed by days to flowering made the greatest direct contribution to yield.

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

Kaul et al. (1979) reported that yield was positively correlated with seed yield. He observed that primary branches per plant followed by fruit yield per plant had the greatest direct effect on yield.

Mahajan and Sharma (1979) reported that yield was positively correlated with plant height, number of fruits per plant and fruit length.

Singh and Singh (1979) reported that yield was significantly and positively correlated with number of fruits per plant, number of branches per plant, fruit length and plant height. Plant height followed by internodal length and fruit number per plant had the greatest direct effect on yield.

Elangovan _et al_. (1980) reported that yield was significantly and positively correlated with number of branches, number of fruits per plant, girth of fruit and fruit length.

Murthy and Bavaji (1980) reported that fruit number followed by days to flowering had a high direct effect on yield.

Arumugam and Muthukrishnan (1981) observed that fruit yield was highly correlated with number of fruits per plant, length of fruit per plant and number of seeds per fruit.

Pratap _et al_. (1982) reported that number of fruits per plant and weight of single fruit made a direct positive contribution to yield.

Meshra and Singh (1985) reported that yield was positively correlated with number of fruits per plant, fruit length, weight of fruits per plant, plant height and number of nodes per plant. On the basis of path coefficient analysis weight of fruit and number of fruits per plant had maximum direct contribution to yield.

Palve et al. (1985) reported that yield was significantly and positively correlated with number of fruits per plant.

Reddy et al. (1985) observed that plant height had direct effect on yield.

Mathews (1986) reported the characters number of flowers per plant, number of fruits per plant and height of the plant contributed most to yield.

Sheela (1986) reported that number of fruits per plant, number of branches. length of fruit, girth of fruit, number of flowers, weight of the single fruit, fruiting phase and number of seeds per fruit were the important characters contributing to yield.

Yadav (1986) observed that plant height, number of fruits per plant and fruit length were positively correlated with yield.

Renie (1988) reported that yield per plant was positively correlated with its component characters like number of fruits per plant, fruiting phase, number of flowers per plant, fruit length and weight of fruits per plant.

Kale *et al*. (1989) reported that yield was significantly and positively correlated with its component characters like plant height, number of branches per plant, leaf area, fruit length and number of fruits per plant.

Jeyapandi and Balakrishnan (1990) reported that fruit yield was positively correlated with plant height, fruit length, fruit weight and number of fruits per plant.

Veeraragavathatham and Irulappan (1990) observed that yield was positively and significantly correlated with number of fruits per plant, fruit girth and internodal length.

Sivagamasundhari *et al*. (1992) reported a strong and positive correlation of yield with number of fruits per plant and weight of single fruit per plant.

2.3. Genetic divergence

The importance of genetic diversity in selection of parents for hybridization has been stressed by many workers. Singh and Gupta (1968) emphasied the importance of genetic diversity of parents in hybrid breeding programme. According to them, the more diverse the parents, within a reasonable range, the more would be the chance of improving the characters in question.

Multivariate analysis by means of Mahalanobis D^2 statistics has been found to be a powerful tool in the hands of the plant breeder for quantifying the degree of divergence between biological populations, to understand the trend on evolution pattern, to assess the relative contribution of different characters towards total divergence and the association between genetic divergence and geographical divergence. Generally eco-geographic diversity has been considered as an index of genetic variability in crop plants. However, this may not be true for every case as pointed out by many workers, that genetic diversity need not necessarily be related to geographic diversity (Murthy and Qadri, 1965; Arunachalam and Jawaharram, 1967; Singh and Bain, 1968 and Gupta and Singh, 1970). The workers observed that many varieties forming one group were geographically diverse, while varieties obtained from the same region were genetically different.

Sachan and Sharma (1971) studied genetic divergence in 24 tomato varieties and grouped them into 10 clusters. Stem length, number of branches, number of inforescence and number of fruits per plant accounted for total divergence.

Chaudhary et al. (1975) studied genetic divergence in 51 varieties of clusterbean. These 51 varieties were grouped into 11 clusters including three single variety clusters. Varieties of different eco-geographical region were found to cluster together.

Peter and Rai (1976) opined that in 25 varieties of tomato studied, there was no apparent parallelism between genetic and geographical divergence. The component characters locule per fruit and plant height were found to contribute maximum for total divergence.

Singh and Singh (1976) studied genetic divergence in 45 genotypes of chilli. The 45 genotypes were grouped into 10 clusters. The clustering pattern of the genotypes usually did not follow the geographical distribution. It was observed that the number of branches, fruit thickness, number of fruits per plant and yield per plant were the potent factors in differentiating the germplasm of chilli.

Singh et al. (1977) studied genetic divergence in 13 varieties of bhindi. The 13 varieties were grouped into seven clusters. The clustering pattern of the genotypes did not follow the geographical distribution. Number of fruits per plant, days to flowering and plant height contributed maximum to total divergence.

Singh and Singh (1979) conducted multivariate analysis in 30 varieties of okra and noticed that the varieties were grouped into eight clusters. Days to flowering, number of fruits per plant and fruit bearing branches were found to be the important contributors to genetic divergence.

Mehra and Peter (1980) based on multivariate analysis in 27 varieties of chilli grouped these varieties into nine clusters. Number of fruits per plant contributed most to diversity.

In bitter gourd genetic divergence studies were conducted by Ramachandran *et al*. (1981) using 25 diverse genotypes. Observations were recorded on eight quantitative characters. The 25 types were grouped into 10 clusters based on D^2 values. They further reported that the characters yield per plant, fruits per plant and fruit length contributed predominantly to divergence.

Chheda and Fatonkun (1982) studied variability in 296 accessions of *Abelmoschus esculentus* from fifteen countries, based on 29 quantitative and qualitative characters. The results revealed considerable genetic diversity within the species. The accessions were divided into 10 groups.

Bhutani *et al*. (1983) studied genetic divergence in 84 tomato varieties. The 84 lines were grouped into 10 clusters according to divergence for eight characters.

Girenko and Pugacheu (1983) studied the morphological characters of about 300 varieties from 32 countries. Based on the study 13 basic groups were identified and the varieties assigned accordingly. Morphological differences among Indian and North American varieties were small, but they were great among varieties from Africa suggesting that okra originated in that contitent.

In ridge gourd multivariate analysis was conducted by Kadam and Kale (1985) considering 14 vegetative and reproductive characters in 30 cultivars. These cultivars were grouped into 20 clusters based on D^2 value.

Ariyo *et al*. (1987) estimated genetic divergence in 30 *A. esculentus* genotypes originating from Nigeria and elsewhere for 14 agronomic characters. The genotypes were grouped into five clusters using Mahalanobis D^2 statistics. There is no relation between clustering pattern and eco-geographical distribution.

Wahab (1989) studied the divergence in bitter gourd using 50 genotypes and found that the genotypes differed significantly for all the 18 characters studied. The 50 genotypes were grouped into five clusters.

Henry and Krishna (1990) used Mahalanobis D^2 statistics to assess the genetic diversity among 24 genotypes of cluster bean for 10 metric traits. The distribution of genotypes into five different clusters was not according to their places of origin.

Varalakshmi and Haribabu (1991) studied genetic divergence in 32 chilli genotypes for 10 characters and based on D^2 values the genotypes were grouped into 11 clusters. Grouping of the genotypes into clusters was not related to geographical origin.

Devadas et al. (1992) studied genetic divergence in 25 vegetable amaranthus genotypes for 13 biometric characters and based on D^2 value the genotypes were grouped into seven clusters.

Parthi et al. (1993) studied genetic divergence using Mahalanobis D^2 statistics for forteen quantitative characters including yield per plant in a collection of thirteen genotypes of bittergourd. The genotypes were grouped into six clusters. Considerable diversity within and between clusters were noted and it was observed that characters like 100 seed weight, number of seeds per fruit and yield per plant contributed maximum to divergence.

Wahab and Gopalakrishnan (1993) studied genetic divergence in eighteen characters in a collection of fifty genotypes. The genotypes were grouped into five clusters. The study revealed that the grouping pattern of the genotypes was not always directly associated with the geographical diversity.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The studies reported here in were undertaken in the Department of Plant Breeding, College of Agriculture, Vellayani during the period 1991-'93.

3.1. MATERIALS

One hundred and twenty genotypes of bhindi (Abelmoschus esculentus (L.) Moench) exhibiting wide diversity in expression of various economic characters were collected from various sources. Of these, 100 genotypes were obtained from the germplasm collection maintained at the Regional centre of the National Bureau of Plant Genetic Resources, Vellanikkara and 20 genotypes were collected locally from various districts of Kerala.

An initial observational trial was laid out using 120 genotypes from which 70 genotypes exhibiting diverse plant and fruit characters, tolerance to yellow vein mosaic disease and tolerance to shoot and fruit borer were selected (Table 1). These 70 genotype were subjected to selfing and the selfed seeds were collected.

Table 1. Particulars of seventy genotypes of bhindi used for the study

Accession number	NBPGR accession number	District
1	2	3
V_1	NBPGR/TCR - 128	Thrissur
V_2	NBPGR/TCR - 871	Thrissur
V_3	NBPGR/TCR - 475 Sel 86,87	Thrissur
V_4	NBPGR/TCR - 906	Thrissur
V_5	NBPGR/TCR - 877	Thrissur
V_6	NBPGR/TCR - 779	Thrissur
V_7	NBPGR/TCR - 811	Thrissur
V_8	TZA/NR - 519 (Sel-29)	Ernakulam
V_9	NBPGR/TCR - 405 Sel 87 1st	Thrissur
V_{10}	NBPGR/TCR - 901	Thrissur
V_{11}	NBPGR/TCR - 352 Sel 86	Thrissur
V_{12}	NBPGR/TCR - 42	Thrissur
V_{13}	NBPGR/TCR - 32	Thrissur
V_{14}	TZA/NR - 520	Ernakulam
V_{15}	NBPGR/TCR - 861	Thrissur
V_{16}	NBPGR/TCR - 13 1st	Thrissur
V_{17}	NBPGR/TCR - 232 Sel 1st	Thrissur
V_{18}	NBPGR/TCR - 382 Sel 87	Thrissur

Contd...

1	2	3
V_{19}	NBPGR/TCR - 29	Thrissur
V_{20}	NBPGR/TCR - 868	Thrissur
V_{21}	NBPGR/TCR - 380 1st	Thrissur
V_{22}	NBPGR/TCR - 7 2nd	Thrissur
V_{23}	NBPGR/TCR - 178 1st	Thrissur
V_{24}	NBPGR/TCR - 857	Thrissur
V_{25}	TZA/NR - 468	Pathanamthitta
V_{26}	NBPGR/TCR - 899	Thrissur
V_{27}	NBPGR/TCR - 376	Thrissur
V_{28}	NBPGR/TCR - 834	Thrissur
V_{29}	NBPGR/TCR - 854	Thrissur
V_{30}	NBPGR/TCR - 859	Thrissur
V_{31}	NBPGR/TCR - 907	Thrissur
V_{32}	NBPGR/TCR - 783	Thrissur
V_{33}	NBPGR/TCR - 893	Thrissur
V_{34}	NBPGR/TCR - 391	Thrissur
V_{35}	NBPGR/TCR - 17	Thrissur
V_{36}	NBPGR/TCR - 382	Thrissur
V_{37}	NBPGR/TCR - 818	Thrissur
V_{38}	NBPGR/TCR - 904	Thrissur
V_{39}	NBPGR/TCR - 291	Thrissur
V_{40}	NBPGR/TCR - 462	Thrissur

Contd...

1	2	3
V_{41}	NBPGR/TCR - 48 Sel 87	Thrissur
V_{42}	TZA/NR - 477	Trivandrum
V_{43}	NBPGR/TCR - 10 Sel 86	Thrissur
V_{44}	NBPGR/TCR - 27 Sel 87 - 3rd	Thrissur
V_{45}	NBPGR/TCR - 865	Thrissur
V_{46}	NBPGR/TCR - 858	Thrissur
V_{47}	NBPGR/TCR - 422	Thrissur
V_{48}	NBPGR/TCR - 796	Thrissur
V_{49}	NBPGR/TCR - 377	Thrissur
V_{50}	NBPGR/TCR - 421 Sel 86 3rd	Thrissur
V_{51}	NBPGR/TCR - 832	Thrissur
V_{52}	NBPGR/TCR - 775	Thrissur
V_{53}	NBPGR/TCR - 905	Thrissur
V_{54}	Balaramapuram local (5)	Trivandrum
V_{55}	NBPGR/TCR - 695	Thrissur
V_{56}	NBPGR/TCR - 813	Thrissur
V_{57}	NBPGR/TCR - 26	Thrissur
V_{58}	TZA/NR - 511	Ernakulam
V_{59}	TZA/NR - 460	Kottayam
V_{60}	NBPGR/TCR - 863	Thrissur
V_{61}	NBPGR/TCR - 27	Thrissur
V_{62}	NBPGR/TCR - 438	Thrissur

Contd...

1	2	3
V_{63}	NBPGR/TCR - 616	Thrissur
V_{64}	NBPGR/TCR - 356 Sel 86	Thrissur
V_{65}	NBPGR/TCR - 840	Thrissur
V_{66}	NBPGR/TCR - 754	Thrissur
V_{67}	NBPGR/TCR - 878	Thrissur
V_{68}	NBPGR/TCR - 876	Thrissur
V_{69}	NBPGR/TCR - 856	Thrissur
V_{70}	NBPGR/TCR - 864	Thrissur

3.2. METHODS

A field experiment was laid out using the selfed seeds of 70 genotypes in Randomised Block Design with 3 replications during August 1992 for estimating the genetic divergence. The spacing adopted was 75 x 45 cm. The crop received timely management practices as per Package of Practices Recommendations of Kerala Agricultural University.

All the observations were recorded from 5 plants at random in each replication and the mean was taken. The observations on the following characters were recorded.

Biometrical Observations

(1) **Days to first flowering** - Number of days taken for first flowering was recorded in each plant.

(2) **Leaf axil bearing the first flower** - The number of the leaf axil from which the first flower produced was recorded.

(3) **Leaf number** - The total number of leaves produced by each plant was counted.

(4) **Leaf area** - Three leaves were collected from each plant from the 3rd, 6th and 9th node Leaf area was determined using a planimeter and mean expressed in square centimetres.

(5) **Number of branches per plant** - The total number of primary branches in each plant was counted at final harvest and recorded.

(6) **Number of flowers per plant** - The total number of flowers produced per plant was counted and recorded.

(7) **Number of fruit per plant** - The total number of fruits produced per plant was counted and recorded.

(8) **Length of fruit** - Length of fruit was measured from the base to the tip, on the 3rd, 6th and 9th node in each plant and mean expressed in centimetres.

(9) **Girth of fruit** - The fruits used for recording the length were taken for measuring the girth. The girth of fruit was measured and mean expressed in centimetres.

(10) **Weight of single fruit** - Weight of each fruit taken at the time of harvest and mean expressed in grams.

(11) **Weight of fruits per plant** - The weight of fruits per plant was calculated from the product of weight of single fruit and the number of fruits per plant.

(12) **Number of seeds per fruit** - The seeds were extracted from each fruit and the total number counted.

(13) **Fruiting phase** - The duration between first harvest and final harvest in each treatment was recorded.

(14) **Height of the plant** - Height of the plant from the ground level to the tip was measured on the last harvest and expressed in centimetres.

3.2.2. Observations on the incidence of disease and pest

3.2.2.1. Yellow vein mosaic disease

The rating scale by Arumugam _et al_. (1975) was used for scoring yellow vein mosaic disease intensity (Table 2).

The scoring was done according to the characteristic symptoms appearing on the leaves or the fruits of each observational plant.

The disease rating mean of each treatment in a replication was calculated as follows:

$$\text{Mean disease rating} = \frac{\text{Sum of disease scores in the observational plants}}{\text{Number of plants}}$$

3.2.2.2. Shoot and fruit borer incidence

Infestation on the shoot and fruit by shoot and fruit borer (_Earias vitella_ F.) in the observational plants recorded, averaged and expressed in percentage.

Table 2. Yellow vein mosaic disease scoring

	Symptom	Grade	Rating Scale
(1)	No visible symptoms characteristic of the disease.	Highly resistant	1
(2)	Very mild symptoms-basal half of primary veins green and mild yellowing of anterior half of primary vein and veinlets.	Resistant	2
(3)	Vein and veinlets turn completely yellow.	Moderately resistant	3
(4)	Pronounced yellowing of vein and veinlets - 50% of leaf lamina turned yellow, fruits exhibit slight yellowing.	Susceptible	4
(5)	Petiole, veins, veinlets and interveinal area turn yellow in colour, leaves start drying from margin, fruits turn yellow in colour	Highly susceptible	5

3.2.3. Statistical Analysis

3.2.3.1. Analysis of variance (ANOVA) and Covariance (ANOCOVA) were used for the estimation of the various genetic parameters

For the characters x_i and x_j

(i) Mean $(\overline{x_i})$

(ii) Environmental variance $= \sigma^2_{ei} =$ MSE

(iii) Genotypic variance $= \sigma^2_{gi} = \frac{MST + MSE}{r}$

(iv) Phenotypic variance $= \sigma^2_{pi} = \sigma^2_{gi} + \sigma^2_{ei}$

where MST and MSE are the mean squares for treatment and error respectively from ANOVA.

(v) Environmental covariance $= \sigma_{eij} =$ MSPE

(vi) Phenotypic covariance $= \sigma_{gij} =$ MSPT

(vii) Phenotypic variance $= \sigma^2_{pij} = \sigma^2_{gij} + \sigma^2_{eij}$

where MSPE and MSPT are respectively the mean sum of products between the characters x_i and x_j from ANOCOVA

(viii) Phenotypic coefficient of variance PCV $= \frac{\overline{x_i}}{\sigma_{pi}} \times 100$

(ix) Genotypic coefficient of variation GCV $= \frac{\overline{x_i}}{\sigma_{gi}} \times 100$

(x) Heritability coefficient $H^2 = \frac{\sigma^2_{gi}}{\sigma^2_{pi}} \times 100$

(xi) Genetic advance GA

on percentage of mean $= K H^2 \frac{\sigma_{pi}}{\overline{x_i}} \times 100$

where K, the selection differential = 2.06 at 5% selection.

3.2.3.2. Grouping of the varieties

The varieties were classified into low, medium and high gro respect to each character as follows :

Less than mean - SEm	Low
Between mean ±SEm	Medium
Above mean +SEm	High

3.2.3.3. Path Analysis

The direct and indirect effects of yield contributing factors were estimated through Path Analysis technique (Dewey and Lu, 1959).

3.2.3.4. D^2 - Analysis

The 70 genotypes were grouped based on 14 characters taken together through Mahalanobis D^2 - analysis (Rao, 1957).

RESULTS

4. RESULTS

The results of the experiment are presented below:

4.1 Variability analysis

The data collected on 16 characters were subjected to analysis of variance for testing the significance of differences among the genotypes with respect to these characters and the results are presented in Table 3.

The 70 types of bhindi studied exhibited significant differences for the 16 characters viz., days to first flowering, leaf number, leaf area, number of branches per plant, number of flowers per plant, number of fruits per plant, length of fruit, girth of fruit, weight of single fruit, weight of fruits per plant, number of seed per fruit, height of the plant, yellow vein mosaic intensity and shoot and fruit borer incidence. Fruiting phase and leaf axil bearing the first flower were not found to be influenced by varietal differences.

Table 3. Variations among the genotypes for different characters

	Days to first flowering X_1	Leaf axil bearing the first flower X_2	Number of leaves per plant X_3	Leaf area (cm^2) X_4	Number of branches per plant X_5	Number of flowers per plant X_6	Number of fruits per plant X_7	Length of fruit (cm) X_8
V_1	45.67	3.67	20.67	139.54	2.33	8.33	6.33	16.33
V_2	45.00	5.00	25.67	146.84	2.33	8.66	5.66	16.66
V_3	50.00	4.34	25.34	172.98	2.33	7.66	5.33	14.00
V_4	46.34	4.34	23.66	225.42	2.00	9.33	7.33	15.66
V_5	47.34	4.67	26.33	129.17	3.00	8.33	6.00	16.00
V_6	44.34	4.00	26.00	151.26	2.67	8.33	6.00	8.33
V_7	44.34	4.00	19.66	166.44	2.67	7.66	5.00	15.66
V_8	44.67	4.34	21.00	174.88	2.34	11.80	9.33	21.00
V_9	50.67	5.00	20.00	157.21	3.66	7.66	4.66	17.00
V_{10}	43.00	3.67	21.00	135.68	2.33	8.00	5.00	21.00
V_{11}	46.00	5.00	23.66	176.37	3.34	10.00	7.00	20.67
V_{12}	48.00	4.00	21.33	166.41	1.66	9.00	6.00	21.34
V_{13}	50.67	4.67	24.00	111.66	2.67	8.33	4.66	13.34
V_{14}	42.33	4.37	23.66	132.80	2.00	7.00	4.67	16.33
V_{15}	45.00	4.34	15.00	211.11	2.66	5.33	3.67	15.00
V_{16}	42.00	4.34	26.33	134.58	2.33	8.67	6.33	17.67
V_{17}	47.00	6.00	27.00	111.02	2.00	7.66	5.00	17.67
V_{18}	43.67	4.00	26.66	154.81	2.00	8.33	6.00	21.00
V_{19}	50.34	3.67	21.33	135.28	1.66	8.00	6.00	14.67
V_{20}	49.37	4.34	26.00	154.67	2.33	10.67	8.67	22.37
V_{21}	47.34	5.00	26.00	156.79	4.33	10.33	7.67	17.37
V_{22}	46.34	3.34	23.61	129.08	2.67	7.66	5.00	16.00

Contd...

Table 3 (Contd...)

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Y_{23}	44.67	4.34	14.60	121.72	2.33	8.66	5.34	15.33
Y_{24}	48.00	4.67	27.33	162.77	2.66	8.00	6.00	15.33
Y_{25}	49.00	4.67	24.00	123.47	2.00	7.66	5.67	19.00
Y_{26}	44.67	4.00	22.00	107.01	2.33	7.33	5.00	16.33
Y_{27}	51.00	4.00	24.60	110.32	2.33	9.00	7.00	17.33
Y_{28}	42.34	4.34	23.33	153.79	2.66	7.66	6.34	20.00
Y_{29}	45.34	4.00	35.33	161.51	2.66	7.67	7.00	13.00
Y_{30}	39.67	4.00	21.66	141.80	2.67	8.33	7.67	15.00
Y_{31}	46.34	3.00	26.33	148.50	2.00	7.67	5.34	13.67
Y_{32}	49.67	4.34	25.00	122.41	2.66	7.33	5.00	17.67
Y_{33}	49.00	4.00	15.66	104.58	2.66	10.67	9.00	15.67
Y_{34}	49.00	4.67	23.66	112.76	2.33	7.66	5.00	13.33
Y_{35}	43.67	3.34	19.00	119.83	2.66	8.00	6.00	23.00
Y_{36}	39.67	4.34	21.33	129.00	2.66	7.33	4.67	19.67
Y_{37}	47.00	4.67	22.33	125.50	2.00	7.66	5.67	22.67
Y_{38}	43.34	4.67	22.00	172.21	3.61	7.66	6.67	15.37
Y_{39}	42.00	5.00	19.00	119.86	2.33	8.00	5.66	16.67
Y_{40}	47.34	4.00	24.66	159.87	2.33	9.00	6.67	14.67
Y_{41}	44.33	4.00	28.33	147.01	1.66	7.66	5.34	15.67
Y_{42}	47.34	3.67	33.66	124.66	2.33	7.00	4.67	14.67
Y_{43}	43.33	4.67	22.33	131.00	3.00	7.67	6.00	15.33
Y_{44}	41.67	3.67	23.66	111.67	2.34	8.00	6.00	17.67
Y_{45}	42.68	5.00	25.66	159.03	2.00	9.66	8.00	20.33
Y_{46}	49.34	4.37	22.66	124.22	2.67	7.66	5.00	9.00
Y_{47}	48.67	4.34	17.33	147.02	3.00	10.66	8.67	15.00
Y_{48}	50.67	4.34	27.33	118.89	2.00	7.66	6.34	15.00
Y_{49}	42.67	6.00	21.00	112.74	2.67	8.00	6.34	18.67
Y_{50}	52.34	4.00	28.00	164.30	2.33	8.00	6.00	16.00

Table 3 (Contd...)

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
V_{51}	48.67	4.67	23.66	152.88	2.66	8.00	5.34	17.33
V_{52}	48.00	6.00	28.33	125.60	2.67	7.66	6.34	14.67
V_{53}	47.00	4.34	28.00	146.94	2.66	9.67	7.34	16.33
V_{54}	48.67	4.00	25.66	182.14	2.33	10.00	8.00	19.67
V_{55}	50.67	4.34	24.33	149.90	3.33	8.33	7.00	13.00
V_{56}	46.33	4.67	21.66	125.20	2.33	8.00	6.67	10.33
V_{57}	48.33	4.34	25.67	125.31	1.60	8.66	6.00	16.33
V_{58}	47.67	4.34	30.33	113.64	3.00	6.66	4.34	21.33
V_{59}	49.34	5.00	36.33	141.22	2.00	7.66	6.00	16.67
V_{60}	52.00	4.67	27.80	107.72	1.61	7.67	5.00	20.00
V_{61}	49.33	4.34	27.67	174.53	2.66	8.67	6.34	18.67
V_{62}	49.32	4.00	26.67	203.13	2.33	10.67	7.64	15.67
V_{63}	51.00	5.00	23.33	164.16	2.33	8.00	7.00	18.67
V_{64}	47.34	4.00	22.67	150.83	2.66	8.67	8.00	24.00
V_{65}	49.67	4.67	26.66	126.20	2.66	8.00	6.34	12.33
V_{66}	40.33	4.34	31.66	145.90	4.00	8.67	7.67	14.00
V_{67}	49.67	4.00	18.00	114.18	2.33	6.00	5.00	19.00
V_{68}	46.67	4.67	27.33	146.46	3.66	8.33	6.00	18.00
V_{69}	45.66	4.34	24.67	158.17	3.00	8.67	7.00	15.33
V_{70}	48.67	4.00	33.34	188.79	5.00	11.67	8.67	20.67
F	3.35*	1.01	2.80*	11.71**	2.54*	3.64*	4.23*	20.64**
SE	1.68	0.46	2.53	7.53	0.38	0.59	0.59	0.69
CD	4.67		7.01	20.88	1.05	1.64	1.64	1.91

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

	Girth of fruit cm X_9	Weight of single fruit (g) X_{10}	Weight of fruits per plant (g) X_{11}	Number of seeds per fruit X_{12}	Fruiting phase (days) X_{13}	Height of the plant (cm) X_{14}	YVM intensity (1-5 scale) X_{15}	Shoot and fruit borer incidence (%) X_{16}
V_1	7.34	20.37	129.16	77.66	52.00	58.00	2.33	23.7
V_2	7.34	23.27	131.66	69.66	53.30	65.00	2.33	19.0
V_3	7.34	24.61	131.66	75.66	52.66	61.00	2.33	14.2
V_4	7.00	15.24	111.48	79.00	52.33	63.00	2.00	0.0
V_5	7.34	25.46	152.93	82.00	54.00	71.66	2.33	0.0
V_6	6.67	29.71	176.75	87.66	50.33	67.33	1.00	0.0
V_7	7.00	20.49	102.88	81.66	52.67	94.66	1.66	19.0
V_8	7.00	19.87	185.22	75.66	50.00	97.00	1.00	0.0
V_9	6.67	19.68	90.17	74.33	50.67	59.66	2.00	9.4
V_{10}	7.00	25.30	127.84	73.66	51.33	73.34	2.33	0.0
V_{11}	6.67	27.38	191.93	76.34	51.33	59.67	1.00	0.0
V_{12}	6.34	21.10	140.73	74.34	50.33	56.33	2.33	14.2
V_{13}	6.67	10.16	46.80	64.34	50.66	62.00	1.66	4.7
V_{14}	7.34	17.16	81.33	74.66	51.67	58.33	2.00	9.4
V_{15}	10.67	17.60	98.50	89.66	51.67	51.00	1.66	4.7
V_{16}	7.67	22.80	144.06	77.00	50.00	65.33	1.66	0.0
V_{17}	8.00	15.54	77.10	77.00	52.33	56.00	2.00	0.0
V_{18}	7.34	18.04	109.78	67.66	51.33	61.33	2.33	14.2
V_{19}	7.34	18.49	112.23	81.33	50.67	67.66	2.00	14.2
V_{20}	7.00	22.54	196.23	78.34	55.67	63.66	2.66	9.4
V_{21}	6.34	21.12	224.10	71.34	51.33	61.66	2.00	4.7
V_{22}	7.00	27.14	134.30	75.00	49.67	56.00	2.66	14.2

Contd...

Table 3 (Contd...)

	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
Y_{23}	6.67	14.68	79.23	79.00	49.33	84.66	1.00	23.71
Y_{24}	6.67	22.48	133.61	78.66	51.33	53.00	2.33	33.28
Y_{25}	7.34	22.36	127.94	76.66	50.67	75.00	2.00	0.00
Y_{26}	6.67	17.31	86.00	77.00	52.67	60.66	2.66	4.71
Y_{27}	8.67	28.08	198.94	71.00	55.33	52.33	1.00	28.57
Y_{28}	8.67	19.73	170.89	80.34	50.67	61.00	1.00	4.74
Y_{29}	7.00	19.44	135.42	80.34	50.66	61.33	2.33	9.42
Y_{30}	7.34	23.19	176.99	82.34	52.37	57.00	1.66	9.42
Y_{31}	7.00	24.40	130.35	76.00	52.00	65.34	3.00	0.00
Y_{32}	8.33	29.58	106.88	77.66	49.00	64.66	2.66	0.00
Y_{33}	7.00	17.84	159.14	67.34	53.33	63.33	2.00	33.28
Y_{34}	7.00	17.48	107.22	69.00	49.12	73.66	2.00	23.77
Y_{35}	6.00	23.72	109.80	73.66	50.00	66.00	2.00	23.71
Y_{36}	7.00	22.79	106.38	85.34	46.10	61.33	2.00	23.71
Y_{37}	7.00	24.87	142.52	71.34	51.60	72.00	2.66	23.71
Y_{38}	8.00	26.43	175.02	82.66	48.66	76.00	1.66	14.28
Y_{39}	7.34	11.37	65.70	75.34	53.00	68.34	1.00	14.28
Y_{40}	8.67	17.62	118.06	87.34	51.00	62.67	2.00	28.57
Y_{41}	7.00	15.39	81.75	66.66	48.10	62.67	2.66	0.00
Y_{42}	7.00	13.67	64.14	85.00	49.33	70.0[illegible]	2.66	28.50
Y_{43}	7.67	15.41	92.90	78.66	49.33	64.00	3.00	19.00
Y_{44}	6.67	20.26	124.13	81.66	53.66	60.67	1.00	33.28
Y_{45}	7.34	29.91	241.48	83.08	53.66	63.33	2.66	0.00
Y_{46}	6.67	14.41	71.77	82.00	50.33	52.67	2.33	0.00
Y_{47}	7.00	10.49	91.73	83.00	54.00	91.66	2.00	0.80
Y_{48}	8.00	19.49	124.17	79.34	52.00	50.00	1.00	23.71
Y_{49}	6.67	20.91	132.96	69.66	50.62	87.00	2.33	23.71
Y_{50}	6.67	30.82	182.20	86.00	50.00	66.08	2.66	14.28

Contd...

Table 3 (Contd...)

	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
Y_{51}	7.67	22.59	120.75	77.00	51.67	67.34	3.00	19.00
Y_{52}	9.67	17.60	124.95	67.33	52.00	65.34	2.33	0.00
Y_{53}	7.67	21.75	166.35	81.66	51.33	74.00	2.00	14.28
Y_{54}	7.67	23.38	185.64	76.77	51.67	62.00	1.66	19.00
Y_{55}	6.34	26.05	182.18	86.66	51.67	79.00	2.33	23.71
Y_{56}	7.34	21.32	140.51	71.00	54.67	61.33	2.33	19.00
Y_{57}	8.00	15.67	94.15	66.00	46.21	65.66	2.33	14.28
Y_{58}	7.67	23.94	107.06	55.67	52.33	84.33	2.00	4.71
Y_{59}	7.67	16.47	92.76	80.34	47.21	73.34	2.33	4.71
Y_{60}	6.67	19.00	96.33	80.34	49.00	65.00	2.33	23.71
Y_{61}	6.34	30.00	194.40	69.66	51.67	78.00	2.33	28.57
Y_{62}	7.34	15.84	121.96	83.80	54.67	62.33	2.00	19.00
Y_{63}	7.00	22.89	162.04	72.66	50.33	68.66	2.33	23.71
Y_{64}	7.00	23.14	184.47	76.00	58.67	73.00	1.00	28.57
Y_{65}	7.00	23.24	145.98	80.34	51.66	62.33	2.33	19.00
Y_{66}	7.34	17.24	132.87	79.34	50.33	85.66	2.66	0.00
Y_{67}	8.33	21.93	109.29	84.00	52.00	67.00	1.00	9.47
Y_{68}	8.00	29.83	180.42	84.66	55.33	63.00	2.33	0.00
Y_{69}	7.67	25.10	177.01	84.34	50.33	85.00	2.33	0.00
Y_{70}	9.67	29.86	259.70	75.34	53.66	98.00	1.00	23.71
F	4.07*	11.40**	7.12**	2.19*	0.88	20.19**	2.51*	5.59*
SE	0.39	1.43	16.31	4.21	1.81	2.39	0.36	0.30
CD	1.04	3.98	45.23	11.69		6.64	0.99	0.85

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

The variances were classified into three, based on normal distribution property as follows.

Criterion	Category
< Mean – SE (mean)	Low
Between mean $\pm$ SE (mean)	Medium
> Mean + SE (mean)	High

Table 4. Distribution of genotypes into low, medium and high classes

Character	Low	Medium	High
X_1	(< 45.02)	(45.02 – 48.32)	(> 48.32)
Days to first flowering	$V_2, V_6, V_8, V_{10}, V_{14}$ $V_{15}, V_{16}, V_{18}, V_{23}, V_{25}$ $V_{26}, V_{28}, V_{30}, V_{35}, V_{36}$ $V_{38}, V_{39}, V_{41}, V_{43}, V_{44}$ V_{45}, V_{49}, V_{66}	$V_1, V_4, V_5, V_7, V_{11}, V_{12}$ $V_{17}, V_{21}, V_{22}, V_{24}, V_{29},$ $V_{31}, V_{37}, V_{40}, V_{42}, V_{51}$ $V_{52}, V_{53}, V_{56}, V_{57}, V_{58}$ $V_{64}, V_{65}, V_{68}, V_{69}$	$V_3, V_9, V_{13}, V_{19}, V_{20}$ $V_{27}, V_{32}, V_{33}, V_{34}, V_{46}$ $V_{47}, V_{48}, V_{50}, V_{54}, V_{55}$ $V_{59}, V_{60}, V_{61}, V_{62}, V_{63}$ V_{67}, V_{70}
X_2	(< 3.87)	(3.87 – 4.81)	(> 4.81)
Leaf axil bearing the first flower	$V_1, V_2, V_{10}, V_9, V_{22}$ $V_{31}, V_{35}, V_{42}, V_{44}$	$V_3, V_4, V_5, V_6, V_7, V_8$ $V_{12}, V_{13}, V_{14}, V_{15}, V_{16}$ $V_{18}, V_{20}, V_{23}, V_{24}, V_{25}$ $V_{26}, V_{27}, V_{28}, V_{29}, V_{30}$ $V_{32}, V_{33}, V_{34}, V_{36}, V_{37}$ $V_{38}, V_{40}, V_{41}, V_{43}, V_{46}$ $V_{47}, V_{48}, V_{50}, V_{51}, V_{53}$ $V_{54}, V_{55}, V_{56}, V_{57}, V_{58}$ $V_{60}, V_{61}, V_{62}, V_{64}, V_{65}$ $V_{66}, V_{67}, V_{68}, V_{69}, V_{70}$	$V_9, V_{11}, V_{17}, V_{21}$ $V_{39}, V_{45}, V_{49}, V_{52}$ V_{59}, V_{63}

Table 4 (Contd...)

Character	Low	Medium	High
X_3	(< 21.88)	(21.88 - 26.99)	(> 26.99)
Number of leaves per plant	$V_1, V_7, V_8, V_9, V_{10}, V_{12}$ $V_{15}, V_{19}, V_{23}, V_{30}, V_{33}$ $V_{35}, V_{36}, V_{39}, V_{47}, V_{49}$ V_{56}, V_{67}	$V_2, V_3, V_4, V_5, V_6, V_{11}$ $V_{13}, V_{14}, V_{16}, V_{18}, V_{20}$ $V_{21}, V_{22}, V_{25}, V_{26}, V_{27}$ $V_{28}, V_{31}, V_{32}, V_{34}, V_{37}$ $V_{38}, V_{40}, V_{43}, V_{44}, V_{45}$ $V_{46}, V_{51}, V_{54}, V_{55}, V_{57}$ $V_{62}, V_{63}, V_{64}, V_{65}, V_{69}$	$V_{17}, V_{24}, V_{29}, V_{41}, V_{42}$ $V_{48}, V_{50}, V_{52}, V_{53}, V_{58}$ $V_{59}, V_{60}, V_{61}, V_{66}, V_{68}$ V_{70}
X_4	(<136.02)	(136.02 - 151.11)	(> 151.11)
Leaf area	$V_5, V_{10}, V_{13}, V_{14}, V_{16}$ $V_{17}, V_{19}, V_{22}, V_{23}, V_{25}$ $V_{26}, V_{27}, V_{32}, V_{33}, V_{34}$ $V_{35}, V_{36}, V_{37}, V_{39}, V_{42}$ $V_{43}, V_{44}, V_{46}, V_{48}, V_{49}$ $V_{52}, V_{56}, V_{57}, V_{58}, V_{60}$ V_{65}, V_{67}, V_{68}	$V_1, V_2, V_{30}, V_{31}, V_{41},$ $V_{47}, V_{53}, V_{55}, V_{59}, V_{64}$ V_{66}	$V_3, V_4, V_6, V_7, V_8, V_9$ $V_{11}, V_{12}, V_{15}, V_{18}, V_{20}$ $V_{21}, V_{24}, V_{28}, V_{29}, V_{38}$ $V_{40}, V_{45}, V_{50}, V_{51}, V_{54}$ $V_{61}, V_{62}, V_{63}, V_{69}, V_{70}$
X_5	(< 2.39)	(2.39 - 3.15)	(> 3.15)
Number of branches per plant	$V_1, V_2, V_3, V_4, V_8, V_{10}$ $V_{12}, V_{14}, V_{16}, V_{17}, V_{18}$ $V_{19}, V_{20}, V_{23}, V_{25}, V_{26}$ $V_{27}, V_{31}, V_{34}, V_{37}, V_{39}$ $V_{40}, V_{41}, V_{42}, V_{44}, V_{45},$ $V_{48}, V_{50}, V_{54}, V_{56}, V_{57},$ $V_{59}, V_{60}, V_{62}, V_{63}, V_{66},$ V_{67}	$V_5, V_6, V_7, V_{13}, V_{15}$ $V_{22}, V_{24}, V_{28}, V_{29}, V_{30}$ $V_{32}, V_{33}, V_{35}, V_{36}, V_{43}$ $V_{46}, V_{47}, V_{49}, V_{51}, V_{52}$ $V_{53}, V_{58}, V_{61}, V_{64}, V_{65}$ V_{69}	$V_9, V_{11}, V_{21}, V_{38}, V_{55}$ V_{68}, V_{70}

Table 4 (Contd...)

Character	Low	Medium	High
X_6	(< 7.74)	(7.74 - 8.92)	(> 8.92)
Number of flowers per plant	$V_3, V_7, V_9, V_{14}, V_{15}, V_{17}, V_{22}, V_{25}, V_{26}, V_{28}, V_{29}, V_{31}, V_{32}, V_{34}, V_{36}, V_{37}, V_{38}, V_{41}, V_{42}, V_{43}, V_{46}, V_{48}, V_{52}, V_{58}, V_{59}, V_{60}, V_{67}$	$V_1, V_2, V_5, V_6, V_{10}, V_{13}, V_{16}, V_{18}, V_{19}, V_{23}, V_{24}, V_{30}, V_{35}, V_{39}, V_{44}, V_{49}, V_{50}, V_{51}, V_{55}, V_{56}, V_{57}, V_{61}, V_{63}, V_{64}, V_{65}, V_{66}, V_{68}, V_{69}$	$V_4, V_8, V_{11}, V_{12}, V_{20}, V_{21}, V_{27}, V_{33}, V_{40}, V_{45}, V_{47}, V_{53}, V_{54}, V_{62}, V_{70}$
X_7	(< 5.63)	(5.63 - 6.81)	(> 6.81)
Number of fruits per plant	$V_3, V_7, V_9, V_{10}, V_{13}, V_{14}, V_{17}, V_{22}, V_{23}, V_{26}, V_{31}, V_{32}, V_{34}, V_{36}, V_{41}, V_{42}, V_{46}, V_{51}, V_{58}, V_{60}, V_{67}$	$V_1, V_2, V_5, V_6, V_{12}, V_{16}, V_{18}, V_{19}, V_{24}, V_{25}, V_{28}, V_{35}, V_{37}, V_{38}, V_{39}, V_{40}, V_{43}, V_{44}, V_{48}, V_{49}, V_{50}, V_{52}, V_{56}, V_{57}, V_{59}, V_{61}, V_{65}, V_{68}$	$V_4, V_8, V_{11}, V_{20}, V_{21}, V_{27}, V_{29}, V_{30}, V_{33}, V_{45}, V_{47}, V_{53}, V_{54}, V_{55}, V_{62}, V_{63}, V_{64}, V_{66}, V_{69}, V_{70}$
X_8	(< 16.13)	(16.13 - 17.51)	(> 17.51)
Length of fruit	$V_3, V_4, V_5, V_6, V_7, V_{13}, V_{15}, V_{19}, V_{22}, V_{23}, V_{24}, V_{29}, V_{30}, V_{31}, V_{33}, V_{34}, V_{38}, V_{40}, V_{41}, V_{42}, V_{43}, V_{45}, V_{46}, V_{47}, V_{48}, V_{50}, V_{52}, V_{55}, V_{56}, V_{62}, V_{65}, V_{66}, V_{69}$	$V_1, V_2, V_9, V_{14}, V_{21}, V_{26}, V_{27}, V_{39}, V_{51}, V_{53}, V_{57}, V_{59}$	$V_8, V_{10}, V_{11}, V_{12}, V_{16}, V_{17}, V_{18}, V_{20}, V_{25}, V_{28}, V_{32}, V_{35}, V_{36}, V_{37}, V_{44}, V_{49}, V_{54}, V_{58}, V_{60}, V_{61}, V_{63}, V_{64}, V_{67}, V_{68}, V_{70}$

Character	Low	Medium	High
X_9	(< 6.93)	(6.93 - 7.71)	(> 7.71)
Girth of fruit	$V_6, V_9, V_{11}, V_{12}, V_{13}, V_{21}, V_{23}, V_{24}, V_{26}, V_{35}, V_{44}, V_{46}, V_{49}, V_{50}, V_{55}, V_{60}, V_{61}$	$V_1, V_2, V_3, V_4, V_5, V_7, V_8, V_{10}, V_{14}, V_{16}, V_{18}, V_{19}, V_{20}, V_{22}, V_{25}, V_{28}, V_{29}, V_{30}, V_{32}, V_{33}, V_{34}, V_{36}, V_{37}, V_{39}, V_{41}, V_{42}, V_{43}, V_{45}, V_{47}, V_{51}, V_{53}, V_{54}, V_{56}, V_{58}, V_{59}, V_{62}, V_{63}, V_{64}, V_{65}, V_{66}, V_{69}$	$V_{15}, V_{17}, V_{27}, V_{31}, V_{38}, V_{40}, V_{48}, V_{52}, V_{57}, V_{67}, V_{68}, V_{70}$
X_{10}	(< 19.66)	(19.66 - 22.52)	(> 22.52)
Weight of single fruit	$V_4, V_{13}, V_{14}, V_{15}, V_{17}, V_{18}, V_{19}, V_{23}, V_{26}, V_{29}, V_{33}, V_{34}, V_{39}, V_{40}, V_{41}, V_{42}, V_{43}, V_{46}, V_{47}, V_{48}, V_{57}, V_{59}, V_{60}, V_{62}, V_{66}$	$V_1, V_7, V_8, V_9, V_{12}, V_{21}, V_{24}, V_{25}, V_{28}, V_{32}, V_{44}, V_{49}, V_{53}, V_{56}, V_{67}$	$V_2, V_3, V_5, V_6, V_{10}, V_{11}, V_{16}, V_{20}, V_{22}, V_{27}, V_{30}, V_{31}, V_{35}, V_{36}, V_{37}, V_{38}, V_{45}, V_{50}, V_{51}, V_{52}, V_{54}, V_{55}, V_{58}, V_{61}, V_{63}, V_{64}, V_{65}, V_{68}, V_{69}, V_{70}$
X_{11}	(< 118.04)	(118.04 - 150.66)	(> 150.66)
Weight of fruits per plant	$V_4, V_7, V_9, V_{13}, V_{14}, V_{15}, V_{17}, V_{18}, V_{19}, V_{23}, V_{26}, V_{32}, V_{34}, V_{35}, V_{36}, V_{39}, V_{41}, V_{42}, V_{43}, V_{46}, V_{47}, V_{57}, V_{58}, V_{59}, V_{60}, V_{67}$	$V_1, V_2, V_3, V_{10}, V_{12}, V_{16}, V_{21}, V_{22}, V_{24}, V_{25}, V_{29}, V_{31}, V_{37}, V_{40}, V_{44}, V_{48}, V_{49}, V_{51}, V_{52}, V_{56}, V_{62}, V_{65}, V_{66}$	$V_5, V_6, V_8, V_{11}, V_{20}, V_{27}, V_{28}, V_{30}, V_{33}, V_{38}, V_{45}, V_{50}, V_{53}, V_{54}, V_{55}, V_{61}, V_{63}, V_{64}, V_{68}, V_{69}, V_{70}$

Table 4 (Contd...)

Character	Low	Medium	High
X_{12}	(< 72.85)	(72.85 - 81.28)	(> 81.28)
Number of seeds per fruit	$V_2, V_{13}, V_{18}, V_{21}, V_{27}, V_{33}, V_{34}, V_{37}, V_{41}, V_{49}, V_{52}, V_{56}, V_{57}, V_{58}, V_{61}, V_{63}$	$V_1, V_3, V_4, V_8, V_9, V_{10}, V_{11}, V_{12}, V_{14}, V_{16}, V_{17}, V_{20}, V_{22}, V_{23}, V_{24}, V_{25}, V_{26}, V_{28}, V_{29}, V_{31}, V_{32}, V_{35}, V_{39}, V_{43}, V_{48}, V_{51}, V_{54}, V_{59}, V_{60}, V_{64}, V_{65}, V_{66}$	$V_5, V_6, V_7, V_{15}, V_{19}, V_{30}, V_{36}, V_{38}, V_{40}, V_{42}, V_{44}, V_{45}, V_{46}, V_{47}, V_{50}, V_{53}, V_{55}, V_{62}, V_{67}, V_{68}, V_{69}, V_{70}$

Character	Low	Medium	High
X_{13}	(< 49.95)	(49.95 - 53.58)	(> 53.58)
Fruiting phase	$V_{22}, V_{23}, V_{32}, V_{34}, V_{38}, V_{60}$	$V_1, V_2, V_3, V_4, V_6, V_7, V_8, V_9, V_{10}, V_{11}, V_{12}, V_{13}, V_{14}, V_{15}, V_{16}, V_{17}, V_{18}, V_{19}, V_{21}, V_{24}, V_{25}, V_{26}, V_{28}, V_{29}, V_{30}, V_{31}, V_{33}, V_{35}, V_{37}, V_{39}, V_{40}, V_{41}, V_{42}, V_{43}, V_{46}, V_{48}, V_{49}, V_{50}, V_{51}, V_{52}, V_{53}, V_{54}, V_{55}, V_{58}, V_{59}, V_{61}, V_{63}, V_{64}, V_{65}, V_{66}, V_{67}, V_{69}$	$V_5, V_{20}, V_{27}, V_{36}, V_{44}, V_{45}, V_{47}, V_{56}, V_{57}, V_{62}, V_{68}, V_{70}$

Table 4 (Contd...)

X_{14}	(< 64.97)	(64.97 - 69.76)	(> 69.76)
Height of the plant	$V_1, V_3, V_4, V_9, V_{11}, V_{12}, V_{13}, V_{14}, V_{15}, V_{17}, V_{18}, V_{20}, V_{21}, V_{22}, V_{24}, V_{26}, V_{27}, V_{28}, V_{29}, V_{30}, V_{32}, V_{33}, V_{36}, V_{40}, V_{41}, V_{43}, V_{44}, V_{45}, V_{48}, V_{54}, V_{56}, V_{62}, V_{65}, V_{68}$	$V_2, V_6, V_{16}, V_{19}, V_{31}, V_{35}, V_{39}, V_{50}, V_{51}, V_{52}, V_{57}, V_{60}, V_{63}, V_{67}$	$V_5, V_7, V_8, V_{10}, V_{23}, V_{25}, V_{34}, V_{37}, V_{38}, V_{42}, V_{46}, V_{47}, V_{49}, V_{53}, V_{55}, V_{58}, V_{59}, V_{61}, V_{64}, V_{66}, V_{69}, V_{70}$

For the character leaf axil bearing the first flower, 10 types came under high class and the values were above 4.81. Fifty one types came under medium class and the values were between 3.87 and 4.81. Nine types were recorded below 3.87 and were categorised as low class.

In the case of days to first flowering 22 types came under high class and the values were above 48.32. Twenty five types were in between 45.02 and 48.32. Twenty three types below 45.02 were categorised as low class.

In case of number of leaves, 16 types were grouped under high class and the values were above 26.99. Thirty six types were recorded between 21.88 and 26.99, so are categorised as medium class. Eighteen types recorded below 21.88, which were categorised as low class.

For leaf area 26 types were categorised as high class and the values were above 151.11. Eleven types were recorded under medium class. Thirty three types categorised as low had values below 136.02..

For number of branches, seven types came under high class and the values were above 3.15. Twenty six types which had values in between 2.39 and 3.15 were categorised as medium class. Under low class 37 types were recorded and the values were below 2.39.

In case of number of flowers per plant, 27 types came under high class and the values were above 8.92. In the medium class there were 28 types having values between 7.74 and 8.92. Fifteen types were grouped as low class which had values below 7.74.

In case of number of fruits per plant 20 types were classified under high class having values above 6.81. Twenty eight types were categorised as medium class ie., between 5.63 and 6.81. Twentytwo types categorised as low, values were below 5.63.

In case of the length of fruit 25 types grouped as high class valued above 17.51. Twelve types come in between 16.13 and 17.51, ie. under medium class. Thirty three types were grouped under low class falling below 16.13.

For girth of fruit 12 types were grouped as high class with values above 7.71. Forty one types came in between 6.93 and 7.71 and fell in the medium class. Seventeen types were grouped under low class with values below 6.93.

In case of weight of single fruit 30 types with values above 22.52 came under the high class. Fifteen types between 19.66 and 22.52 came under the medium class. Twenty five types came under low class with values below 19.66.

In case of weight of fruits per plant 21 types were grouped under high class with values above 150.66. Twenty three types were between 118.04 and 150.66 and fell in the medium class. Twenty six types were below 118.04 and were grouped as low class.

For the number of seeds per fruit 22 types were grouped as high class with values above 81.28. Thirty two types came under medium class ie. between 72.85 and 81.28. Sixteen types were grouped as low class having values below 72.85.

With respect to fruiting phase, 12 types were grouped as high class with values above 53.58. Fifty two types were grouped as medium class with values between 49.95 and 53.58. Six types came under low class with values below 49.95.

For the character height of the plant 22 types were grouped as high class with values above 69 76. Fourteen types came under medium class with values varying between 64.97 and 69.76. Thirty four types came under low class with values below 64.97.

4.2 Genetic Parameters

The phenotypic coefficient of variation, the genotypic coefficient of variation, heritability in broad sense and expected genetic advance were estimated and are presented in Table 5 and Fig. 1.

4.2.1 Phenotypic coefficient of variation (PCV)

Maximum PCV was recorded for weight of fruits per plant (36.69) and minimum for days to first flowering (8.35). Number of branches per plant was also highly variable.

4.2.2 Genotypic coefficient of variation (GCV)

Maximum GCV was recorded by weight of fruits per

Table 5. Genetic parameters with respect to various characters

Characters	Mean	SE	PCV	GCV	H^2%	G.A.as % of mean
Days to first flowering	46.70	1.68	8.35	5.54	44.00	7.57
Leaf axil bearing the first flower	4.34	0.46	18.61	0.91	0.24	0.09
Number of leaves per plant	24.41	2.53	22.75	13.92	37.53	17.57
Leaf area (cm^2)	143.61	7.53	19.43	17.17	78.12	31.27
Number of branches per plant	2.77	0.38	31.67	18.48	34.00	20.54
Number of flowers per plant	8.33	0.59	16.96	11.61	46.88	16.39
Number of fruits per plant	6.22	0.59	23.82	17.61	51.88	25.47
Length of fruit (cm)	16.82	0.69	19.51	18.17	86.74	34.88
Girth of fruit (cm)	7.32	0.39	13.28	9.45	50.65	13.80
Weight of single fruit (g)	21.09	1.43	24.96	21.99	77.62	39.93
Weight of fruits per plant (g)	134.35	16.31	36.69	30.06	67.13	50.75
Number of seeds per fruits	77.07	4.21	11.21	5.97	28.44	6.56
Fruiting phase	51.67	1.81	N.E	N.E	N.E	N.E
Height of the plant (cm)	67.37	2.39	16.77	15.59	86.48	29.88

Figure 1. Genetic parameters of the different characters.

1. Days to first flowering
2. Leaf axil bearing the first flower
3. Number of leaves per plant
4. Leaf area
5. Number of branches per plant
6. Number of flowers per plant
7. Number of fruits per plant
8. Length of fruit
9. Girth of fruit
10. Weight of single fruit
11. Weight of fruits per plant
12. Number of seeds per fruit
13. Not estimable
14. Height of the plant

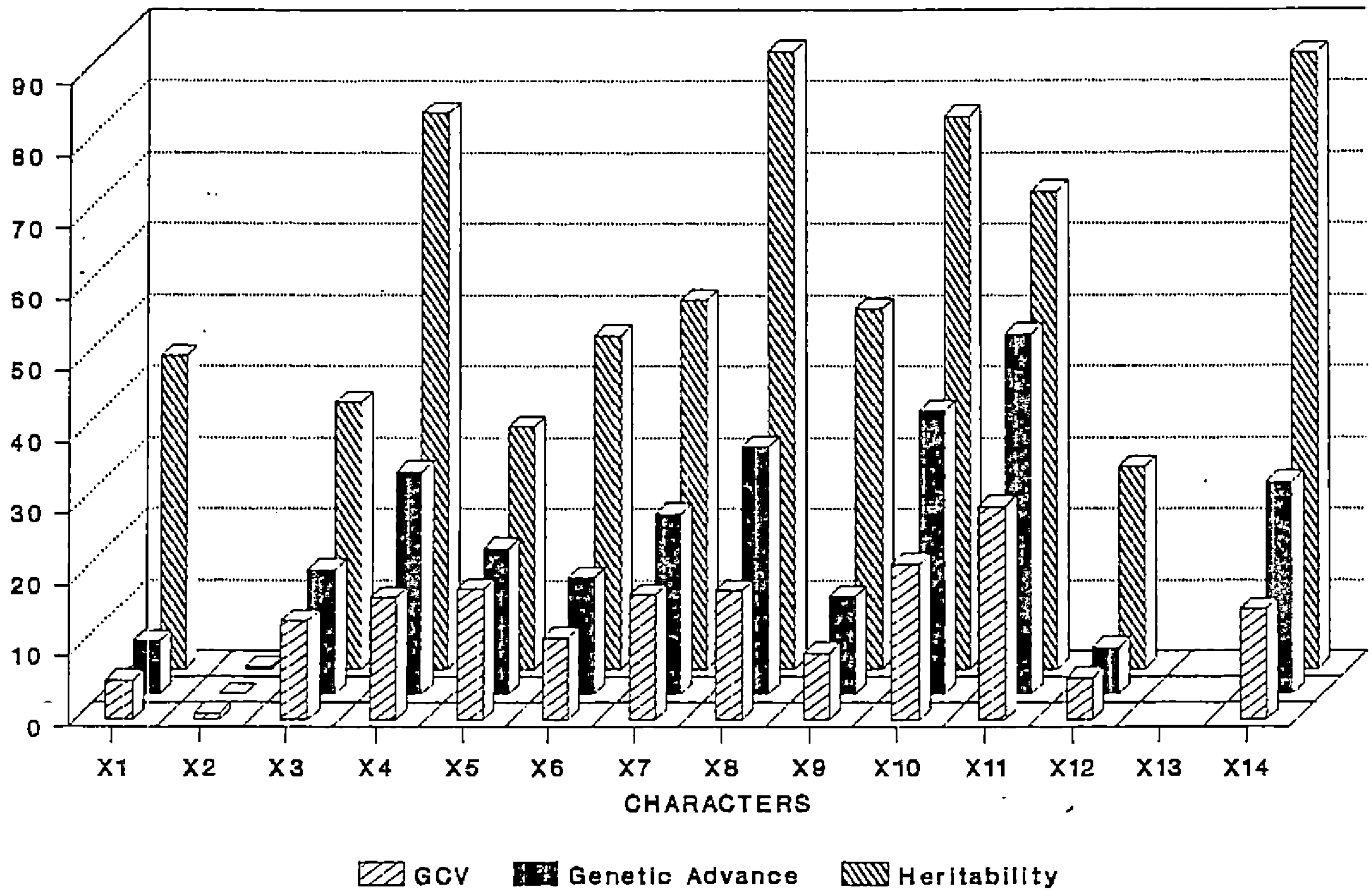

Figure 1. Genetic parameters with respect to various characters

plant (30.06) and minimum for the leaf axil bearing the first flower (0.91)

4.2.3 Heritability in the broad sense

High values of heritability were recorded for the characters viz., length of the fruit (86.74%), height of the plant (86.48%), leaf area (78.12%), weight of the single fruit (77.62%) and weight of the fruits per plant (67.13%). Moderate heritability values were observed for number of fruits per plant (51.88%), girth of fruit (50.65%), number of flowers per plant (46.88%), days to first flowering (44%), leaf number (37.53%) and number of branches per plant (34.00%). Number of seeds per fruit (28.44%) and leaf axil bearing the first flower (0.24%) exhibited low heritability .

4.2.4 Genetic Advance

Weight of the fruits per plant (50.75%) recorded the maximum genetic advance followed by weight of single fruit (39.93%), length of fruit (34.88%), leaf area (31.27%), height of the plant (29.88%), number of fruits per plant (25.47%), number of leaves per plant (17.57%), number of branches per plant (20.54%), number of flowers per plant (16.39%) and girth of fruit (13.80%). Very low values were observed for days to first flowering (7.57%) and number of seeds per fruit (6.56%). The lowest value was registered by leaf axil bearing the first flower (0.09%).

4.3 Phenotypic, genotypic and the environmental correlations among the various characters

The results are given in Tables 6, 7 and 8 and the genotypic correlation is represented in Fig. 2.

4.3.1 Phenotypic correlation

Days to first flowering was significantly and positively correlated with number of flowers per plant. Leaf axil bearing the first flower showed significant negative correlation with number of flowers per plant and weight of the fruits per plant. Leaf area exhibited significant positive correlation with number of branches, number of flowers per plant, number of fruits per plant, weight of single fruit, weight of the fruits per plant and number of seeds per fruit. Number of branches per plant exhibited significant positive correlation with number of fruits per plant, weight of the single fruit, weight of fruits per plant and the height of the plant. Number of flowers per plant showed significant positive correlation with number of fruits per plant, weight of fruits per plant and the height of the plant. Number of fruits per plant showed significant positive correlation with the weight of fruits per plant and height of the plant. Length of fruit exhibited significant positive correlation with weight of single fruit, weight of fruits per plant and the height of the plant. However,

Table 6. Phenotypic correlation coefficient

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X1 Days to first flowering	-	0.0886	0.0863	0.0005	-0.0432	0.5090**	0.0431	-0.0580	0.1079	0.0022	0.0223	-0.1091	-0.0344
X2 Leaf axil bearing the first flower		-	0.1302	-0.0185	0.0859	-0.4440**	-0.0100	-0.0260	0.0400	-0.0801	-0.2050**	-0.129	0.0194
X3 Number of leaves per plant			-	0.0836	0.1002	0.0218	0.0410	-0.0554	0.1007	0.0880	0.0186	-0.0186	0.0100
X4 Leaf area				-	0.1662*	0.2496**	0.2462**	0.0429	0.1301	0.1697*	0.2991**	0.1897*	0.0803
X5 Number of branches per plant					-	0.1317	0.1492*	-0.0343	0.0846	0.2021**	0.2754**	0.0414	0.2627**
X6 Number of flowers per plant						-	0.7891**	0.1273	-0.0811	0.1007	0.5546**	0.0274	0.2241*
X7 Number of fruits per plant							-	0.1160	0.0016	0.1309	0.6996**	0.0981	0.2434**
X8 Length of fruit								-	-0.4648**	0.2363**	0.2277**	-0.2109**	0.1479*
X9 Girth of fruit									-	0.0027	0.0568	0.0611	-0.0346
X10 Weight of single fruit										-	0.7312**	0.0624	0.0413
X11 Weight of fruits per plant											-	0.0948	0.1412*
X12 Number of seeds per fruit												-	0.0531
X13 Height of the plant													-

significant negative correlation was recorded for the girth of fruit and number of seeds per fruit. Significant positive correlation was obtained for the weight of single fruit with weight of the fruits per plant. Weight of the fruits per plant had significant positive correlation with the height of the plant. No significant correlation was obtained for number of leaves per plant with other characters. Girth of fruit was found to be insignificantly correlated with all the other characters except length of fruit.

4.3.2 Genotypic correlation

Significant and positive correlation was recorded for days to first flowering with the leaf axil bearing the first flower and number of leaves per plant. Leaf axil bearing the first flower exhibited significant positive correlation with number of branches per plant, length of fruit, girth of fruit, weight of fruits per plant and the height of the plant. However, significant negative correlation was obtained for number of leaves per plant, leaf area, number of flowers per plant, weight of single fruit and number of seeds per fruit. Significant positive correlation was recorded for number of leaves per plant with weight of single fruit and weight of fruits per plant. Leaf area exhibited significant positive correlation with number of

7. Genotypic correlation coefficient

rs	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
o first ring	-	0.3968**	0.2646**	0.0125	-0.1108	0.1331	-0.0219	-0.1210	-0.0275	0.0879	0.0332	-0.1085	-0.0952
xil g the flower		-	-0.5597**	-0.7252**	2.0454**	-0.4697**	0.0072	0.2841**	0.3952**	-1.0575**	0.4051**	-1.7320**	0.5889**
of leaves ant			-	0.1068	0.0290	0.1296	0.1176	-0.0770	0.0991	0.2505**	0.2818**	-0.1077	0.0424
rea				-	0.2744**	0.4229**	0.4322**	0.0627	0.1752**	0.2394*	0.6689**	0.4352**	0.0870
of branches ant					-	0.4467**	0.3853**	-0.0457	0.1388*	0.3691**	0.5781**	0.1694*	0.4255**
of flowers ant						-	0.9138**	0.2554**	0.1251	0.1007	0.5714**	-0.1740*	0.3515**
of fruits ant							-	0.2176**	-0.0287	0.1840**	0.6689**	-0.0084	0.3036*
of fruit								-	-0.0963	0.2772**	0.3086**	-0.3099**	0.1696*
of fruit									-	-0.0021	0.0660	0.1217	0.0471
t of single										-	0.0969	0.1418*	0.0802
t of fruits lant											-	0.1098	0.1823*
r of seeds ruit												-	-0.0842
t of the plant													-

branches per plant, number of flowers per plant, number of fruits per plant, girth of fruit, weight of single fruit, weight of fruits per plant and number of seeds per fruit. Significant positive correlation was obtained for the number of branches per plant with number of flowers per plant, number of fruits per plant, girth of fruit, weight of single fruit, weight of fruits per plant, number of seeds per fruit and the height of the plant. Number of flowers per plant exhibited significant positive correlation with number of fruits per plant, length of fruit, weight of fruits per plant and the height of the plant whereas, significant negative correlation was recorded with the number of seeds per fruit. Number of fruits per plant showed significant positive correlation with length of fruit, weight of single fruit, weight of the fruits per plant and the height of the plant. Significant and positive correlation was obtained for the length of fruit with weight of single fruit, weight of fruits per plant and the height of the plant, while with number of seeds per fruit it exhibited significant negative correlation. Weight of single fruit exhibitied significant and positive correlation with the number of seeds per fruit. Weight of fruits per plant exhibited significant and positive correlation with the height of the plant.

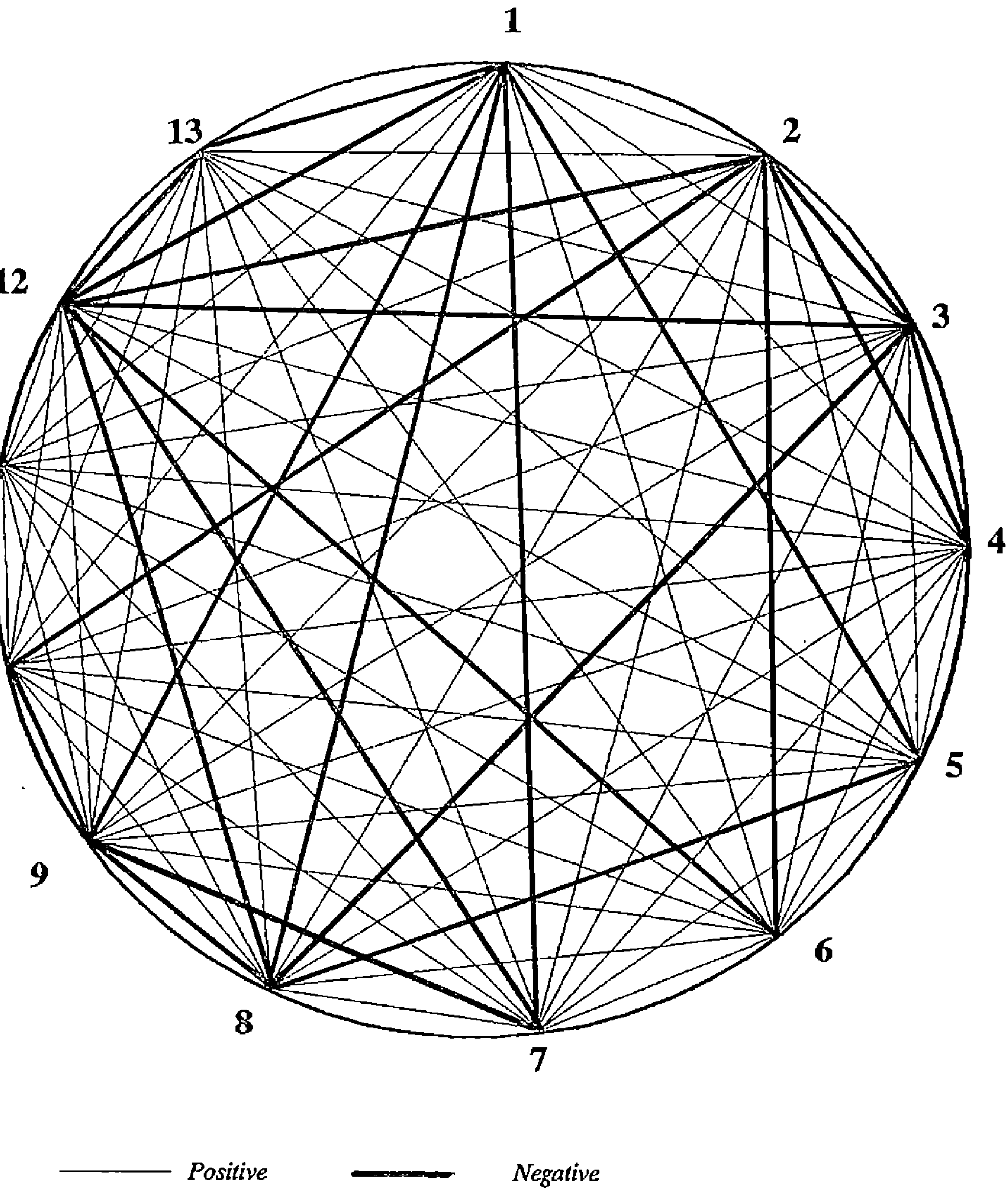
1
13
2
12
3
4
5
9
6
8
7
Positive
Negative

Table 8. Environmental corrolation coefficient

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X1 Days to first flowering	-	0.1012	-0.0360	-0.0195	-0.0006	-0.0065	0.1032	0.06160	0.2254**	0.1389**	0.5750**	-0.1177	0.0886
X2 Leaf axil bearing the first flower		-	0.1864**	0.0291	0.0334	--0.0827	-0.0147	-0.1074	0.0372	-0.0724	-0.0645	-0.099	-0.0192
X3 Number of leaves per plant			-	0.0698	0.0843	-0.0565	-0.0198	-0.0398	0.1035	-0.1264	-0.1321	0.02496	-0.0486
X4 Leaf area				-	0.0648	-0.0185	-0.0892	-0.0514	0.0603	-0.0756	-0.1303	-0.0391	0.0502
X5 Number of branches per plant					-	-0.0788	-0.0229	-0.0320	0.0472	0.0322	-0.0022	-0.0533	0.1065
X6 Number of flowers per plant						-	0.6706**	-0.1354	-0.0386	0.1158	0.5600**	0.1475*	0.0012
X7 Number of fruits per plant							-	-0.1184	0.3346**	0.0431	0.7520**	0.1727*	0.1567*
X8 Length of fruit								-	0.0665	0.0509	-0.0375	-0.1848*	0.0073
X9 Girth of fruit									-	0.0121	0.0455	0.0250	-0.0132
X10 Weight of single fruit										-	0.5756**	-0.0105	-0.1641**
X11 Weight of fruits per plant											-	0.0966	0.0104
X12 Number of seeds per fruit												-	-0.0205
X13 Height of the plant													-

4.3.3 Environmental correlation

Days to first flowering exhibited significant positive correlation with the girth of fruit, weight of single fruit and weight of fruits per plant. Leaf axil bearing the first flower had significant positive correlation with number of leaves per plant. Number of flowers per plant showed significant positive correlation with number of fruits per plant, weight of the fruits per plant and number of seeds per fruit. Significant positive correlation was recorded for number of fruits per plant with the girth of fruit, weight of the fruits per plant, number of seeds per fruit and the height of the plant. Length of fruit was significantly and negatively correlated with number of seeds per fruit. Weight of single fruit exhibited significant positive correlation with weight of fruits per plant while it exhibited negative correlation with the height of the plant. The characters number of leaves per plant, leaf area and number of branches per plant were found to be insignificantly correlated with all the other characters.

4.4 Path Analysis

Path analysis was done using those characters which showed positive and negative correlations with yield. Path analysis is effective in partitioning the observed genotypic correlation into direct and indirect effects. The direct and the indirect effects of various characters on yield in bhindi are presented in Table 9 and Fig. 3.

The maximum direct effect on yield was contributed by number of fruits per plant (0.6025) while its genotypic correlation with yield was 0.6689. The positive indirect effect via. number of branches per plant (0.0914), length of fruit (0.0196), weight of single fruit (0.1067), leaf area (0.0272) and negative indirect effect via. girth of fruit (-0.0007), days to first flowering (-0.0009), height of the plant (-0.0339) and number of flowers per plant (-0.1431) along with its direct effect resulted in this genetic correlation.

Weight of single fruit exhibited the second highest positive direct effect on yield (0.5799) and its genotypic correlation with yield was 0.7969. It had positive indirect effect via. number of branches per plant (0.0876), length of fruit (0.0250), days to first flowering (0.0037), number of fruits per plant (0.1109), leaf area (0.0151) and negative indirect effect via. girth of fruit (-0.0001), height of the plant (-0.0095) and number of flowers per plant (-0.0158) along with its direct effect contributed to this genotypic correlation.

Table 9. Direct and indirect effects of various characters on yield

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Total Correlation
X_1 Days to first flowering	0.0426	0.0008	-0.0263	-0.0208	-0.0132	-0.0109	-0.0006	0.0510	0.0106	0.0322
X_2 Leaf area	0.0005	0.0630	0.0651	-0.0662	0.2604	0.0057	0.0044	0.1338	-0.0097	0.4621
X_3 Number of branches per plant	0.0047	0.0173	0.2373	-0.0699	0.2321	-0.0041	-0.0035	-0.2141	0.0475	0.5781
X_4 Number of flowers per plant	0.0057	0.0267	0.1060	-0.1566	0.5505	0.2300	-0.0032	0.0584	-0.0392	0.5714
X_5 Number of fruits per plant	-0.0009	0.0272	0.0914	-0.1431	0.6025	0.0196	-0.0007	0.1067	-0.0339	0.6689
X_6 Length of fruit	-0.0052	0.0040	-0.0108	-0.0400	0.1310	0.0901	-0.0024	0.1608	-0.0189	0.3086
X_7 Girth of fruit	-0.0010	0.0110	0.0329	0.0196	-0.0173	-0.0087	0.0258	-0.0012	0.0053	0.0560
X_8 Weight of single fruit	0.0037	0.0151	0.0876	-0.0158	0.1109	0.0250	-0.0001	0.5799	-0.0095	0.7969
X_9 Height of the plant	-0.0041	0.0055	0.1010	-0.0550	0.1829	0.1530	-0.0012	0.0494	-0.1115	0.1823

Residual value - 0.2177

Diagonal elements - Direct effect

Off diagonal elements - Indirect effect

Number of branches per plant exhibited positive direct effect on yield (0.2373) and its genotypic correlation with yield was 0.5781. Positive indirect effect via. days to first flowering (0.0047), leaf area (0.0173), number of fruits per plant (0.2321) and height of the plant (0.0475) and negative indirect effect via. number of flowers per plant (-0.0699), length of fruit (-0.0041), girth of fruit (-0.0035) and weight of single fruit (-0.2141) along with its direct effect contributed to this genotypic correlation.

Length of fruit had a positive direct effect on yield (0.0901). The positive indirect effect via. weight of single fruit (0.1608), number of fruits per plant (0.1310), leaf area (0.0040) and negative indirect effect via. number of branches per plant (-0.0108), girth of fruit (-0.0024), days to first flowering (-0.0052), height of the plant (-0.0189) and number of flowers per plant (-0.0400) along with its direct effect contributed towards the positive genotypic correlation (0.3086).

The correlation between leaf area and yield was positive (0.4621) while the direct effect of leaf area on yield was 0.0630. Its exhibited positive indirect effect via. number of branches per plant (0.0651), length of fruit (0.0057), girth of fruit (0.0044), days to first flowering (0.0005), weight of single fruit (0.1388), number of fruits

Figure 3. Path diagram

Y	-	Yield
X_1	-	Days to first flowering
X_2	-	Leaf area
X_3	-	Number of branches per plant
X_4	-	Number of flowers per plant
X_5	-	Number of fruits per plant
X_6	-	Length of fruit
X_7	-	Girth of fruit
X_8	-	Weight of single fruit
X_9	-	Height of the plant

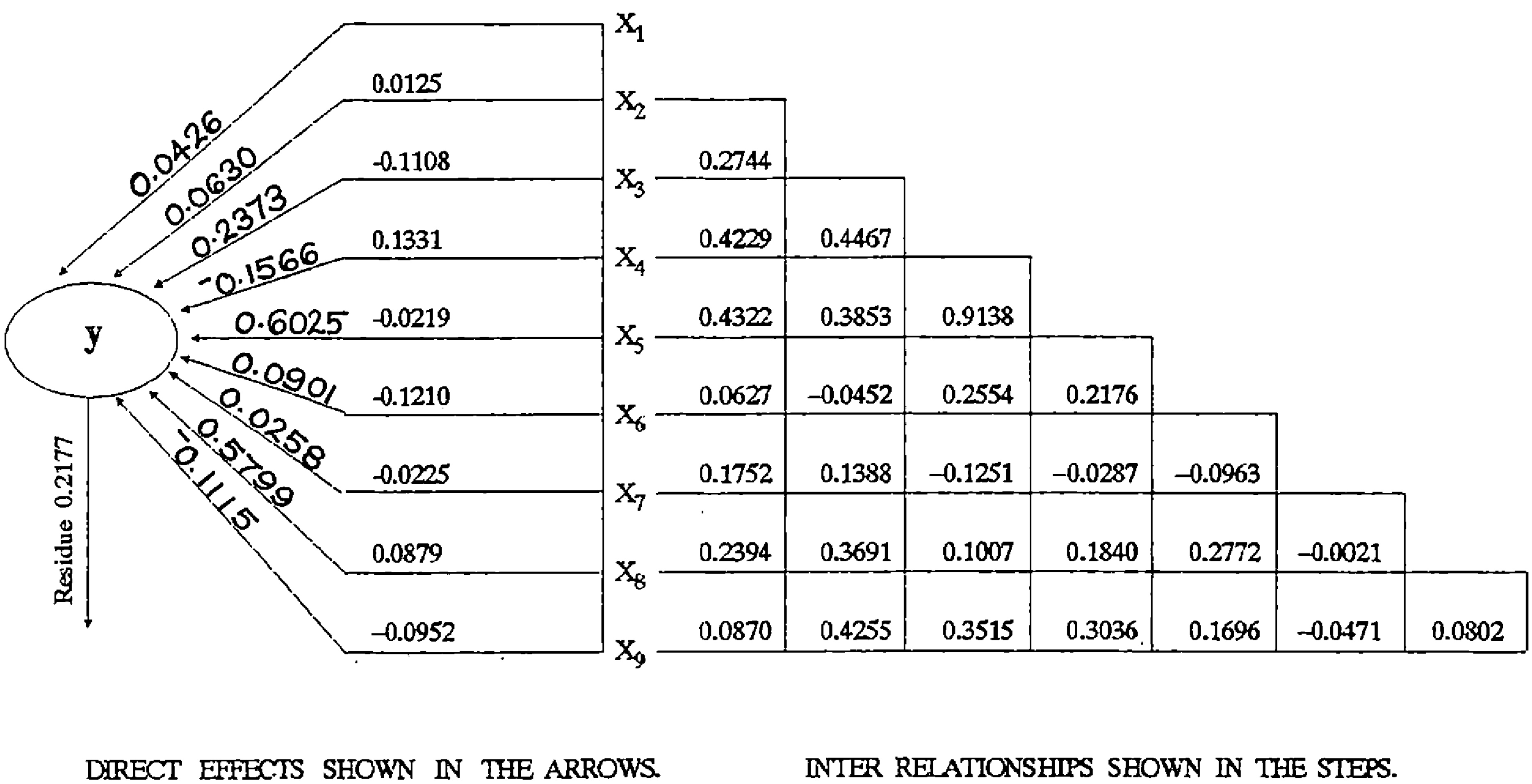

Figure 3. Path Diagram

per plant (0.2604) and negative indirect effect via. height of the plant (-0.0097) and number of flowers per plant (-0.0662). The high positive value for number of fruits per plant along with the other positive indirect effects and the direct effect are responsible to this genetic correlation.

The correlation between days to first flowering and yield was 0.0332 while its direct effect was 0.0426. The positive indirect effect via. weight of single fruit (0.0510), height of the plant (0.0106), leaf area (0.0008) and negative indirect effect via. number of branches per plant (-0.0263) , length of fruit (-0.0109), girth of fruit (-0.0006), number of flowers per plant (-0.0208) and number of fruits per plant (-0.0132) along with the direct effect resulted in this genetic correlation.

Girth of fruit had positive direct effect on yield (0.0258), while it had correlation value 0.0660. The positive indirect effect via. number of branches (0.0329) height of the plant (0.0053), number of flowers per plant (0.0196), leaf area (0.0110) and negative indirect effect via. length of fruit (-0.0087), days to first flowering (-0.0010), weight of single fruit (-0.0012) and number of fruits per plant (-0.0173) together with its direct effect resulted in the genotypic correlation.

The correlation between height of the plant and yield was positive (0.1823) while the direct effect of height of the plant on yield was negative (-0.1115). The positive indirect effect via. number of branches per plant (0.1010) length of fruit (0.1530), weight of single fruit (0.0494), number of fruits per plant (0.1829) and leaf area (0.0055) are responsible for this positive correlation. The negative indirect effect via. girth of the fruit (-0.0012), days to first flowering (-0.0041) and number of flowers per plant (-0.0550) also contributed to the genotypic correlation.

The correlation between number of flowers per plant and yield was positive and high (0.5714) while its direct effect on yield was negative (-0.1566). The positive indirect effect via. number of branches (0.1060), length of fruit (0.2300), days to first flowering (0.0057), weight of single fruit (0.0584), number of fruits per plant (0.5505) and leaf area (0.0267) resulted in the positive correlation while it had a negative indirect effect via. girth of fruits (-0.0032) and height of the plant (-0.0392). Number of fruit per plant mainly contributed to the high genotypic correlation.

All the above characters explained the variation in yield by about 78 per cent as evident from the residual value of 0.2177.

4.5 Genetic divergence among genotypes

The 70 genotypes included in the study were subjected to D^2 analysis based on the 14 characters that were considered in this investigation, inorder to classify them into group constellations.

The seventy genotypes included in the study were found to fall into six clusters, with varying number of genotypes in each cluster (Table 10). Fifty seven genotypes were included in cluster I, four genotypes in cluster II, three genotypes in cluster III, two genotypes in cluster IV, three genotypes in cluster V and one genotype in cluster VI. The clustering pattern of the genotypes did not follow the geographical distribution.

The cluster means of 14 characters are furnished in Table 11. Variations among some of the genotypes are shown in Fig. 4a-f, 5a and 5b.

Among the six clusters, cluster I showed the highest cluster mean for leaf axil bearing the first flower (4.40) and the lowest for the girth of fruit (7.11).

Cluster II showed the highest cluster mean of 34.24 for number of leaves per plant and the lowest cluster mean was recorded for length of fruit (14.58) and fruiting phase (49.38).

Table 10. Genotypes included in clusters

Cluster	Total Number	Genotypes
I	57	V_{1}, V_{2}, V_{3}, V_{5}, V_{6}, V_{7}, V_{8}, V_{9}, V_{10}, V_{11}, V_{12}, V_{13}, V_{14}, V_{16}, V_{17}, V_{18}, V_{19}, V_{20}, V_{21}, V_{22}, V_{24}, V_{25}, V_{26}, V_{27}, V_{28}, V_{30}, V_{31}, V_{32}, V_{34}, V_{35}, V_{36}, V_{37}, V_{38}, V_{39}, V_{40}, V_{41}, V_{43}, V_{44}, V_{45}, V_{46}, V_{48}, V_{49}, V_{50}, V_{51}, V_{52}, V_{53}, V_{54}, V_{55}, V_{56}, V_{57}, V_{60}, V_{63}, V_{64}, V_{65}, V_{67}, V_{68}, V_{69}
II	4	V_{42}, V_{59}, V_{66}, V_{29}
III	3	V_{23}, V_{33}, V_{47}
IV	2	V_{4}, V_{62}
V	3	V_{58}, V_{61}, V_{70}
VI	1	V_{15}

Table 11. Cluster means of fourteen characters

Characters	Cluster					
	I	II	III	IV	V	VI
Days to first flowering	46.62	45.58	47.44	47.33	48.55	42.37
Leaf axil bearing first flower	4.40	4.25	4.23	4.17	4.22	4.34
Number of leaves per plant	23.98	34.24	15.86	25.16	30.44	15.00
Leaf area	140.16	143.32	124.44	214.27	158.95	211.11
Number of branches per plant	2.49	2.74	2.56	2.16	3.33	2.67
Number of flowers per plant	8.42	7.83	9.39	10.00	9	5.33
Number of fruits per plant	6.11	6.33	7.67	7.5	6.45	3.67
Length of fruit (cm)	16.96	14.58	15.33	15.66	20.22	15.00
Girth of fruit (cm)	7.11	7.33	7.12	7.17	7.89	10.67
Weight of single fruit (g)	21.63	16.71	14.33	15.54	27.68	17.60
Weight of fruits per plant (g)	136.17	106.29	109.98	116.72	185.38	98.5
Number of seeds per fruit	77.07	81.25	76.44	81.00	66.89	89.00
Fruiting phase	52.13	49.38	52.22	53.50	52.55	52.00
Height of the plant (cm)	67.15	72.58	79.88	74.83	86.77	51.00

Cluster III showed the highest cluster mean for number of fruits per plant (7.67) and lowest for weight of single fruit (14.33) and leaf area (124.44).

Fruiting phase (53.50), number of flowers per plant (10.00) and leaf area (214.27) showed the highest cluster means in cluster IV whereas leaf axil bearing the first flower (4.17) and number of branches per plant (2.16) exhibited the lowest cluster means in that cluster.

Cluster V showed the highest cluster means for number of branches per plant (3.33), length of fruit (20.22), days to first flowering (48.55), weight of single fruit (27.68), height of the plant (86.77) and weight of fruits per plant (185.38). This cluster showed the lowest cluster mean for number of seeds per fruits (66.89)

Cluster VI showed the highest cluster means for girth of fruit (10.67) and number of seeds per fruit (89.00) whereas it had the lowest cluster means for number of leaves per plant (15.00), days to first flowering (42.37), height of the plant (51.00), number of flowers per plant (5.33), number

Figure 4 (a-f)

Variation among the genotypes for the plant characters

Figure 4a

Figure 4b

Figure 4c

Figure 4d

Figure 4e

Figure 4f

Figure 5a. Variation among the genotypes for fruit characters

No.	Genotypes
1	NBPGR/TCR-356 Sel 86
2	TZA/NR-519
3	NBPGR/TCR-834
4	NBPGR/TCR-878
5	NBPGR/TCR-291
6	TZA/NR-520
7	NBPGR/TCR-382
8	NBPGR/TCR-864
9	NBPGR/TCR-754
10	NBPGR/TCR-865

Figure 5b. Variation in the number of seeds per fruit

No.	Genotypes
1	NBPGR/TCR-382
2	NBPGR/TCR-834
3	NBPGR/TCR-291
4	TZA/NR-520
5	NBPGR/TCR-878
6	NBPGR/TCR-754
7	NBPGR/TCR-865

Figure 5a

Figure 5b

Table 12. Average intra and inter cluster distances

(D) = $\sqrt{D^2}$ values

Cluster	I	II	III	IV	V	VI
I	117.62	224.72	209.96	180.16	202.75	269.39
II		103.34	396.56	258.82	205.70	450.88
III			195.22	289.39	343.15	234.39
IV				89.88	263.44	230.27
V					134.98	425.14
VI						0

Diagonal values are intra cluster distances.

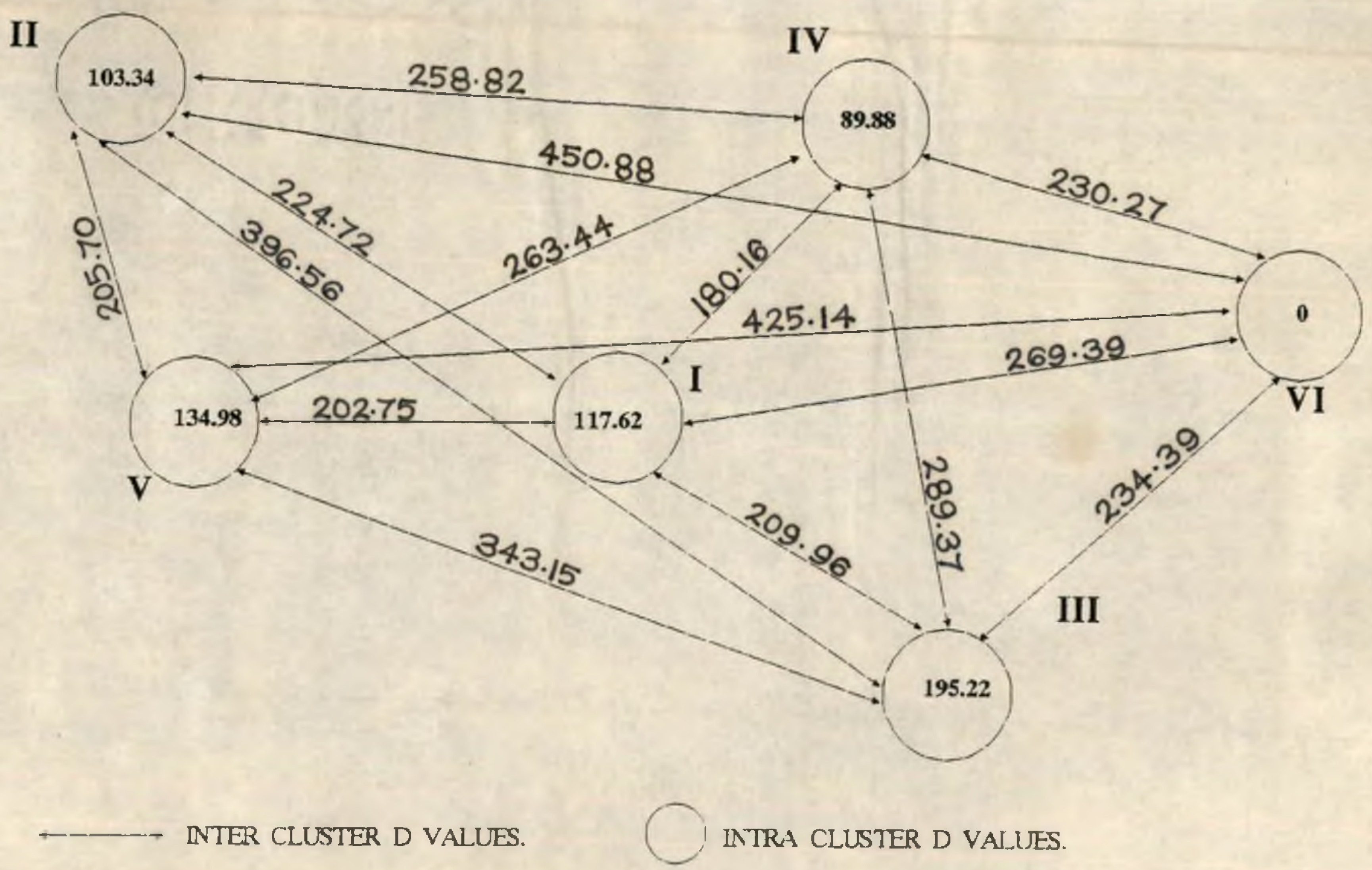

Figure 6. Cluster Diagram

of fruits per plant (3.67) and weight of fruits per plant (98.50).

The intra and inter cluster distances (D) were workedout based on the total D^2 values (Table 12). The intra cluster D values ranged from 0.00 to 195.22 while the inter cluster D values ranged from 180.16 to 450.88. The intra cluster distances were lesser than the inter cluster distances suggesting that the clusters were homogenous within themselves and heterogenous among themselves. The intra cluster distance was maximum in cluster III (195.22) and minimum in cluster IV (89.88). The maximum divergence was observed between clusters II and VI (450.88). The minimum divergence was observed between clusters I and IV (180.16). The genotypes grouped together are less divergent than the ones which fell into different clusters. The inter cluster relationships are repersented diagrammatically in Figure 6., the square root of average D^2 between the clusters being used to represent the relative disposition of clusters.

DISCUSSION

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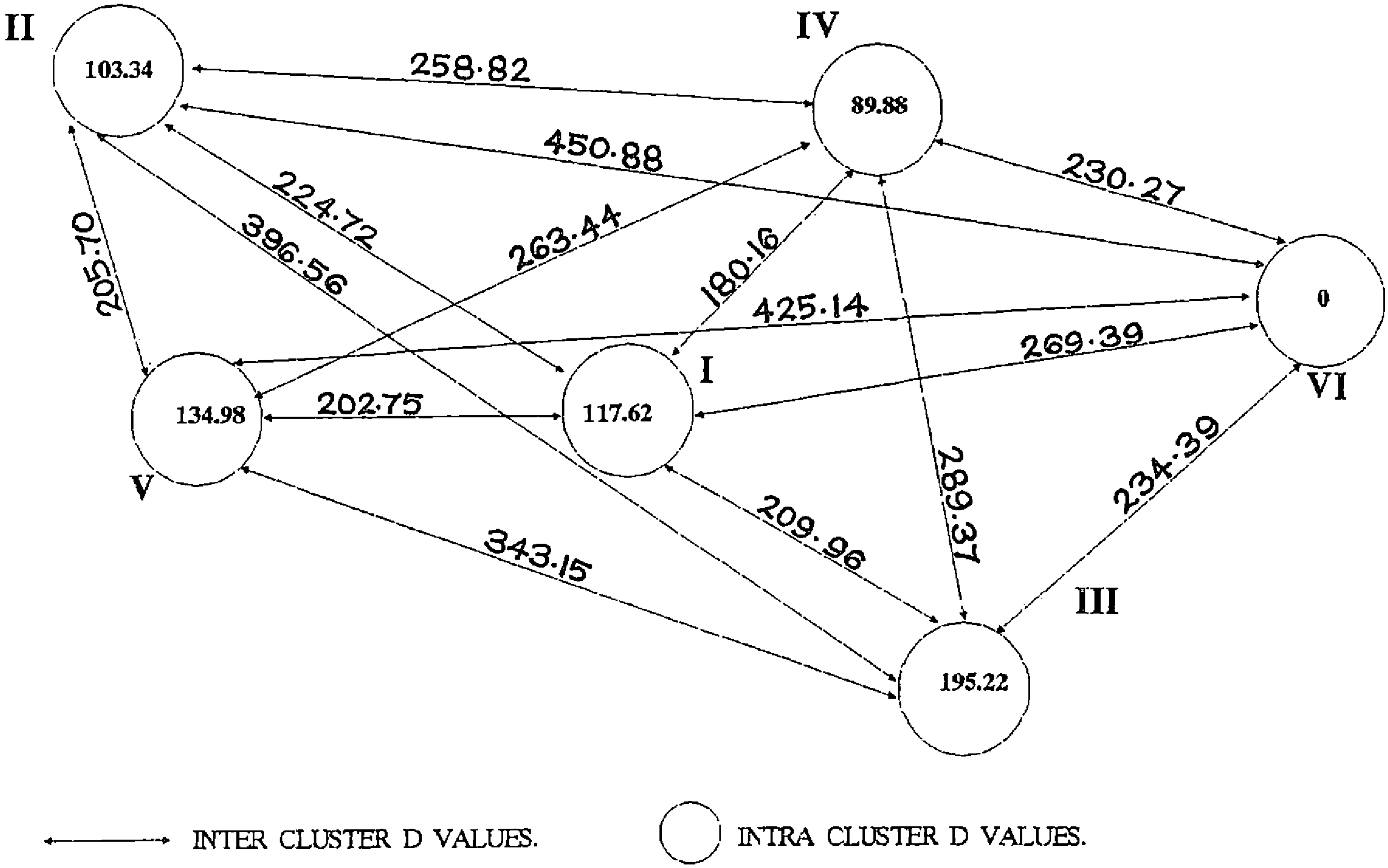
VI						0

Diagonal values are intra cluster distances.



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DISCUSSION

5. DISCUSSION

In the present study 70 genotypes of bhindi were evaluated for estimation of genetic divergence. The results are discussed hereunder.

5.1 Variability

The primary aim of a plant breeder is to improve yield and quality by evolving superior genotypes. Selection of superior genotypes will be effective only when genetic variability exists in the material chosen for improvement. The observed variability for a character is the product of interaction of hereditary effects of concerned genes and the influence of micro and macro environment.

Variance and coefficient of variation help to measure the variability in a population. It is necessary to partition the overall variability into heritable and non heritable components. The differences between the genotypes were significant for 14 out of 16 characters studied viz. days to first flowering, number of leaves per plant, leaf area, number of branches per plant, number of flowers per plant, 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, height of the plant, YVM intensity, shoot and fruit borer incidence. Success in genetic improvement of a crop would, to a large extent, depend upon a wide genetic base resulting in a wider genetic variability. In the present investigation it is seen that the range of variation for most of the characters is large particularly with respect to number of branches (1.66 - 5.00), number of leaves (14.66 - 36.33), length of fruit (8.33 - 24.00), days to first flowering (39.66 - 52.33), number of seeds per fruit (55.66 - 89.66), height of the plant (50 - 98), leaf area (104.50 - 225.42) and weight of fruits per plant (46.80 - 259.70).

This indicates the presence of sufficient variability in the population under study (Table 3).

The 70 genotypes were grouped into low, medium and high classes for all the 14 characters. The genotypes with high values were confined to the high class and genotypes with low values were confined to the low class. Those genotypes which had values inbetween these two classes were grouped under the medium class (Table 4). For most of the characters studied, majority of the genotypes fell into the medium class on grouping. For the most ecomonic character viz. weight of fruits per plant the 70 genotypes were found to be distributed almost equally in the three classes. This shows that the genotypes selected for the study had sufficient variability with regard to the yield.

5.2 Genetic parameters

5.2.1 Coefficient of variation

High genotypic coefficient of variation observed for weight of fruits per plant, weight of single fruit, number of branches per plant, length of fruit, leaf area, number of fruits per plant and height of the plant indicate the presence of high degree of variability and better scope for the improvement of these characters through selection (Table 5). The high values observed for number of branches were in conformity with the findings of Kaul et al. (1979) and Renie (1988). Balachandran (1984) reported high genotypic coefficient of variation for number of branches, number of fruits per plant and weight of fruits per plant which is in conformity with the results obtained in the study. High genotypic coefficient of variation for plant height, leaf area, number of fruits per plant, weight of single fruit and weight of fruits per plant is in agreement with the findings of Thaker et al. (1981). High genotypic coefficient of variation observed for weight of fruits per plant, weight of single fruit and number of fruits per plant is in agreement with the findings of Majumdar et al. (1974), Mathews (1986) and Yadav (1986). High genotypic coefficient of variation observed for plant height is in agreement with the findings of Rao (1972), Meshra and Chhonkar (1979)

Mathews (1986), Yadav (1986), Balakrishnan and Balakrishnan (1988) and Ariyo (1990).

The genotypic coefficient of variation was low for leaf number, number of flowers per plant, girth of fruit, number of seeds per fruit and days to first flowering, with the leaf axil bearing the first flower, the least. Contrary to this result, Meshra and Chhonkar (1979) and Ariyo (1990) reported high genotypic coefficient of variation for number of seeds per fruit. The low genotypic coefficient of variation recorded for the leaf axil bearing the first flower is in agreement with the findings of Sheela (1986) and Renie (1988). The low genotypic coefficient of variation recorded for number of flowers per plant, leaf number and days to first flowering is in agreement with the findings of Rao (1972). Balakrishnan and Balakrishnan (1988) reported low genotypic coefficient of variation for the girth of fruit which is in agreement with the results of this study.

5.2.2 Heritability and genetic advance

Burton (1952) suggested that genotypic coefficient of variation along with heritability would provide a better picture of the amount of advance to be expected by phenotypic selection.

In the present study, length of fruit, height of the plant, leaf area, weight of single fruit and weight of fruits per plant recorded high heritability values indicating that they are less influenced by environment (Table 5).

The above findings are in agreement with the results of Rao (1972) for height of the plant; Lal _et al_. (1977) for the length of fruit, height of the plant, leaf area and weight of single fruit; Mahajan and Sharma (1979) and Meshra and Chhonkar (1979) for the fruit length and plant height; Mahajan and Sharma (1979) and Murthy and Bavaji (1980) for fruit length; Pratap _et al_. (1980) for length of fruit, height of the plant, leaf area and weight of single fruit; Palaniveluchamy _et al_. (1982), Vashistha _et al_. (1982) and Reddy _et al_. (1985) for height of the plant; Maksaud _et al_. (1984) and Mathews (1986) for weight of fruits per plant; Balakrishnan and Balakrishnan (1988) for the weight of single fruit and weight of fruits per plant and number of fruits per plant and Ariyo (1990) for height of the plant and length of fruit.

Moderate values of heritability were recorded for days to first flowering, leaf number, number of branches, number of flowers per plant, number of fruits per plant and girth of the fruit. Moderate heritability recorded for the number of fruits per plant is in agreement with the findings of Korla and Sharma (1984) and Balachandran (1984). Kale *et al*. (1989) reported moderate heritability for the number of branches and number of fruits per plant and is in conformity with the results obtained here. Contrary to the above, high value of heritability for the number of fruits per plant was reported by Ramu (1976), Singh and Singh (1978), Murthy and Bavaji (1980), Maksaud (1984), Palve *et al*. (1985), Balakrishnan and Balakrishnan (1988) and Ariyo (1990). Sheela (1986) reported moderate heritability for days to first flowering and is in agreement with the result obtained in this study. Contrary to the result obtainted here Rao (1972), Lal *et al*. (1977), Singh and Singh (1978), Murthy and Bavaji (1980) and Palve *et al*. (1985) reported high heritability for days to first flowering. Mathews (1986) reported high heritability for number of leaves which is contradictory to the result obtained in this study. Moderate heritability was recorded for girth of fruit in the present study. However, Singh *et al*. (1974), Lal *et al*. (1977) and Mahajan and Sharma (1979) reported high heritability for girth of fruit. Low values of heritability was recorded for leaf axil bearing the first flower and number of seeds per fruit. Low values of heritability for the leaf axil bearing the first flower is in conformity with the findings of Renie (1988) whereas, Korla and Sharma (1984) observed moderate value of heritability for the leaf axil bearing the first flower. Contrary to the results obtained in this study, Meshra and Chhonkar (1979), Yadav (1986) and Ariyo (1990) reported high heritability for number of seeds per fruit.

Heritability values alone may not provide a clear picture of the breeding value. Heritability along with genetic advance is more effective and reliable in predicting the resultant effect of selection than heritability alone (Johnson et al., 1955).

High heritability and appreciable genetic advance were recorded by leaf area, length of fruit, weight of single fruit, weight of fruits per plant and height of the plant. High heritability along with high genetic advance indicated the role of additive gene action for the character concerned as suggested by by Panse and Sukhatme (1957).

The above result is in agreement with the findings of Rao (1972), Meshra and Chhonkar (1979) and Renie (1988) for height of the plant; Singh and Singh (1978), Palve et al. (1985), Mathews (1986) and Balakrishnan and Balakrishnan (1988) for weight of fruits per plant; Meshra and Chhonkar (1979) and Balakrishnan and Balakrishnan (1988) for weight of single fruit and Murthy and Bavaji (1980) and Palve et al. (1985) for length of fruit.

Moderate heritability and appreciable genetic advance were recorded for leaf number, number of branches per plant, number of flowers per plant, number of fruits per plant and girth of fruit. Moderate heritability and appreciable genetic advance for girth of fruit is in agreement with the finding of Lal _et al_. (1977). Moderate to high heritability and appreciable genetic advance observed for number of branches per plant is in conformity with the findings of Meshra and Chhonkar (1979) and Balachandran (1984) indicating additive gene action.

Moderate heritability and low genetic advance for days to first flowering is in agreement with the findings of Palve _et al_. (1985) and Sheela (1986).

Low heritability and low genetic advance were recorded for the leaf axil bearing the first flower and number of seeds per fruit indicating non additive gene action and that these characters are highly influenced by environmental factors. Low heritability and low genetic advance noticed for leaf axil bearing the first flower is in conformity with the findings of Renie (1988).

5.3 Correlation studies

Yield, an extremely complex character is the result of many growth functions of the plant. A knowledge on the degree of association among quatitative characters would help the breeder to pin point a character or characters whose selection would automatically result in an overall progress of such characters which are positively correlated with yield and would also result in the elimination of such characters which are negatively correlated with yield.

Yield was found to have positive genotypic correlation with leaf axil bearing the first flower, number of branches per plant, number of leaves per plant, length of fruit, girth of fruit, days to first flowering, weight of single fruit, number of seeds per fruit, height of the plant, number of flowers per plant, number of fruits per plant and leaf area (Table 7).

The positive genotypic correlation of yield with leaf axil bearing the first flower observed in the present study is contradictory to the results of Sheela (1986) and Renie (1988). The leaf axil bearing the first flower had a positive correlation with the number of branches, length of fruit, girth of fruit, days to first flowering, height of the plant, number of flowers per plant, number of fruits per plant and leaf area.

The positive association of number of branches to yield is in agreement with the findings of Singh et al.

(1974), Roy and Chhonkar (1976), Singh and Singh (1978), Elangovan et al. (1980), Sheela (1986) and Kale et al. (1989) and was contradictory to the findings of Meshra and Singh (1985). The number of branches per plant had a positive genotypic correlation with other yield components as number of leaves per plant, girth of fruit, weight of fruits per plant, weight of single fruit, number of seeds per fruit, height of the plant, number of flowers per plant, number of fruits per plant and leaf area.

Positive genotypic correlation observed between number of leaves per plant and yield is in accordance with the results of Singh et al. (1974). Increase in number of leaves per plant was also associated with increase in the girth of fruit, days to flowering, weight of single fruit, height of the plant. number of flowers per plant, number of fruits per plant and leaf area.

Yield was found to be positively associated with the length of fruit and is in agreement with the findings of Singh and Singh (1979), Mahajan and Sharma (1979), Pratap et al. (1979), Elangovan et al. (1980), Arumugam and Muthukrishnan (1981), Balachandran (1984), Maksaud et al. (1984), Sheela (1986), Yadav (1986), Kale et al. (1989) and

Jeyapandi and Balakrishnan (1990). Length of fruit had a positive correlation with the weight of single fruit. Long fruits with more weight have a direct bearing in augmenting total yield. Length of fruit was also positively correlated with other yield components viz. leaf area, height of the plant, number of flowers per plant and number of fruits per plant.

Yield was found to be enhanced by the increase in girth of fruit and is in agreement with the findings of Elangovan et al. (1980) and Veeraraghavathatham and Irulappan (1990). Contradictory to this result Majumdar et al. (1974), Balachandran (1984) and Sheela (1986) reported negative correlation between yield and girth of fruit. Increase in girth of fruit is positively correlated with number of seeds per fruit and leaf area.

Positive genotypic correlation was observed between days to first flowering and yield and is in conformity with the findings of Arumugam and Muthukrishnan (1981). However, contradictory to the present finding Majumdar et al. (1974), Sheela (1986) and Yadav (1986) recorded negative association between days to first flowering and yield.

Positive genotypic correlation was observed between yield and weight of single fruit as reported by Singh et al. (1974), Roy and Chhonkar (1976), Pratap et al. (1979), Maksaud et al. (1984), Meshra and Singh (1985), Sheela (1986) and Sivagamasundhari et al . (1992). Weight of single fruit is directly correlated with the number of fruits per plant, number of seeds per fruit, height of the plant, number of flowers per plant and leaf area.

Arumugam and Muthukrishnan (1981) and Sheela (1986) reported positive genotypic correlation between number of seeds per fruit and yield as observed in the present study.

Height of the plant was also identified as a major yield component confirmed by the observations of Rao and Kulkarni (1978), Singh and Singh (1979), Elangovan et al. (1980), Arumugam and Muthukrishnan (1981), Maksaud et al. (1984), Mathews (1986), Yadav (1986), Kale et al. (1989) and Jeyapandi and Balakrishnan (1990) while it was not in agreement with the results of Balachandran (1984).

Positive genotypic correlation observed between number of flowers per plant and yield is in agreement with the findings of Singh et al. (1974), Pratap et al. (1979), Sheela (1986), Mathews (1986) and Renie (1988). Increase in the number of flowers per plant is associated with the increase in the number of fruits per plant and leaf area.

The direct association of yield with the number of fruits per plant is in agreement with findings of Elangovan et al. (1980), Murthy and Bavaji (1980), Arumugam and Muthukrishnan (1981), Balachandran (1984), Meshra and Singh (1985), Palve et al. (1985), Sheela (1986), Mathews (1986), Yadav (1986), Renie (1988), Kale et al. (1989), Veeraragavathatham and Irulappan (1990), Jeyapandi and Balakrishnan (1990) and Sivagamasundari et al. (1992).

Yield was found to be positively correlated with leaf area and is in agreement with the findings of Kale et al. (1989). Contrary to the result obtained in this study, Renie (1988) reported that yield was negatively correlated with leaf area.

5.4 Path Analysis

The path coefficient analysis devised by Wright (1921) provides an effective means of findings out direct and indirect causes which contributes towards yield. Hence an assessment of the merit of each character by analysing the direct and indirect effects of each character towards yield is a valuable information in selecting characters for crop improvement.

Path analysis revealed that number of fruits per plant had the highest positive direct effect on yield followed by weight of single fruit, number of branches per plant, length of fruit, leaf area, days to first flowering, girth of fruit, height of the plant and number of flowers per plant (Table 9). The maximum direct effect towards yield was exerted by number of fruits per plant. This is in conformity with the findings of Ramu (1976), Roy and Chhonkar (1976), Kaul _et_ _al_. (1979), Pratap _et_ _al_. (1979), Singh and Singh (1979) Murthy and Bavaji (1980), Meshra and Singh (1985) and Renie (1988) while its indirect effect via. days to first flowering, height of the plant, girth of fruit and number of flowers per plant were negative. The indirect effect through number of branches, length of fruit, weight of single fruit and leaf area were positive.

Weight of the single fruit also exhibited positive direct effect towards yield which is in conformity with the findings of Majumdar _et_ _al_. (1974), Pratap _et_ _al_. (1979), Singh and Singh (1979), and Meshra and Singh (1985) while it exhibited negative indirect effect via. girth of the fruit, height of the plant and number of flowers per plant and positive indirect effect via number of branches per plant, length of fruit, days to first flowering, number of fruits per plant and leaf area.

Number of branches also exhibited a positive direct effect towards yield. The high correlation value with yield is due to the other positive indirect effects as well as direct effect. The indirect effect via. number of fruits per plant mainly contributed to this high correlation. This result is in conformity with the findings of Kaul et al. (1979).

Length of the fruit exhibited a positive direct effect towards yield. High correlation value with yield is due to the positive indirect effect via weight of single fruit, number of fruits per plant and leaf area.

Leaf area exhibited positive direct effect towards yield. Leaf area exerts positive indirect effect via number of fruits per plant, weight of single fruit, days to first flowering, girth of fruit, length of fruit, number of branches per plant.

The positive direct effect of days to first flowering found in this study is in agreement with the findings of Ajmal et al. (1979) and Murthy and Bavaji (1980). The correlation value of this character with yield was reduced probably due to negative indirect effects via. number of branches per plant length of fruit, girth of fruit, number of flowers per plant and number of fruits per plant.

Girth of fruit exhibited a positive direct effect towards yield. The positive indirect effect via number of orancnes, height of the plant, number of flowers per plant and leaf area along with its direct effect are responsible for this genotypic correlation.

Height of the plant and number of flowers per plant showed negative direct effect towards yield. The negative direct effect shown by the number of flowers per plant is in agreement with the findings of Renie (1988).

On the basis of the present investigation it can be concluded that the selection based on number of fruits per plant, weight of single fruit and number of branches per plant will result in the development of high yielding types of bhindi.

The characters studied in this model explained the variation in yield by about 77 per cent as indicated by the residue value of 0.2177.

5.5 Genetic divergence among genotypes

In any plant breeding programme, the main objective is the development of elite crop varieties through genetic upgrading of economic crops.

The importance of genetic diversity of parents in hybridisation programme has been emphasised by many workers. The more diverse the parents within a reasonable range, the more would be the chances of improving the characters in question. Mahalanobis D^2 statistics has been found to be a powerful tool in the hands of plant breeders to assess the degree of relationship among the genotypes and to group them based on their phenotypic expression.

One of the main objectives of the present investigation was to assess the genetic diversity among the genotypes of bhindi and to group them into clusters based on their genetic distance.

The 70 genotypes included in the study were subjected to D^2 analysis based on the 14 characters that were considered in this investgation, inorder to classify them into group constellations. The result are presented in Table 10. The 70 genotypes were found to fall into six clusters with varying number of genotypes in each cluster. Fifty seven genotypes were included in cluster I, four in cluster II, three in cluster III, two in cluster IV, three in cluster V and one in cluster VI. From this it is evident that the genotypes which exhibited minimum divergence got clustered together (Peter and Rai, 1976). The distrubition of genotypes into six different clusters was not according to their places of orgin showing that the genotypes forming one group were geographically diverse, while genotypes obtained from the same region were genetically different. This is in agreement with the findings of Murthy and Qadri (1965), Arunachalam and Jawaharram (1967), SIngh and Bain (1968), Gupta and Singh (1970), Chaudhary et al. (1975), Singh and Singh (1976), Singh et al. (1977), Ariyo et al. (1987), Henry and Krishna (1990) and Varalakshmi and Haribabu (1991).

Among the six clusters studied (Table 11) cluster V showed high mean values for yield, height of the plant, weight of single fruit, days to first flowering, length of fruit and number of branches indicating that cluster V is superior to the rest of the clusters in respect of desirable attributes. Cluster IV was superior for characters like fruiting phase, number of flowers per plant and leaf area. Cluster III is superior for the character number of fruits per plant, cluster II for number of leaves and cluster I for leaf axil bearing the first flower. Cluster VI had low mean values for majority of the characters showing that it is highly inferior compared to the other clusters.

D values presented in Table 12 indicated that the minimum genetic distance was between clusters I and IV and maximum between clusters II and VI. The other clusters were found to occupy intermediary positions with regard to their genetic distances. Thus it is to be concluded that cluster I and cluster IV were genetically closer while cluster II and cluster VI were wider. It has been suggested that crossing among divergent parents is likely to yield heterotic hybrids. Therefore selection of parents from cluster II and cluster VI for hybridization is likely to give heterotic hybrids.

High intra cluster distance within a cluster indicated high degree of variability within that cluster offering scope for improvement by various selection methods. The maximum intra cluster distance was shown by cluster III (195.22), followed by cluster V (134.98), cluster I (117.62), cluster II (103.34) and cluster IV (89.88) thereby indicating highest degree of variability in cluster III.

A cluster diagram showing all the six clusters along with their intra and inter cluster distance are furnished in Fig. 6. This diagram gives an overall picture of the distribution of the six clusters.

Among the 70 genotypes compared with respect to the 14 characters, V_{49} and V_{52} belonging to cluster I was found to be top ranking for leaf axil bearing the first flower. V_{59} of cluster II exhibited maximum number of leaves. The genotype V_{69} belonging to cluster V recorded maximum value for length of fruit. With regard to the girth of the fruit and number of seeds per fruit, V_{15} belonging to cluster VI was found to rank first. The genotype V_{50} of cluster I was found to rank first among the genotypes for the days to first flowering and weight of single fruit. It was with respect to fruiting phase and number of fruits per plant that V_{57} and V_8 of cluster I ranked first. For the characters height of the plant, number of flowers per plant weight of fruits per plant, and number of branches per plant, the maximum values were recorded by V_{70} in cluster V. V_4 belonging to cluster IV showed the maximum value with regard to leaf area.

As evident from the path analysis the model for selection of a high yielding variety is to be based on more number of fruits, weight of single fruit and more number of branches per plant. Studies on genetic divergence revealed that the cluster I and cluster IV are genetically closer while cluster II and cluster VI are wider. Crossing among divergent parents is likely to yield heterotic hybrids. In future breeding programme selection of parents from clusters II and cluster VI for hybridization is likely to give heterotic hybrids.

SUMMARY

SUMMARY

The present study was conducted in the Department of Plant Breeding, College of Agriculture, Vellayani during the period 1991-1993. Seventy genotypes of bhindi belonging to different agro-climatic regions of Kerala were grown in a Randomised Block Design with three replications. Data were collected on 14 characters viz. days to first flowering, leaf axil bearing the first flower, leaf number, leaf area, number of branches per plant, number of flowers per plant, 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, fruiting phase and height of the plant, yellow vein mosaic intensity and shoot and fruit Borer.

The following are the important results obtained in this investigation.

1. Analysis of variance revealed significant difference among the treatments for 14 out of 16 characters studied.

2. Genotypic coefficient of variation was maximum for weight of fruits per plant and minimum for leaf axil bearing the first flower.

3. Heritability estimate was maximum for length of fruit while leaf axil bearing the first flower recorded the lowest heritability value. Characters like leaf area, weight of single fruit, height of the plant and weight of the fruits per plant also exhibited high heritability indicating lesser environmental influence on these characters.

4. Genetic advance as percentage of mean showed that weight of the fruits per plant had maximum genetic gain. High heritability coupled with high genetic advance was recorded for length of fruit, weight of single fruit, leaf area and height of the plant indicating the presence of additive gene action.

5. At genotypic level, yield per plant showed positive correlation with all the characters. Number of branches per plant, number of flowers per plant, number of fruits per plant and leaf area showed high positive correlation with yield. Weight of single fruit had maximum association with yield.

6. Path coefficient analysis at genotypic level revealed that number of fruits per plant, weight of single fruit and number of branches per plant exerted high direct influence on yield. This shows that a model based on

number of branches per plant, number of fruits per plant and weight of single fruit should be given due weightage by vegetable breeders in making selection for high yielding strains in bhindi.

7. On the basis of genetic distances computed with reference to 14 economic characters, the 70 genotypes of bhindi were grouped into six clusters. Cluster I, II, III, IV, V and VI contained fifty seven, four, three, two, three and one genotypes respectively. The maximum divergence was obtained between clusters II and VI. The minimum divergence was obtained between clusters I and IV. The intra cluster distance was maximum in cluster III and minimum in cluster IV.

REFERENCES

REFERENCES

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

Anonymous 1989. *Package of practices Recommendations* Kerala Agricultural University, Mannuthy

Ariyo, O.J. 1990. Variation and heritability of fifteen characters in okra (*Abelmoschus esculentus* (L.) Moench) *Tropic. Agric.*, 67(3): 213-216

Ariyo, O.J, Akenova, M.E., Fatokun, C.A. 1987. Plant character correlation and path analysis of pod yield in okra (*Abelmoschus esculentus* (L.) Moench) *Euphytica* 36(20): 677-686

Arumugam, R., Chelliah, S. and Muthukrishnan, C.R. 1975. *Abelmoschus manihot* - a source of resistance to bhindi yellow vein mosaic. *Madras agric. J.*, 62: 310-312

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

Arunachalam, V. and Jawaharram. S.R. 1967. Geographical diversity inrelation to genetic divergence in cultivated sorghum *Indian. J. Genet.*, 27 : 369-380

Balachandran, P.V. 1984. Estimation of heterosis in bhindi (*Abelmoschus esculentus* (L.) Moench) M.Sc. (Ag.) thesis. Kerala Agric. Univ., Thrissur

Balakrishnan, S. and Balakrishnan, R. 1988. Studies on variability in bhindi (*Abelmoschus esculentus* (L.) Moench) *South Indian Hort.*, 36(6): 300-302

Bhutani, R.D., Kalloo., P.R. and Pratap. P.S. 1983. Genetic divergence among tomato genotypes for quality characters and yield *Indian J. agric. Sci.*, 53(2) : 108-111

Burton, G.W. 1952. Quantitative inheritance in grasses. *Proc. 6th Int. Grassld. Congr.* : 277-283

Chaudhary, B.D., Bhat, P.N. and Singh, V.P. 1975. Genetic diversity in cluster bean *Indian J. agric. Sci.*, 45 (11-22) : 530-535

Chheda, H.R. and Fatonkun, C.N. 1982. Numerical analysis of variation patterns in okra (*Abelmoschus esculentus* (L.) Moench). *Botanical Gazette.*, 143 (2): 253-261

*

Dahatonde, M.P. 1970. Studies on resistance in some of the bhindi varieties to the Jassid Empoasca devastans D. and shoot and fruit borer, Earias Faba Stoll. M.Sc (Ag.) thesis, Mahatma Phule Krishi Vidhya Peeth, Rahuri (Unpublished)

Devadas V.S., Gopalakrishnan P.K., and Peter K.V. 1992. Genetic divergence in vegetable amaranthus. South Indian Hort., 40(1) : 16-20

Dewey, D. R. and Lu, H.K. 1959. A correlation and path coefficient analysis components of crested wheat grass seed production. Agron. J., 51 : 515-518

Elangovan, M., MuthuKrishnan., C.R and Iruläppan, I. 1980. A study of correlation analysis in bhindi (Abelmoschus esculentus (L.) Moench). South Indian Hort., 28 : 28-30

*

Girenko, M. M. and Pugacheu, I.I. 1983 Morphological diversity in okra. Trudy popuiklandnoi Botanika, Genetika, Selektsii., 81: 27-37

Gupta, M.P. and Singh, R.B. 1970. Genetic divergence for yield and its component in green gram. Indian J. Genet., 30 : 212-221

Henry, A. and Krishna, G.V.S.R. 1990. Genetic divergence in cluster bean. Madras agric. J., 77(2): 117-120

Jeyapandi, A. and Balakrishnan, R. 1990. Correlation analysis in bhindi. South Indian Hort., 38(2) 83-85

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimation of genetic and environmental variability in soybean. Agron. J., 47: 314-318

Kadam, P.Y. and Kale, P.N. 1985. Genetic divergence in ridge gourd (*Luffa acutangula* (L.) Roxb.) Veg. Sci., 12: 96-104

Kale, P.B., Dod, V.N. and Tapar, R.R. 1989. Variability and correlation studies in okra. PKV Res. J., 13: 1-5

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

Khan, M.A. and Mukhopadhyay, S. 1986. Screening of okra (*Abelmoschus esculentus*) varieties tolerant to yellow vein mosic virus (YVMV). Research and Development Reporter, 3 : 86-87

Korla, B.N. and Sharma, P.P. 1984. Genetic variability in okra. Haryana J. hort. Sci., 13 : 165-169

Lal, S., Shekhar, C. and Srivastava, J.P. 1977. A note on genetic studies in bhindi -heritability and genetic advance., Indian J. Hort., 34 : 49-50

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

Majumdar, M.K., Chatterjee, S.D., Bose, P. and Bhattacharya, D. 1974. Variability interrelationships and path coefficient analysis for some quantitative characters in okra (Abelmoschus esculentus (L.) Moench). Indian J. agric. Sci., 18 : 13.20

Maksaud, M.A., Hetal, R.M. and Mohammed, M.H. 1984. Heritability estimates and correlation studies of six economic characters in okra Ann. Agric. Sci., 29 : 439-452

Mathews, H. 1986. Evaluation of the F_2 generation of interspecific hybrids of Abelmoschus with reference to yellow vein mosaic resistance and yield. M.Sc.(Ag.) thesis, Kerala Agric. Univ., Thrissur

Mehra, C.S. and Peter, K.V. 1980. Genetic divergence in chilli. Indian J. agric. Sci., 50(6): 477-481

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

Meshra, R.S. and Singh, D.N. 1985. Correlation and path-coefficient analysis in okra. South Indian Hort., 33 : 360-366

*Mitidieri, J. and Vencovsky, R. 1974. Revista de Agriculture, Brazil, 49: 3-6. (In Vegetable crops in India (Ed.) T,K. Bose and M.G. Som 1990).

Mote, V.N. 1982. Studies on the varietal resistance of okra to fruit borer. J. Maharastra Agric. Univ., 7 : 188-190

Murthy, B.R. and Qadri, M.I. 1965. Analysis of divergence in some self compatible forms of Brassica campestris var brown sarson. Indian J. Genet., 25: 48-58

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

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

Palaniveluchamy, K. Muthukrishnan, C.R. and Irulappan, I. 1982. Studies on heritability and genetic advance in bhindi. Madras agric. J., 69 : 597-599

Palve, S.B., Rajput, J.C. and Jamdagni, B,M. 1985. Genetic variability and correlation studies in okra (Abelmoschus esculentus). Indian J. Agric. Res., 19: 20-22

Panse, V.G. and Sukhatme, P.V. 1957. Statistical methods for Agricultural Research Workers. ICAR, New Delhi

Parthi, G., Mishra H.N. and Tripathy, P. 1993. Genetic divergence in bitter gourd (Momordica charantia L.). South India Hort. 41: 6 344-349.

*
Patil, A.S. 1975. Studies on resistance of bhindi varieties to jassid, fruit and shoot borer. M.Sc (Ag.) thesis Mahatma Phule Krishi Vidhyapeeth, Rahuri. (Unpublished)

Peter, K.V. and Rai, B. 1976. Genetic divergence in tomato Indian J. Genet., 36(3) : 379-383

Pratap, P.S., Dhankar, B.S. and Pandita, M.L. 1979. Interrelationship and path analysis studies in okra. (Abelmoschus esculentus) Haryana Agric. Univ. J. Res., 9: 312-32

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

Pratap, P.S., Dhankar, B.S. and Gautam, R.R. 1982. Variability studies in okra (Abelmoschus esculentus (L.) Moench). Haryana Agric. Univ. J. Res., 12: 433-437

Ramachandran, C., Gopalakrishnan, P.K. and Peter, K.V. 1981. Genetic divergence in bittergourd. Veg. Sci., 7 : 100-104

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

*
Rao, C.R. 1952. Advanced statistical method in Biometrical Research. John Wiley and Sons, New York

Rao, T.S. 1972. Note on the natural variability for some qualitative and quantitative characters in okra. (Abelmoschus esculentus (L.) Moench). Indian J. agric. Sci., 42: 432-438

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. Agri. Res. J. Kerala. 16 : 76-78

Reddy, K.R., Singh, R.P. and Rai, A.K. 1985. Variability and association analysis in okra. Madras agric. J., 72 : 478-480

Renie Alex. 1988. Progeny studies of inter specific crosses of Abelmoschus. M.Sc. (Ag.) thesis, Kerala Agric. Univ., Thrissur

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

Sachan, K.S. and Sharma, J.R. 1971. Multivariate analysis of genetic divergence in Tomato. Indian J. Genet., 31(1) : 86-98

Sharma, B.R. and Sharma, O.P. 1984. Field evaluation of okra germplasm against yellow vein mosaic virus. Punjab hort. J., 24 : 131-13[illegible]

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

Sheela, M.N. 1986. Evaluation of bhindi hybrids for yield and its components. M.Sc. (Ag.) thesis, Kerala Agric. Univ., Thrissur

Singh, A. and Singh, H.N. 1976. Genetic divergence in chilli. Indian J. Genet., 36(3) : 425-429

Singh, K., Malik, Y.S. and Mehrotra, N. 1974. Genetic variability and correlation studies in bhindi. Veg. Sci., 1: 47-54

Singh, R.B. and Bain, S.S. 1968. Genetic divergence for ginning outturn and its components in upland cotton. Indian. J. Genet., 28(2) : 262-268

Singh, R.B. and Gupta, M.P. 1968. Multivariate analysis of divergence in upland cotton. Indian. J. Genet., 28(2) : 151-157

Singh, S.P. 1986. Estimation of genetic variances of yield and other characters in okra. Indian J. agric. Sci., 30(3) : 245-24

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

Singh, S.P. and Singh, H.N. 197 Genetic divergence in okra (Abelmoschus esculentus (L.) Moench). Indian J. Hort., 36: 156-170

Singh, S.P. Srivastava, H.N. and Singh, N.P. 1977. Genetic divergence and nature of heterosis in okra. Indian J. agric. Sci., 47(11) 54

Sivagamasundari. S., Irulappan, I., Arumugam, P. and Jayasankar, S. 1992. Association analysis in okra. South Indian Hort. 40(3) : 182-183.

Teli, V.S. and Dahalaya, V.P. 1981. Studies on varietal resistance in okra (Abelmoschus esculentus (L.) Moench) to shoot and fruit borer (Earias vitella F.). South Indian Hort., 29 : 54-60

Thaker, D.N., Tikka, S.B., 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

Varalakshmi, B. and Haribabu, K. 1991. Genetic divergence, heritability and genetic advance in chilli (capsicum annuum). Indian J Genet. 51(2): 174-178

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

Veeraraghavathatnam, D. and Irulappan 1990 Genetic analysis in okra. (Abelmoschus esculentus (L.) Moench). South Indian Hort. 18(2) : 75-82

Wahab, M.A. 1989. Homoestatic analysis of components of genetic variance and inheritance of fruit colour, fruit shape and bitterness in bittergourd (Momordica charantia (L.)) Ph.D. thesis, Kerala Agric. Univ., Thrissur

Wahab. M.A. and Gopalakrishnan, P.K. 1993. Genetic divergence in bitter gourd (Momordica charantia L.) South Indian Hort. 41: 4 232-234

*
Wright, S. 1921. Correlation and causation. J. Agric. Res., 20: 557-587

Yadav, D.S. 1986. Variability and interrelations between yield and its components in okra (Abelmoschus esculentus (L.) Moench). Indian J. Hort., 43 : 274-276

* Originals not seen

GENETIC DIVERGENCE IN BHINDI
(*Abelmoschus esculentus* (L.) Moench)

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ABSTRACT OF THE THESIS SUBMITTED
IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN AGRIC
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

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Vellayani - Trivandrum
1993

ABSTRACT

A study was conducted in the Department of Plant Breeding, College of Agriculture, Vellayani during the period 1991-93. The main aim was to estimate the magnitude of genetic divergence in a collection of bhindi varieties to select suitable ones for use as parents for developing commercial hybrid varieties. The estimation of genetic parameters of important economic characters, the association among these characters, direct and indirect effects and D^2 values were undertaken

Seventy genotypes of bhindi were evaluated in an RBD with three replications. The genotypes showed significant differences in most of the characters studied except fruiting phase and leaf axil bearing the first flower. Genotypic coefficient of variation was maximum [illegible] of fruits per plant and minimum for days to first flowering. Heritability estimate was maximum for length of fruit while it was minimum for leaf axil bearing the first flower. Genetic advance as percentage of mean was maximum for weight of fruits per plant. High heritability coupled with high genetic advance was recorded for length of fruit, leaf area, weight of single fruit, height of the plant and weight of the fruits per plant. At genotypic level yield per plant showed positive correlation with all the characters studied. Path

coefficient analysis at genotypic level revealed that the number of fruits per plant, weight of single fruit and number of branches exhibited high direct influence on yield

The study indicated that the model for selection of high yielding varieties of bhindi should be based on the number of fruits per plant, weight of single fruit and number of branches.

D^2 analysis revealed that the 70 genotypes were grouped into six clusters. Clusters I, II, III, IV, V and VI contained fifty seven, four, three, two, three and one genotypes respectively. The maximum divergence was obtained between clusters II and VI and the minimum between clusters I and IV. The intra cluster distance was maximum in cluster III and minimum in cluster IV.

In future breeding programme for the development of heterotic hybrids parent may be selected from clusters II and VI for hybridization.