EVALUATION OF GENETIC DIVERGENCE IN ASHGOURD (*Benincasa hispida* Cogn.)

By

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THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN AGRICULTURE
(PLANT BREEDING AND GENETICS)
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF PLANT BREEDING AND GENETICS
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM
KERALA

2001

DECLARATION

I, hereby declare that this thesis entitled 'evaluation of genetic divergence in ashgourd (*Benincasa hispida* Cogn.)' 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.

Yours faithfully,

Lovely
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(99-11-29)

CERTIFICATE

Certified that this thesis entitled 'evaluation of genetic divergence in ashgourd (*Benincasa hispida* Cogn.)' is a record of research work done independently by Ms. Lovely B. 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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DEDICATED
TO
MY LOVING PARENTS

ACKNOWLEDGEMENT

I wish to place on record my profound feeling of gratitude and indebtedness to 'the God Almighty' for his unspeakable help, rendered through various hands, which helped me pursue this endeavor to completion.

I express my exuberant pleasure to extend my deep sense of gratitude and indebtedness to the Chairperson of my advisory committee, Dr. Radhadevi, Associate professor, Department of Plant Breeding and Genetics, for her invaluable guidance, constructive criticism and sustained encouragement during the course of investigation.

My fervent gratitude to Dr. P. Manikantan Nair, Professor and Head, Department of Plant Breeding and Genetics, for his valuable comments and suggestions and constant encouragement throughout the period of the study.

My most sincere thanks are due, to Dr. Vijayaraghava Kumar, Associate Professor, Department of Agricultural Statistics, for his help in the planning of the study, analysis of data and interpretation of results and critical scrutiny of the manuscript.

I am particularly grateful to Dr. M. Abdul Wahab, Associate professor, Department of Olericulture, for his valuable suggestions and wholehearted approach throughout the investigation, critical comments and constructive perusal of the manuscript.

I express my sincere gratitude to all teaching staff and students of the Department of Plant Breeding and Genetics for their support and co-operation at various stages of the course of the study.

I am also grateful to all the non-teaching staff and labourers of the Department of Plant Breeding and Genetics for their sincere help and co-operation during the entire fieldwork.

I wish to place on record my sincere thankfulness to Mr. C. E. Ajith Kumar, Junior Programmer, Department of Agricultural Statistics, for the help in statistical analysis of the data.

I must convey my deep feeling of gratitude to my friends Manju, Daliya, Leaya, Leena and Ajith for their selfless help and moral support throughout the course of study and research.

I express my heartfelt thanks to Vidya chechi, Radhika chechi and Sindhumol chechi for all their encouragement and co-operation throughout the completion of the course.

I am greatly indebted to my father and mother for their blessings and prayers and Julie and Johny for their sincere help and support without which I could not have completed this work.

I wish to place on record a note of thanks to Kerala Agricultural University for granting me the KAU Junior fellowship.

Lovely B.

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INTRODUCTION

1. INTRODUCTION

Vegetables play a vital role in health and nutrition of people throughout the world. They are valuable sources of vitamin, minerals, carbohydrates and proteins. Vegetable crops not only provide nutritional security but also are capable of producing more biomass compared to cereal crops.

Several cucurbitaceous crops constitute a principal group of cross fertilized vegetables. Ashgourd is an important cucurbitaceous vegetable grown in China, India, Philippines and elsewhere in Asia. The vegetable is a rich source of vitamins A, B, C, proteins, carbohydrate and minerals. It is considered to be of medicinal value of particular importance to people suffering from nervousness and debility (Chadha, 1993). They may be eaten raw but more often are cooked or pickled. The ripe fruit is used for preparing a sweet meat in North India.

Ash gourd is believed to have originated in southeastern Asia. No wild species are reported for this crop. The only species in the genus is *Benincasa hispida* known as waxgourd, winter melon, white pumpkin, Chinese squash etc. (Bose and Som, 1990). The name wax gourd refers to the thick, waxy cuticle that typically developes on mature fruits. The specific epithet *hispida* refers to the hirsute pubescence on the foliage and immature fruits (Robinson and Decker, 1997).

Being a cross fertilized crop there exists considerable scope for the exploitation of hybrid vigour. The first step for this is to assess the existing genetic variability, which will enable to identify the suitable types for use as parents for evolving commercial hybrids. Review of literature indicated that only a meager attempt has been made in ashgourd in these directions. Hence the present work was undertaken with the following objectives.

- To estimate extent of available variability for important characters in ashgourd.
- To study extent of genetic diversity among the genotypes and to group them into clusters based on genetic distance.
- To estimate the role of genetic constitution in the expression of the character.
- To measure the degree and pattern of association between the character.
- To identify superior genotypes

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

A review of literature on the subject is attempted in this chapter. Crop improvement in ashgourd has been much less compared to other cucurbits. Hence an attempt has been made to review the available literature on various aspects of some important cucurbitaceous crops. Details of information available have been pooled and brief review made, covering genetic variability, correlation of variables, heritability, genetic advance, path co-efficient, genetic diversity and selection index.

2.1. Genetic Parameters

The preliminary step in any crop improvement programme is the search for variability in the germplasm. An insight into the magnitude of variability present in a crop species is of utmost importance as it provides the basis for effective selection. Variability available in a population could be partitioned into heritable and nonheritable components with the aid of genetic parameters such as phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, and genetic advance (GA), which serves as a basis for selection (Johnson *et al.*, 1955).

2.1.1. Coefficient of variation

Pynadath (1978) studied genetic variability in a collection of 25 genotypes of snakegourd. High variation was observed for days to first male and female flower anthesis, fruits per plant, yield per plant, fruit length, girth and weight, flesh thickness, seeds per fruit and 100-seed weight. Highest GCV was reported for fruit weight followed by fruit girth.

In pumpkin 18 genotypes were studied for genetic variability by Gopalakrishnan (1979). Significant variation with wide range was recorded for all the 25 quantitative characters studied. Maximum value of GCV was observed for male flowers per plant followed by fruits per plant.

Biometrical studies in ashgourd revealed significant difference for fruit yield, length of main vine, female flowers per plant, average fruit weight, weight of first mature fruit, node to first female flower, nodes on main axis, internodal circumference, leaves per plant, circumference of fruit, fruit length, flesh thickness, seeds per fruit and 100-seed weight (George, 1981). Variability was limited for days to first female flower anthesis.

In muskmelon, highest GCV and PCV were recorded for marketable yield per plant followed by total yield per plant and average fruit weight by Swamy *et al.* (1985). Hamid *et al.* (1989) observed a wide range of variability for fruit bearing, fruit weight and fruit size in a collection of 9 local germplasms of ashgourd.

In pumpkin highest GCV was reported for seeds per fruit and lowest for node number of female flower (Sureshbabu, 1989). While highest PCV was seen for yield per plant and lowest for days to first male flower. Highly significant variation for all the characters under study, were recorded in bittergourd by Vahab (1989). Highest GCV and PCV were observed for yield per plant, fruits per plant and fruit weight, while it was moderate for fruit length and low for early flower formation.

Mariappan and Pappiah (1990) reported wide range of variation among 45 genotypes of cucumber for most traits. Highest PCV was recorded for seeds per fruit followed by weight of seeds per fruit. The difference between PCV and GCV was low for all the characters studied.

Significant difference with wide range of variation for all the characters among 25 varieties including indigenous and exotic types was noted in cucumber (Rastogi and Deep, 1990 b). The difference between PCV and GCV was low. Highest values of PCV and GCV were recorded by days to fruit maturity and lowest by fruit yield per plant.

Genetical studies in cucumber revealed wide range of variability for all the characters except branches per vine and flesh thickness. This was confirmed by the wide range of PCV and GCV for all the characters studied (Satyanarayana, 1991). Varghese (1991) studied in 48 genotypes of snakegourd and reported high variation for days to first female flower, fruit harvest, yield per plant, number of fruits and seeds per fruit. Highest PCV and GCV were recorded for fruiting nodes on main vine and lowest for total crop duration.

In a study for the evaluation of dessert type of muskmelon for southern region of Kerala, genotypic differences among the cultivars were the primary source of variation (Chacko, 1992). Moderate to high GCV was observed for yield. Significant differences were observed for all the characters studied in pointedgourd by Singh *et al.* (1992). High GCV was reported for yield and number of fruits.

GCV was high for fruiting nodes on main vine, male flowers per plant, sex ratio, fruits per plant and crude fibre content in snakegourd (Varghese and Rajan, 1993).

Hegde *et al.* (1994) studied the performance of watermelon varieties in paddy fallows under Malanad conditions. Considerable variation for the various yield and yield related characters was observed in the study. In six monoecious lines of cucumber, yield and its components showed significant genetic variance (Prasad and Singh, 1994a).

Considerable variation for the various yield and yield related characters was reported in watermelon by Rajendran and Thamburaj (1994). High PCV and GCV was recorded for average fruit weight, seeds per fruit, 100-seed weight and fruit yield per plant. Sirohi (1994) observed significant variation with wide range for all the characters studied in pumpkin.

Shibukumar (1995) noted significant differences for all the characters in the variability studies in 20 genotypes of watermelon. 100-seed weight, number of fruits per plant and node to first female flower had high PCV and GCV.

Fifty pumpkin genotypes differed significantly in all characters except yield per plant (Babu *et al.*, 1996). The GCV was highest for seeds per fruit followed by average fruit weight and productive branches per plant.

Gopal *et al.* (1996) observed moderate to high GCV, indicating a high degree of genetic variation for all the characters in pumpkin.

Considerable variance in respect of yield and earliness was reported among six slicing cucumber cultivars from an observational trial in Kerala (Kerala Agricultural University,1996a). Among the cultivars tested EC179394 and Sheetal were promising for yield and local preference. In ridgegourd significant genotypic variability was observed for characters relating to growth, maturity and fruit yield (Khanikar *et al.*, 1996).

Ram *et al.* (1996) evaluated germplasm of various cucurbits, including pumpkin, watermelon, cucumber, bottlegourd, bittergourd and muskmelon. High variability was shown for days to first male flower (except in muskmelon), days to first female flower, node to first male or female flower, vine length (except in muskmelon), primary laterals, nodes on main vine, fruits per plant and fruit length, breadth and weight.

In cucumber significant differences were reported among the 22 diverse genotypes for all the characters studied (Gayathri, 1997). GCV was high for yield per plant, fruits per plant and average fruit weight. Days to first male flower opening and days to female flower opening had the lowest GCV. Kumaran *et al.* (1997) observed that the estimates of GCV were smaller than the estimates of PCV for most of the traits studied in pumpkin. However GCV was high for mean fruit weight, number of fruits per plant, number of seeds per fruit and yield per plant.

Variability studies in ridgegourd revealed significant differences for vine length, primary branches, internodal length, days to first female flower, nodes to first female flower, sex ratio, days to first harvest, fruits per plant, yield per plant, average fruit weight, fruit length, fruit girth, seeds per fruit and crop duration (Anitha, 1998).

Menon (1998) conducted a study for cataloging and identification of promising ashgourd ecotypes in relation to season and maturity. Maximum GCV was observed for primary branches per plant followed by fruit yield per plant.

In bottlegourd significant differences for vine length, primary branches, days to first primary branches, days to first female flower opening, nodes to first female flower, sex ratio, fruits per plant, fruit yield per plant, fruit length, fruit girth, 100-seed weight, seeds per fruit and crude fibre content were noted (Mathew, 1999). Mohanty and Mishra (1999) observed high GCV and PCV for yield and number of fruits per plant in pumpkin. PCV was greater than GCV for all traits.

Wide variation in seed, growth and yield characters was noted in a study on character association of seeds with plant morphology in snakegourd (Ashok, 2000). Bisognin and Storck (2000) reported significant estimates for genetic variance of large fruit diameter and neck diameter and for environmental variance of fruit shape in bottlegourd. Highest PCV and GCV were observed for fruit yield per plant followed by mean weight of fruit, fruit length and seeds per fruit in bittergourd by Iswaraprasad (2000).

2.1.2. Heritability and genetic advance

In crop improvement only the genetic component is transmitted to the next generation. The extent of improvement further depends upon the intensity of selection and genetic advance obtained from the population. High heritability is not always an indication of high genetic advance (Johnson *et al.*), 1955).

Highest value of heritability was observed for fruit length followed by fruit girth in snakegourd (Pynadath, 1978). Yield per plant recorded a comparatively low estimate of heritability while the lowest value was for fruits per plant.

George (1981) conducted biometrical studies in ashgourd. He reported highest heritability value for percentage fruit set followed by fruits per plant and average fruit weight. Average fruit weight had the highest estimate of genetic advance followed by weight of first mature fruit and fruit yield per plant.

In muskmelon high heritability was observed for presence or absence of sutures and netting, fruit shape, flesh thickness, average fruit weight, total yield per plant and titrattable acidity (Swamy *et al.*, 1985). High heritability coupled with high genetic advance was noted for yield per vine and fruit weight.

Heritability and genetic advance had high estimates for days to flowering in ridgegourd as reported by Kadam and Kale (1987). In cucumber also days to first female flower had high values of heritability and genetic advance (Prassunna and Rao, 1988). Fruits per vine and average fruit weight had high heritability.

Dahiya *et al.* (1989) conducted heritability studies on 7 characters in 45 genotypes of roundmelon. Results indicated high heritability and genetic advance for all the characters studied. In pumpkin yield had low heritability while seeds per fruit recorded the highest genetic advance (Sureshbabu, 1989).

High heritability coupled with high genetic advance was seen for fruit length in cucumber by Abusaleha and Dutta (1990). In pumpkin flesh thickness and fruit weight had high heritability (Borthakur and Shadeque, 1990). Fruit weight recorded high values of heritability and genetic advance.

Mariappan and Pappiah (1990) observed high heritability for fruit girth, length, days to first staminate flower, seeds per fruit and fruit weight in cucumber. Fruit weight had high heritability and genetic advance. High values of heritability were seen for yield per plant and days to fruit maturity in cucumber by Rastogi and Deep (1990a). Fruit yield, fruits per vine and fruit weight had high heritability coupled with high genetic advance.

In a study with 16 divergent genotypes of pointedgourd fruit diameter had high heritability and low genetic advance (Sarkar *et al.*, 1990). Sharma and Dhankar (1990) observed high heritability and genetic advance for fruits per plant in bottlegourd.

Chaudhary *et al.* (1991) reported high heritability and genetic advance for fruits and yield per plant in bittergourd. In cucumber high values of heritability and genetic advance was observed for marketable fruit yield, percentage of deshaped fruit and marketable fruits per vine (Satyanarayana, 1991).

Evaluation of dessert type of muskmelon for southern region of Kerala was done by Chacko (1992). He observed association of high heritability with high genetic advance for yield per vine. Prasad and Singh (1992) reported high heritability and genetic advance for fruit length, fruit breadth and fruit weight in cucumber. In pointedgourd all characters were highly heritable (Singh *et al.*, 1992). High heritability with expected genetic advance was seen for fruits and yield per plant.

In snakegourd the heritability was high for total duration of the crop and crude protein content of the fruits (Varghese and Rajan, 1993). Male flowers per plant, sex ratio, fruiting nodes on main vine and fruits per plant exhibited high heritability and genetic advance. Yield per plant, fruit length, total crop duration, days to first harvest and days to first male flower anthesis had high heritability and low genetic advance.

Paiva (1994) worked out the genetic parameters in spineless gherkin using 36 half-sib progenies. High mean heritability values were estimated for fruit number and yield per plant. High heritability and genetic advance for more than 12 growth and yield attributes were observed in a collection of cucumber (Prasad and Singh, 1994b).

In watermelon high heritability for 100-seed weight, average fruit weight, yield per vine and seeds per fruit was reported by Rajendran and

Thamburaj (1994). High heritability and genetic advance were seen for average fruit weight, yield, fruits per plant, seeds per fruit and 100-seed weight.

Twenty genotypes of watermelon were subjected to variability studies by Shibukumar (1995). All the characters namely days to germinate, percentage of germination, internodal length, vine length, branches per plant, days to first male flower, node to first male flower, days to first female flower, node to first female flower, days to first harvest, node to first fruit, fruits per plant, weight of fruits per plant, individual fruit weight, flesh thickness, rind thickness, seeds per fruit and 100-seed weight had high heritability and low genetic advance except number of seeds per fruit. Gopal *et al.* (1996) reported high heritability accompanied by high genetic advance for length of vine in watermelon.

In snakegourd mean fruit weight, seeds per fruit, fruit length and fruit yield per plant had high heritability coupled with high genetic advance (Mathew, 1996; Mathew and Khader, 1999). Rajput *et al.* (1996) reported high heritability in bittergourd for almost all the yield and related characters. High heritability was noted in bottlegourd for node to first female flower, fruits per plant, yield per plant, vine length and yield ratio. (Singh *et al.*, 1996). In a recurrent selection in 3 slicing cucumber populations, low to moderate heritability was observed for fruit yield, earliness and quality by Wehner and Cramer (1996).

Gayathri (1997) recorded high heritability and genetic advance for yield per plant, fruits per plant, average fruit weight and node to first female flower in 22 diverse genotypes of cucumber. Days to first male and female flower opening had the lowest heritability.

High heritability coupled with high genetic advance was observed for vine length, mean fruit weight, fruits per plant, seeds per fruit and fruit yield per plant in pumpkin (Kumaran *et al.*, 1997). Heritability was lowest for fruit number and highest for quality index as recorded by Paiva (1997) in genetic evaluation of cucumber.

In ridgegourd high heritability along with high genetic advance was shown by vine length, sex ratio, fruits per plant, yield per plant, fruits length and seeds per fruit (Anitha, 1998). Days to first female flower and days to harvest had highest heritability but low genetic advance.

Menon (1998) observed high heritability for seeds per fruit and circumference of fruits in a study for cataloging and identification of promising ecotypes in ashgourd. Primary branches per plant had the highest genetic advance. High heritability and high genetic advance was seen for primary branches per plant, fruit yield per plant, seeds per fruit and average fruit weight.

In ivygourd high heritability was shown by primary branches per plant, fruit yield per plant and nodes to first flower production (Joseph 1999). Mathew (1999) reported high heritability and genetic advance for vine length, primary branches, node to first female flower, fruit length, fruit girth and seeds per fruit in bottlegourd.

Moderate heritability with moderately high genetic advance was recorded for yield per plant in pumpkin (Mohanty and Mishra, 1999). Days to first anthesis, first female flowering node, flesh thickness, vine length and male flowers per plant showed moderate to high heritability accompanied by low genetic advance.

Radhika (1999) recorded highest heritability for days to first female flower and lowest value for vine length in a study with 6 parents and 15 hybrids of snakegourd. Female flowers and seeds per fruit had moderately high heritability values with high genetic advance estimates. Days to first fruit harvest and vine length had low heritability and genetic advance values.

Heritability of fruit shape was moderate in bottlegourd (Bisognin and Storck, 2000). Deepthy (2000) observed high heritability and genetic advance for keeping quality, yield per plant, seeds per fruit, 100-seed weight, mean fruit weight, male flowers per plant, female flowers per plant, fruits per plant, productive branches per plant and sex ratio in melon. High heritability and genetic advance were seen for days to first male flower opening, fruit diameter, flesh thickness, fruit duration and crop duration. Lowest estimate of heritability was for node to first female flower and days to first fruit harvest.

Iswaraprasad (2000) recorded high heritability for days to first male flower, days to first female flower, days to first fruit harvest, female flowers per plant, fruits per plant, mean weight of fruit, fruit yield per plant, fruit length, fruit girth, flesh thickness, seeds per fruit, 100-seed weight, crop duration and fruit colour in a study using 7 parents and 21 hybrids of bittergourd. All characters except days to first fruit harvest and crop duration had high estimates of genetic advance.

2.2. Correlation studies

Most of the economically important characters like yield is an extremely complex trait and 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.

In snakegourd yield per plant was highly associated with primary branches, days to first female flower, fruit weight and girth (Pynadath, 1978). Fruit weight, fruit girth, number of fruits, node to first female flower are the important characters contributing to yield on account of their high direct effects. Female flowers and fruit length are also important with moderate direct effects and substantial indirect effects.

Ramachandran (1978) reported that fruit weight, fruits per plant and length of main vine had high direct positive effects on yield. Primary branches per plant, female flowers per plant and fruit length had negative direct effects on fruit yield in bittergourd.

Fruit yield per plant was significantly and positively correlated with length of main vine, female flowers per plant, average fruit weight and weight of first mature fruit in a biometrical study conducted by George

(1981) in ash gourd. The average fruit weight had the maximum direct effect followed by vine length. Significant negative correlation was seen between vine length and internode circumference.

Singh *et al.* (1987) observed that yield was significantly correlated with length of fruit, diameter of fruit and weight of seed in parwal. Days to flowering, fruit diameter, fruit weight and size and weight of seed have direct effect on yield while fruit length, pulp thickness and seed number per fruit had indirect effect.

Abusaleha and Dutta (1988) recorded the association of yield with fruit girth and flesh thickness to be positive and that with days to first male and female flowers to be negative in cucumber. Highest direct effect was observed for fruits per vine and fruit length.

Positive correlation of yield with fruits per vine in watermelon was reported by Singh and Singh (1988). Highest direct effect was for average fruit weight. Indirect effect through days to first female flower was negative. Singh *et al.* (1989) observed significant positive association in respect of all the traits in muskmelon.

Highest direct effect on yield was for average fruit weight in watermelon (Rajendran and Thamburaj, 1989). Indirect effects were positive for most of the characters, except days to first female flower, which is negative. Yield per plant was positively correlated with fruit weight and fruits per plant in bittergourd (Lawande and Patil, 1989).

In pointed gourd, positive association of yield with fruit numbers and seed numbers and negative correlation with days to first flowering and picking was observed by (Prasad and Singh, 1990). High yield was also associated with late flowering. Number of fruits and early yield had the highest positive direct effect in roundmelon (Pandita *et al.*, 1990) Positive association of fruit numbers per plant and fruit weight with total yield per plant was reported in cucumber. (Rastogi and Deep, 1990a).

High correlation was observed between seed weight per fruit and fruit weight and fruit length in short fruited limes of cucumber, but these traits were poorly correlated in the slicing lines (Milotary, *et al.*, 1991). Kadam *et al.* (1992) found positive association of yield with fruits per plant and fruit weight in ridgegourd.

Highest direct effect on yield was observed for days to maturity in cucumber (Solanki and Shah, 1992). Prasad and Singh (1992) observed significant and positive correlation of yield per plot with vine length, fruit length, fruit weight, fruit breadth, flesh thickness and placental thickness in cucumber.

High yield was positively correlated with number of fruits per plant in pointed gourd (Singh *et al.*, 1993). Fruits per plant, days to first picking and average fruit weight were responsible for yield increase. In watermelon, average fruit weight was positively correlated with fruits per vine (Rajendran and Thamburaj, 1993).

There was a significant positive genotypic correlation between number of pistillate flowers, number of parthenocarpic fruits and yield and between parthenocarpic yield, number of fruits and average single fruit weight in cucumber. (Chen *et al.*, 1994). But the direct effects of number of pistillate flowers and yield are much lower than its indirect effect on number of fruits.

Length of main creeper, leaves per plant, fruits per plant, fruit weight and fruit size index have direct influence on yield of pumpkin (Borthakur and Shadeque, 1994). In snakegourd, Devadas *et al.* (1995) reported that large fruits have the highest number of seeds, but seed size did not significantly influence germination percentage.

Saika *et al.* (1995) observed that yield per plant had strong positive association with main vine length, secondary branches, leaf area, fruiting percentage, fruits per plant, fruit weight and fruit length both at phenotypic and genotypic levels in cucumber. Fruits per plant had maximum direct genotypic effect on yield followed by fruit weight.

In cucumber total yield had a significant positive correlation with total fruit number, fruit growth rate and average fruit weight (Ma *et al.*, 1995). Stem diameter and plant height also had an effect on total yield.

Correlation and path analysis studies on 21 genotypes of bittergourd indicated that fruit yield per vine was positively correlated with fruits per vine, average fruit weight, fruit length, percentage fruit set, vine length and leaf area per vine (Rajput *et al.*, 1995). Fruit yield per vine was negatively correlated with days to first harvest both at genotypic and phenotypic levels. Strong positive direct effects on yield were observed for drymatter per vine and percentage fruit set. Direct negative effects on yield were noticed for days to first female flower appearance and days to first harvest.

Paranjape and Rajput (1995) found that in bittergourd yield was mainly contributed by fruits per vine, average fruit weight, fruit length and female flowers. The fruit weight had maximum direct bearing on yield. However vine length, primary branches, nodes on main axis, leaf area, fruit length, fruits per vine and seed content indirectly contributed towards yield.

In salad cucumber correlation studies between some quantitative characters indicated that yield was significantly correlated with fruit number and weight (Neikov *et al.*, 1995).

Yield per plant recorded high positive genotypic and phenotypic correlation with fruits per plant, branches per plant, weight of individual fruit, flesh thickness and percentage of germination in watermelon (Shibukumar, 1995). Negative correlation was seen for yield per plant with length of vine, node to first fruit was produced and days to first harvest. Fruits per plant recorded positive direct effect on yield followed by weight of individual fruits.

In muskmelon fruit yield was positively correlated with fruit weight, fruits per vine and flesh thickness as observed by Dhaliwal *et al.* (1996). Fruit weight and fruits per vine were negatively correlated. Fruit yield was directly affected by days to first female flower followed by fruits per vine, node to first female flower and fruit weight.

Gopal *et al.* (1996) recorded positive and significant correlations of branches per vine and female flowers per vine with yield in watermelon. Fruits per plant, average fruit weight, fruit girth and fruit diameter were highly correlated with yield in cucumber (Gayathri, 1997). Fruit girth exerted maximum direct positive effect on yield followed by average fruit eight and fruits per plant.

Midseason traits (length of internodes with first female flower, length of primary axis, primary branches and leaves per plant) exhibited insignificant genotypic and phenotypic direct effects on fruit yield in muskmelon (Gwanama *et al.*, 1998). Late season traits (weight of first mature fruit and fruits per plant) had significant genotypic direct effects on fruit yield.

Kumaran *et al.* (1998) reported positive and significant correlations for days to first female flower, vine length, mean fruit weight, fruits per plant and seeds per fruit with fruit yield per plant in pumpkin. Fruits per plant exhibited the highest direct effect on yield. High indirect positive effects were exerted by fruits per plant and mean fruit weight.

Correlation studies in 16 parental lines of bottlegourd indicated that yield per plant was positively correlated with average fruit weight, of edible fruit and fruits per plant (Kumar and Singh, 1998). Yield per plant was negatively associated with the node bearing first female flower, days to first harvest and vine length.

Vine length, primary branches, internodal length, days to first female flower, node to first female flower, days to harvest, fruit set, fruits per plant, average fruit weight crop duration had significant positive correlations with yield in ridgegourd (Anitha, 1998).

Menon (1998) observed that the fruits per plant had the highest positive and significant phenotypic correlation with yield in ashgourd. Highest genotypic correlation of yield was found with female flowers per plant. Yield was positively and significantly correlated with length of main vine, primary branches per plant, nodes on main vine, internode length, leaves per plant at 30 days after sowing, female flowers per plant, percentage of female flowers, average fruit weight, fruits per plant, percentage of fruit set, circumference of fruit, fruit length, seeds per fruit and 100-seed weight. Average fruit weight exhibited the highest positive direct effect on fruit yield followed by percentage of fruit set, female flowets per plant, nodes on main vine, internodal length, male flowers per plant, percentage of female flowers and 100-seed weight. Leaves per plant at 30 days after sowing exhibited a negative direct effect on fruit yield.

Fruits per plant, average fruit weight, fruit girth and fruit length showed significant positive correlation with yield in ivygourd (Joseph, 1999). Fruits per plant had the highest positive direct effect on yield.

In bottlegourd yield was significantly and positively correlated with duration of crop and fruits per plant (Mathew, 1999). Length of fruit had its highest direct positive effect on yield followed by fruit girth. Days to first female flower imparted highest negative effect on yield followed by 100-seed weight. Fruits per plant had positive direct effect and crop duration had negative effect on yield.

Zhang *et al.* (1999) reported that the three traits with the largest direct positive action on early yield were average fruit weight, harvested fruits per plant and average fruit length in cucumber. In pumpkin Devadas *et al.* (1999) observed that total number and dry weight of seeds per fruit and 100-seed weight were greatest in big fruits. Fruit weight was significantly correlated with polar and equatorial diameter, total number, and dry weight of seeds per fruit and 100-seed weight.

Correlation and path coefficient studies in pointedgourd indicated that fruit weight, fruit diameter and number of primary branches per plant were positively and significantly correlated with yield per plant at genotypic and phenotypic levels (Sarkar *et al.*, 1999). Fruit volume followed by fruit weight and fruit diameter has maximum positive direct effect on yield.

Yield per plant showed positive and significant correlation with fruits per plant and diameter of fruits at genotypic and phenotypic levels in ivygourd as reported by Sarnaik *et al.* (1999). The yield was also significantly and positively correlated with the length of internode at genotypic level.

Ashok (2000) noted strong association between yield and fruit characters and fruits per plant in snakegourd. In ridgegourd yield per vine was significantly and positively associated with fruit girth, weight and volume of fruits, fruits per vine, branches per vine and fruits per branch (Rao *et al.*, 2000). Negative association was observed with days and node of first female flower. Number of fruits per vine and weight of fruit had high direct effect on yield per vine.

2. 3. Genetic Divergence

Genetic distance is a measure of gene differences between populations or individuals. A properly maintained world collection of germplasm or genetic stock should be evaluated for the choice of genetically divergent parents for hybridization under transgressive breeding programme. Segregation and recombination produce many new gene combinations in F_2 and later generations, when genotypically different individuals are crossed.

2.3.1. Clustering of genotypes

Genetic diversity plays an important role in plant breeding because hybrids between lines of diverse origin generally display a greater heterosis than those between closely related strains. Hence as preliminary step of heterosis breeding, it is desirable to investigate the nature and degree of divergence in a population of the different groups. Clustering of genotypes using Mahalanobis D^2 statistic measures the degree of diversification and determines the relative proportion of each component character to the total divergence. The genotypes grouped together are less divergent than the ones, which are placed in different clusters.

Using 25 diverse genotypes genetic divergence was studied in bittergourd (Ramachandran *et al.,* 1981). Observations were recorded on 8 quantitative characters. The genotypes were grouped into 10 clusters in which yield per plant, fruits per plant and fruit length contributed predominantly to the total divergence.

Genetic divergence was studied for 14 quantitative characters in a collection of 30 cultivars in ridgegourd by Kadam and Kale (1985). They were grouped onto 20 clusters and fruit number per vine and yield per vine were the important factors contributing towards divergence.

Mathew *et al.* (1986) estimated the genetic distance among 5 botanical varieties of *Cucumis melo* for 4 quantitative characters. Of the 4 characters studied seeds per fruit did not contribute to total divergence while fruits per plant contributed the maximum. The distance was greatest between muskmelon (var. inodorus) and snakemelon (var. flexuosus) and least between longmelon (var. utilissimum) and snapmelon (var. momordica).

Genotypes differed significantly for all the 18 characters studied in bittergourd (Vahab, 1989). The genotypes were grouped into 5 clusters. Varghese (1991) grouped 48 genotypes of snakegourd into 10 clusters. Maximum number of genotypes was present in the cluster I (13) followed by III and V.

In bittergourd genetic divergence for 14 quantitative characters were studied by Parhi *et al.* (1993). The 13 genotypes were grouped into 6 clusters. The characters 100-seed weight, number of seeds per fruit and yield per plant made maximum contribution to divergence.

Deng *et al.* (1994) observed a highly significant correlation between total yield per plant of hybrids and genetic distance between parental lines in cucumber. However if genetic distance was computed using condensation transformation a highly significant positive correlation was obtained between early yield per plant and genetic distance.

In pumpkin fifty genotypes were classified into 5 clusters based on Mahalanobis D^2 statistic by Babu *et al.* (1996), containing 2, 7, 9, 12 and 20 genotypes respectively. Genetic diversity was assessed in a collection of 34 genotypes of snakegourd (Mathew, 1996). Maximum contribution to total divergence was by days to first female flower, first fruit harvest, crop duration and 100-seed weight. According to multivariate analysis, 6 clusters were identified in a collection of pumpkin genotypes (Rios *et al.*, 1997). Skin colour and yield contributed most to genotype clustering.

2.3.2. Eco-geographic diversity Vs genetic diversity

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. Several workers observed that many varieties forming one group were geographically diverse while varieties obtained from the same region were genetically different.

The distribution of genotypes of bhindi into 6 different clusters was not according to their places of collection showing that the genotypes forming one group were geographically diverse, while genotypes obtained from the same region were genetically different (Bindu, 1993).

Vahab and Gopalakrishnan (1993) reported that grouping pattern of genotypes was not always directly associated with geographic diversity in bittergourd. The same group consisted of genotypes of different source or origin and the lines of the same source or origin fell into different groups also.

In snakegourd genetic diversity was assessed using Mahalanobis D^2 statistic with 34 genotypes in 9 clusters. Genetic diversity was not correlated with geographic diversity (Mathew, 1996).

Multivariate analysis of 55 F_1, led to grouping of 11 parents into 6 clusters in sesame (Dikshit and Swain, 2000). No relationship between geographic origin and genetic diversity was observed. In Indian mustard genetic divergence was studied in 64 genotypically diverse genotypes by Verma and Sachan (2000). No parallelism was noted between geographic diversity and genetic diversity.

Studies on genetic divergence in cowpea revealed that different genotypes from different sources were included in different clusters indicating that genetic diversity and geographical diversity were not related

(Anbuselvam *et al.,* 2000). Raje and Rao (2001) found that genetic diversity was unrelated to geographical diversity in a germplasm collection of mungbean.

2.4. Selection Index

The economic worth of a plant depends upon several characters. So while selecting a desirable plant from a segregating population the plant breeder has to give due consideration to characters of economic importance. Selection index is one such method of selecting plants for crop improvement based on several characters of importance. This method was proposed by Smith using Fisher's (1936) discriminant function.

A selection index was formulated for twenty genotypes in watermelon by Shibukumar (1995) using the characters yield per plant, number of fruits per plant, weight of individual fruit and total soluble solids. With 20% selection, the varieties Sugar Baby, Asahi Yamato, HW 1 and Fuken were identified superior and suitable for cultivation.

Gayathri (1997) prepared selection index for a collection of cucumber genotypes based on major components of yield namely, node to first female flower, days to first harvest, fruits per plant, average fruit weight, fruit length, fruit girth, fruit diameter and yield per plant. The highest index score was recorded by CS12 followed by CS11, CS9 and Punerikhira.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study was conducted to estimate the genetic diversity in a collection of ashgourd genotypes to select appropriate types to be used for generating commercial hybrid varieties. The investigation was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during the period 1999-2001.

3.1. MATERIALS

The basic material for the study included 25 collections of ashgourd from different agroclimatic regions of South India including the released variety, KAU local from Kerala Agricultural University. The details of the accessions collected are given in the table 1.

3.2. METHODS

3.2.1. Experimental Techniques

3.2.1.1. Design and Layout

The seeds of the 25 genotypes were laid out in randomized block design with 3 replications during July 1999. In each replication, 4 pits per genotype were taken and a single plant was maintained in each pit.

Table 1. Particulars of genotypes used for the study

Accession No.	Accession / variety	Source
T_1	Palakkad local – 1	Parali, Palakkad
T_2	Wayanad local – 1	Sultan Battery, Wayanad
T_3	Iddukki local – 1	Kattappana, Idukki
T_4	Bangalore local – 1	Bangalore
T_5	Tamilnadu local – 1	Madhurai, Tamilnad
T_6	Kozhicode local – 1	Kallayi, Kozhicode
T_7	Wayanad local – 2	Kalpetta, Wayanad
T_8	Thrissur local –1	Mannuthy, Thrissur
T_9	Bangalore local – 2	Bangalore
T_{10}	Thrissur local –2	Cheroor, Thrissur
T_{11}	Palakkad local – 2	Nenmara, Palakkad
T_{12}	Kottayam local – 1	Ettumanoor, Kottayam
T_{13}	Vellayani local	College of Agriculture, Vellayani
T_{14}	Allepey local – 1	Edathua, Allepey
T_{15}	Idukki local - 2	Munnar, Idukki
T_{16}	Thiruvananthapuram local – 1	Nedumangad, Thiruvananthapuram
T_{17}	Idukki local – 3	Kattappana, Idukki
T_{18}	Idukki local – 4	Peerumed, Idukki
T_{19}	Idukki local – 5	Vazhathoppu, Idukki
T_{20}	KAU local	Kerala Agricultural University
T_{21}	Thiruvananthapuram local – 2	Vattiyoorkavu, Thiruvananthapuram
T_{22}	Kottayam local – 2	Alathoor, Kottayam
T_{23}	Palakkad local – 3	Nenmara, Palakkad
T_{24}	Kottayam local – 3	Devalokam, Kottayam
T_{25}	Kottayam local - 4	Kanjikkuzhi, Kottayam

3.2.1.2. Cultural Practices

Normal cultural methods as per the package of practices recommendation of the Kerala Agricultural University (Kerala Agricultural University, 1996b) were adopted. Seeds were sown in pits of 60 cm diameter and 35-45 cm depth taken at a spacing of 4.5 x 2.0 m. Fertilizers at the rate of 28:10:10 g NPK were given per pit. Weeding and raking of the soil were done at the time of fertilizer application.

3.2.2. Biometric Observations

Four plants per genotype were selected for recording the biometric observations. The following observations were made adopting standard procedures and average values were recorded for each replication.

3.2.2.1. Days to first male flower

Number of days taken from sowing to the bloom of the first male flower was recorded.

3.2.2.2. Node to first male flower

Number of nodes from the base of the plant to the node where the first male flower appeared was recorded.

3.2.2.3. Days to first female flower

Number of days taken from sowing to the bloom of the first female flower was recorded.

3.2.2.4. Node to first female flower

Number of nodes from the base of the plant to the node where the first female flower appeared was recorded.

3.2.2.5. Days to first fruit harvest

Number of days taken from sowing to the harvest of the first formed fruit was recorded.

3.2.2.6. Vine length

Length of the vine from the base of the plant to the terminal bud was measured and recorded.

3.2.2.7. Branches per plant

The number of primary branches of each plant was counted and recorded.

3.2.2.8. Fruits per plant

The total number of fruits produced on a single plant was counted and recorded.

3.2.2.9. Mean fruit weight

The sum of the weights of five fruits selected at random from each plant was taken and their average was expressed in kilograms.

3.2.2.10. Fruit yield per plant

Fruit yield per plant was computed as the sum total of the weight of all the fruits in that plant and expressed in kilograms.

3.2.2.11. Fruit length

The length of five fruits harvested from each plant at random was recorded, the average worked out and expressed in centimeters.

3.2.2.12. Fruit girth

The girth at three portions of the5 fruits were taken, averaged and expressed in centimeters.

3.2.2.13. Flesh thickness

Each fruit taken to record the above two observations was cut at the middle, the thickness of the flesh measured and recorded in centimeters.

3.2.2.14. Dry matter content

A known weight of the flesh of the fruit was taken and dried in oven at 60^0C until it recorded consistent weights consecutively. The dried weight was expressed as the dry matter content in percent.

3.2.2.15. Seeds per fruit

The seeds were taken from 5 fruits and the total number was counted, averaged and recorded.

3.2.2.16. 100-seed weight

A random sample of 100 fully developed seeds per fruit was weighed and the average weight expressed in grams.

3.2.2.17. Duration of the crop

The number of days taken by the plant from germination to the harvest of the last fruit was considered as the duration of the crop.

3.2.2.18. Pest and disease incidence

No scoring was done for pests and diseases since there were no incidences because of effective control measures.

3.2.2.19. Fruit colour

No scoring for the colour of fruit was done since there was no characteristic variation in the colouration of the fruits.

3.2.3. Statistical analysis

3.2.3.1. Analysis of variance (ANOVA) and covariance (ANCOVA) for randomised block design (RBD) in respect of the various characters was done.

3.2.3.2. Mean – The mean of the i^{th} character X_i ($\bar{x}_i$) was worked out.

3.2.3.3. Variance and Covariance

The variance and covariance components were calculated as per the following formulae.

For the character X_i,

- Environmental variance, $\sigma_{ei}^2 = MSE$
- Genotypic variance, $\sigma_{gi}^2 = \frac{MST - MSE}{r}$
- Phenotypic variance, $\sigma_{pi}^2 = \sigma_{gi}^2 + \sigma_{ei}^2$

where MST and MSE are respectively, the mean sum of squares for treatment and error, respectively from ANOVA and r, the number of replications.

- Environmental covariance, $\sigma_{eij} = MSPE$
- Genotypic covariance, $\sigma_{gij} = \frac{MSPT - MSPE}{r}$
- Phenotypic covariance, $\sigma_{pij} = \sigma_{gij} + \sigma_{eij}$

where the MSPT and MSPE are, respectively, the mean sum of products between the i^{th} and j^{th} characters for genotype and environment from ANCOVA.

3.2.3.4. Grouping of genotypes

The genotypes were classified low, medium and high categories with respect to each character as follows:-

Definition		Category
Less than mean – $2SE_m$	:	Poor
Between mean ± $2SE_m$	:	Medium
More than mean + $2SE_m$	:	Better

where SE_m is the standard error of the mean for each character.

$$SE_m = \left(\frac{MSE}{r}\right)^{1/2}$$

The above classification was in the reverse order i.e., better, medium and poor for the characters days to first male flower, days to first female flower, node to first male flower and node to first female flower.

3.2.3.5. Genetic parameters

3.2.3.5.1. Coefficient of variation

Variability that existed in the population for various characters were apportioned using the estimates of coefficient of variation.

For the character X_i,

- Phenotypic coefficient of variation, PCV = $\frac{\sigma_{pi}}{\bar{X}_i} \times 100$
- Genotypic coefficient of variation, GCV = $\frac{\sigma_{gi}}{\bar{X}_i} \times 100$
- Environmental coefficient of variation, ECV = $\frac{\sigma_{ei}}{\bar{X}_i} \times 100$

Where σ_{pi}, σ_{gi} and σ_{ei} are the phenotypic, genotypic and environmental standard deviations respectively.

3.2.3.5.2. Heritability and genetic advance

3.2.3.5.2.1. Heritability coefficient

Jain (1982) proposed the mathematical relationship of variance estimates on computation of heritability, which is usually expressed as a percentage.

$$\text{Heritability (broad sense), } H^2 = \frac{\sigma_{gi}^2}{\sigma_{pi}^2} \times 100$$

The heritability % were categorized as suggested by Robinson *et al.* (1949) namely, low (0-30), moderate (30-60) and high (above 60).

3.2.3.5.2.2. Genetic advance under selection

Genetic advance as percentage of mean was calculated as per the formula given by Lush (1949).

$$\text{Genetic advance, GA} = \frac{k\,H^2\ \sigma_{pi}}{\bar{X}_i} \times 100$$

H^2 – heritability in broad sense

σ_{pi} – phenotypic standard deviation

k – selection differential that is 2.06 in case of 5% selection in large samples (Miller et al., 1958).

Genetic advance as percentage were categorized into low (<20%) and high (>20%) as suggested by Robinson *et al.* (1949).

3.2.3.6. Correlation analysis

The correlation coefficients (phenotypic, genotypic and environmental) between two characters denoted as i and j were worked out as

$$\text{Genotypic correlation } (r_{gij}) \quad \frac{\sigma g_{ij}}{\sigma g_i \times \sigma g_j}$$

$$\text{Phenotypic correlation } (r_{pij}) \quad \frac{\sigma p_{ij}}{\sigma p_i \times \sigma p_j}$$

$$\text{Environmental correlation } (r_{eij}) \quad \frac{\sigma e_{ij}}{\sigma e_i \times \sigma e_j}$$

where σg_{ij}, σp_{ij} and σe_{ij} are the genotypic, phenotypic and environmental co-variances between the characters i and j.

3.2.3.7. Path coefficient analysis

The direct and indirect effects of component characters on yield were estimated through path analysis technique (Wright, 1954 and Dewey and Lu, 1959).

3.2.3.9. Mahalanobis D^2 analysis

Genetic divergence was studied using Mahalanobis D^2 statistic as described by Rao (1952). The genotypes were clustered by Tochers method.

3.2.3.10. Selection index

The various genotypes were discriminated based on 17 characters using the selection index developed by Smith (1947) using the discriminant function of Fisher (1936).

The selection index is described by the function $I = b_1x_1 + b_2x_2 + \dots\dots\dots + b_kx_k$. The function $H = a_1G_1 + a_2G_2 + \dots\dots\dots\dots + a_kG_k$ describes the merit of a plant where $x_1, x_2, \dots\dots\dots x_k$ are the phenotypic values and $G_1, G_2, \dots\dots\dots\dots G_k$ are the genotypic values of the plant with respect to the characters $X_1, X_2, \dots\dots\dots\dots X_k$. H denotes the genetic worth of the plant. The economic worth assigned to each character is assumed to be equal to unity i.e., $a_1, a_2, \dots\dots\dots\dots a_k = 1$. The regression coefficients $b_1, b_2, \dots\dots b_k$ are estimated in such a way that the correlation between H and I is maximum. The procedure will reduce to and equation of the form $b = P^{-1}Ga$, where P is the phenotypic and G is the genotypic variance covariance matrix respectively from which the b values were solved out.

RESULT

4. RESULT

The performance of 25 genotypes was evaluated for various morphological and yield traits. The recorded observations were statistically analysed and the results are presented in this chapter.

4.1. Mean performance

The mean values of the 25 genotypes for all the characters namely, days to first male and female flower, node to first male and female flower, days to fruit harvest, vine length, branches per plant, mean fruit weight, fruits per plant, fruit yield per plant, fruit length, fruit girth, flesh thickness, seeds per fruit, dry matter content, 100-seed weight and crop duration are presented in the table 2. The variation in fruit shape, size, length and girth is presented in the plates 1 and 2. A wide range of variation was noticed for all the characters.

Days to first male flower and female flower ranged from 49.00 (T_{24}) to 65.65 (T_8) and 58.00 (T_{24}) to 76.00 (T_{21}) respectively.

Node to the first male flower was maximum in T_6 (26.33) and minimum in T_{25} (8.67). The maximum number of nodes to produce the first female flower was for T_8 (28.33) and the minimum was for T_3 and T_{25} (7.67).

Table 2. Varietal differences with respect to various characters

Genotypes	Days to first male flower	Days to first female flower	Node to first male flower	Node to first female flower	Days to first fruit harvest	Vine length (m)	Branches per plant	Fruits per plant	Mean fruit weight (kg)	Fruit yield per plant (kg)	Fruit length (cm)	Fruit girth (cm)	Flesh thickness (cm)	Dry matter content (%)	Seeds per fruit	100-seed weight (g)	Duration of the crop
T_1	58.17	60.33	25.17	27.67	88	11.08	2.00	5.00	3.13	12.75	21.70	42.53	3.07	2.98	826.67	4.43	152
T_2	54.83	61.00	14.75	19.56	87	9.22	1.67	4.67	7.16	24.76	24.00	73.10	4.07	2.72	1910.00	4.25	152
T_3	61.67	67.67	12.00	17.67	87	12.94	1.67	2.67	6.30	14.92	38.40	63.47	3.97	3.50	1983.33	4.90	152
T_4	57.17	64.33	14.34	22.33	77	12.00	2.33	3.67	6.53	17.75	28.77	69.73	2.97	3.35	1543.33	6.40	142
T_5	57.17	68.33	13.17	20.00	77	11.97	2.00	2.33	6.43	13.09	41.73	50.33	3.47	4.06	933.33	4.72	142
T_6	63.27	67.33	26.33	19.67	87	15.08	1.33	5.00	2.25	11.19	20.67	45.57	1.97	3.54	340.00	3.91	152
T_7	56.96	60.43	13.65	20.22	87	10.27	2.33	3.33	6.29	19.78	23.43	74.27	3.17	3.06	1760.00	4.97	152
T_8	65.65	65.67	19.89	28.33	87	8.40	2.67	4.67	2.62	13.92	19.67	35.13	1.93	3.48	258.33	2.23	152
T_9	57.00	59.93	15.38	21.17	87	12.32	1.00	4.00	6.73	21.56	23.00	52.30	2.23	3.00	1061.67	5.31	152
T_{10}	59.00	68.67	13.63	19.33	87	10.31	1.33	2.33	6.11	12.37	24.43	69.53	3.13	3.49	1386.67	6.75	152
T_{11}	59.67	61.33	12.67	21.00	77	9.23	1.67	3.33	3.23	8.43	25.97	72.23	4.47	2.48	386.67	6.16	142
T_{12}	57.17	66.33	16.67	21.00	102	8.33	1.33	3.33	4.77	13.27	16.33	49.07	3.07	3.24	603.33	6.07	142
T_{13}	59.33	64.33	18.10	19.00	87	10.73	2.00	4.33	5.20	19.17	35.47	62.70	5.00	3.62	693.33	4.59	152
T_{14}	58.25	64.67	15.58	20.00	87	14.80	1.00	4.00	7.62	24.37	28.33	70.77	3.57	2.95	590.00	6.40	152
T_{15}	55.50	66.43	15.25	24.11	87	7.09	1.33	5.00	1.02	5.37	16.93	30.70	2.17	3.91	493.33	3.85	152
T_{16}	57.40	70.67	17.00	21.67	102	7.95	2.00	6.33	0.80	3.83	12.23	30.33	1.23	4.49	176.67	3.49	142
T_{17}	62.67	64.67	16.00	20.23	98	11.66	1.33	4.00	3.70	15.10	24.37	44.00	2.83	3.06	666.67	5.89	142
T_{18}	63.00	67.00	15.33	21.67	98	11.18	2.00	7.33	0.82	6.17	13.17	33.97	1.10	4.30	93.33	5.13	142
T_{19}	58.67	60.67	12.33	18.67	98	11.06	2.33	6.33	1.42	8.07	20.00	36.43	2.37	3.80	416.67	3.63	142
T_{20}	60.25	59.50	14.67	19.83	87	9.49	2.33	5.00	7.33	30.84	36.87	67.73	5.20	2.90	623.33	4.76	152
T_{21}	62.33	76.00	11.33	18.00	98	8.05	2.00	7.33	0.85	5.62	11.43	29.3	0.87	4.26	103.33	3.27	142
T_{22}	62.67	71.33	19.67	23.67	102	10.36	2.33	5.33	6.23	30.22	33.27	57.23	3.80	3.03	480.00	5.02	142
T_{23}	57.00	71.67	14.75	18.67	102	10.66	1.00	4.00	6.22	17.33	24.60	52.23	2.97	3.39	580.00	4.69	142
T_{24}	49.00	58.00	15.5	18.50	98	10.76	1.33	3.67	5.22	14.17	29.27	51.73	3.17	3.30	716.67	4.44	152
T_{25}	53.00	63.67	8.67	17.67	98	11.50	1.67	3.33	5.92	14.87	31.03	48.00	4.20	3.08	676.67	6.00	152
Mean	58.67	65.20	15.67	20.79	90.88	10.66	1.76	4.41	4.55	15.16	25.00	52.49	3.04	3.40	772.13	4.85	
F	10.15**	9.93**	9.82**	3.12**		37.77**	3.21**	6.53**	19.54**	28.58**	87.01**	60.24**	17.86**	37.02**	277.75**	46.48**	
SE	1.13	1.42	1.25	1.55		0.32	0.27	0.59	0.53	1.36	0.87	1.92	0.27	0.08	32.69	0.16	
CD	3.23	4.04	3.52	4.41		0.91	0.77	1.52	1.50	3.87	2.47	5.47	0.76	0.22	92.93	0.46	

Significant at 1%

The longest vine was seen for T_6 (15.08m) and T_{14} was on par with it, while T_{15} had the shortest vine (7.09m). A narrow range of 1 to 2.67 was observed for the number of branches per plant. Maximum branches per plant was seen in T_8 (2.67), which was on par with T_4, T_7, T_{20}, T_{22}, T_1, T_{16} and T_{15}.

Fruits per plant had a range of 2.33 to 7.33. Maximum fruits were obtained from T_{18} and T_{21}, which were on par with T_{16} and T_{19}. T_5 and T_{10} had the minimum fruits.

Highest mean fruit weight was seen for T_{14} (7.62kg). A wide range of 0.80 to 7.62 was observed for this character. The lowest mean fruit weight was for T_{16} (0.80kg).

Fruit yield per plant was highest for T_{20} (30.84kg), which was on par with T_{20}. The lowest fruit yield was for T_{16} (3.83kg), which was on par with T_{15}, T_{21} and T_{18}.

Longest fruits were seen in T_5 (41.73cm) and shortest fruits in T_{21} (11.43cm). A wide range of 29.30 (T_{21}) to 74.27 (T_7) was seen for fruit girth. Maximum flesh thickness was seen for T_{20} (5.20cm) and minimum for T_{21} (0.87cm). Dry matter content was highest in T_{16} (4.49%)and lowest in T_{11} (2.48%).

Seeds per fruit was highest in T_3 (1983.33) and lowest in T_{18} (93.33). A wide range of 2.23 (T8) to 6.75 (T10) was observed for 100-seed weight.

Plate 1. Variation in fruit characters

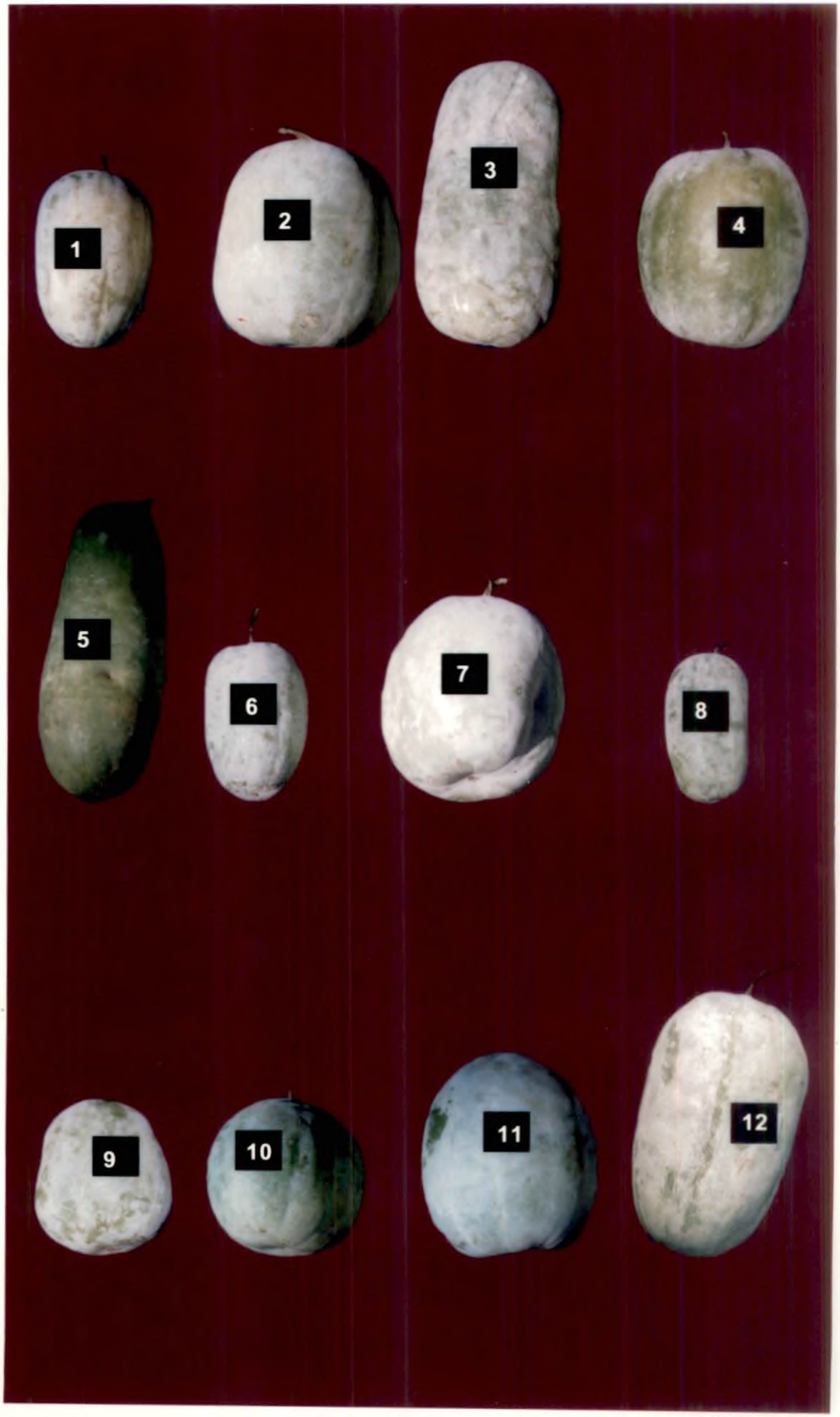
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Plate 2. Variation in fruit characters

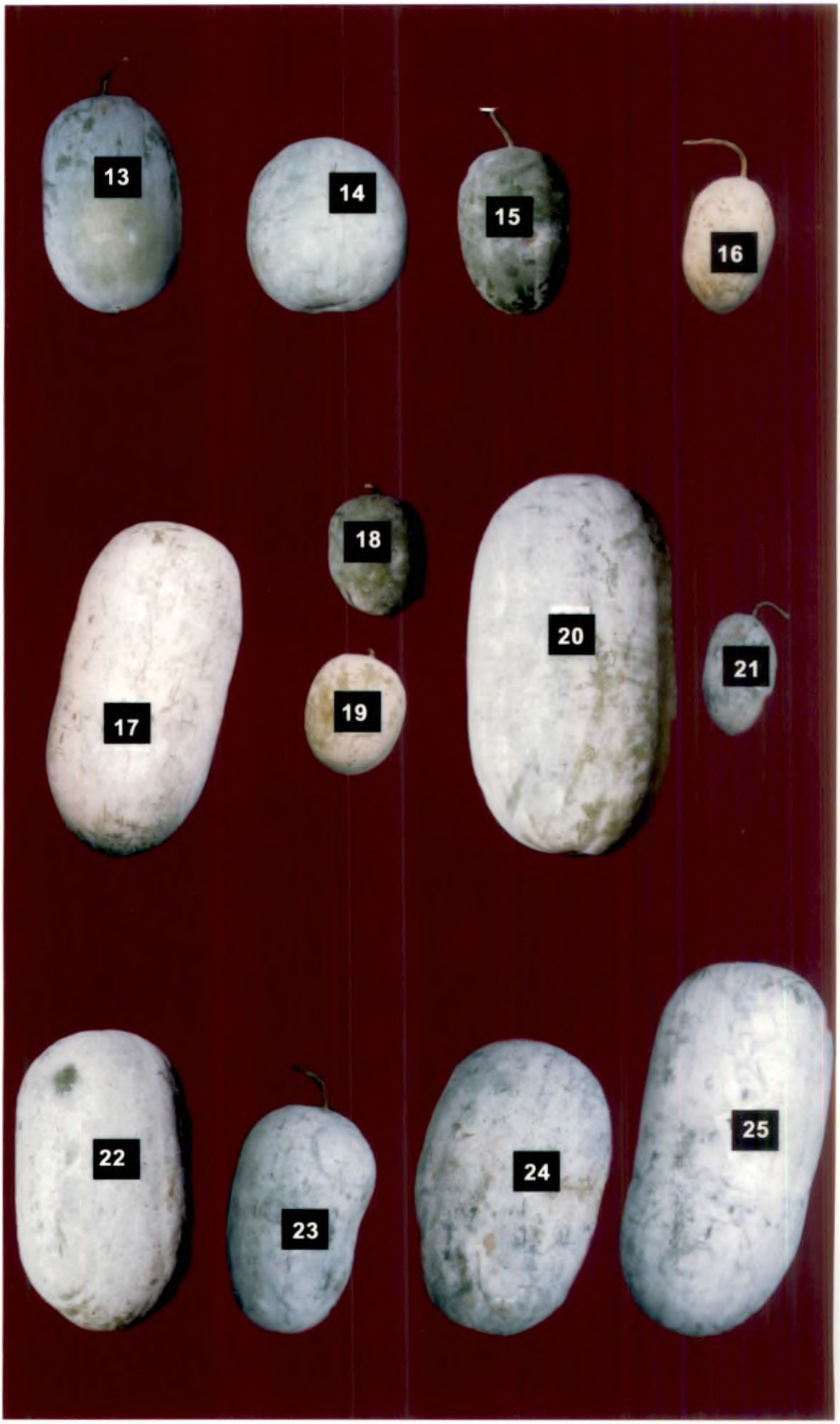
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Table 3. Classification of genotypes

Characters	Class: Poor	Class: Medium	Class: Better
Days to first male flower	T_3, T_6, T_8, T_{17}, T_{18}, T_{21}, T_{22}	T_1, T_4, T_5, T_7, T_9, T_{10}, T_{11} T_{12}, T_{13}, T_{14}, T_{16}, T_{19}, T_{20}, T_{23}	T_2, T_{15}, T_{24}, T_{25}
Days to first female flower	T_5, T_{10}, T_{16}, T_{21}, T_{22}, T_{23}	T_3, T_4, T_6, T_8, T_{12}, T_{13}, T_{14}, T_{15}, T_{17}, T_{18}, T_{25}	T_1, T_2, T_7, T_9 T_{11}, T_{20}, T_{24}
Node to first male flower	T_1, T_6, T_8, T_{22}	T_2, T_4, T_7, T_9, T_{10}, T_{12}, T_{13}, T_{14}, T_{15}, T_{16}, T_{17}, T_{18}, T_{20} T_{23}, T_{24}	T_3, T_5, T_{11}, T_{19} T_{21}, T_{25}
Node to first female flower	T_1, T_8, T_{15}	T_2, T_4, T_5, T_6, T_7, T_9, T_{10}, T_{11}, T_{12}, T_{13}, T_{14}, T_{16}, T_{17}, T_{18}, T_{19}, T_{20}, T_{21}, T_{22}	T_3, T_{25}
Vine length	T_2, T_8, T_{11}, T_{12}, T_{15}, T_{16}, T_{20}, T_{21}	T_1, T_7, T_{10}, T_{13}, T_{18}, T_{19}, T_{22}, T_{23}, T_{24}	T_3, T_4, T_5, T_6, T_9, T_{14}, T_{17}, T_{25}
Branches per plant	T_9,T_{14},T_{23}	T_1, T_2, T_3, T_5, T_6, T_{10}, T_{11}, T_{12}, T_{13}, T_{15}, T_{16}, T_{17}, T_{18}, T_{21}, T_{24}, T_{25}	T_4, T_7, T_8, T_{19}, T_{20}, T_{22}
Fruits per plant	T_3, T_5, T_7, T_{10}, T_{11}, T_{12}, T_{25}	T_1, T_2, T_4, T_6, T_8, T_9, T_{13}, T_{14}, T_{15}, T_{17}, T_{20}, T_{22}, T_{23}, T_{24}	T_{16}, T_{18}, T_{19}, T_{21}
Mean fruit weight	T_1, T_6, T_8, T_{11}, T_{15}, T_{16}, T_{18}, T_{19}	T_{12}, T_{13},T_{17},T_{21},T_{22},T_{24}	T_2, T_3, T_4, T_5, T_7, T_9, T_{10}, T_{14}, T_{23}, T_{25}
Fruit yield per plant	T_6, T_{10}, T_{11}, T_{15}, T_{16}, T_{18}, T_{19}, T_{21}	T_1, T_3, T_4, T_5, T_8, T_{12}, T_{17}, T_{23}, T_{24}, T_{25}	T_2, T_7, T_9, T_{13}, T_{14}, T_{20}, T_{22}
Fruit length	T_1, T_6, T_8, T_9, T_{12}, T_{15}, T_{16}, T_{18}, T_{19}, T_{21}	T_2, T_7, T_{10}, T_{11} T_{17}, T_{23}	T_3, T_4, T_5, T_{13}, T_{14}, T_{20}, T_{22}, T_{24},T_{25}
Fruit girth	T_1, T_6, T_8, T_{15}, T_{16}, T_{17}, T_{18}, T_{19}, T_{21}, T_{25}	T_5, T_9, T_{12}, T_{23}, T_{24}	T_2, T_3, T_4, T_7, T_{10}, T_{11}, T_{13}, T_{14}, T_{20}, T_{22}
Flesh thickness	T_6, T_8, T_9, T_{15}, T_{16}, T_{18}, T_{19}, T_{21}	T_1, T_4, T_5, T_7, T_{10}, T_{12}, T_{14}, T_{17}, T_{23}, T_{24}	T_2, T_3, T_{11}, T_{13}, T_{20}, T_{22}, T_{25}
Dry matter content	T_1, T_2, T_7, T_9, T_{11}, T_{14}, T_{17}, T_{20}, T_{22}, T_{25}	T_3, T_4, T_6, T_8, T_{10}, T_{12}, T_{18}, T_{23}, T_{24}	T_5, T_{13}, T_{15}, T_{16}, T_{19}, T_{20}, T_{21}
Seeds per fruit	T_6, T_8, T_{11}, T_{12}, T_{13}, T_{14}, T_{15}, T_{16} T_{17}, T_{18}, T_{19}, T_{20}, T_{21}, T_{22}, T_{23}, T_{25}	T_1, T_{24}	T_2, T_3,T_4,T_5 T_7,T_9,T_{10}
100-seed weight	T_1, T_2, T_6, T_8,T_{15}, T_{16}, T_{19}, T_{21}, T_{24}	T_3, T_5, T_7, T_{13}, T_{18}, T_{20}, T_{22}, T_{23}	T_4, T_9, T_{10}, T_{11}, T_{12}, T_{14}, T_{17}, T_{25}

The genotypes were classified into 3 based on normal distribution property and presented in table 3. The genotypes T_2, T_3 and T_4 were found to performing better for most of the characters while T_6, T_{15}, T_{16} and T_{21} were poor in most of the characters.

4.2. Genetic parameters

The phenotypic, genotypic and environmental variances for the various characters have been calculated and presented in the table 4. Estimates of variance showed that for all the characters, genetic variance makes up the major part of the phenotypic variance with very little contribution by the environment.

4.2.1. Coefficient of variation

The phenotypic coefficient of variance, genotypic coefficient of variance and environmental coefficient of variance were worked out using the mean data and presented in the table 4 and Fig.1.

4.2.1.1. Phenotypic coefficient of variance

The phenotypic coefficient of variance for all the characters is given in the table 4. It was very high for the seeds per fruit (70.82). Mean fruit weight and fruit yield per plant also had high PCV i.e., 53.75 and 49.67 respectively, indicating a high degree of variation. PCV was very less for days to first male and female flower production.

Table 4. Estimates of genetic parameters with respect to various characters

Sl. No.	Characters	Variance σ_p^2	σ_g^2	σ_e^2	Co-efficient of variation (%) PCV	GCV	Heritability as % (H^2)	Genetic advance as % of mean
1.	Days to first male flower	15.99	11.82	4.17	6.75	5.86	75.30	10.48
2.	Days to first female flower	24.07	18.01	6.06	7.52	6.51	74.84	11.60
3.	Node to first male flower	18.42	13.75	4.68	27.39	23.66	74.61	42.09
4.	Node to first female flower	12.32	5.10	7.22	16.89	10.86	41.36	14.39
5.	Vine length (m)	4.11	3.80	0.31	19.02	18.29	92.46	36.23
6.	Branches per plant	0.38	0.16	0.22	35.18	22.92	42.46	30.77
7.	Fruits per plant	2.45	1.59	0.86	35.44	28.54	64.83	47.33
8.	Mean fruit weight (kg)	5.99	5.16	0.84	53.75	49.87	86.07	95.31
9.	Fruit yield per plant	56.67	51.11	5.56	49.67	47.17	90.19	92.28
10.	Fruit length (cm)	67.25	64.99	2.27	32.80	32.24	96.63	65.29
11.	Fruit girth (cm)	230.42	219.31	11.11	28.91	28.21	95.18	56.69
12.	Flesh thickness (cm)	1.43	1.22	0.22	39.39	36.30	84.89	68.89
13.	Dry matter content (%)	0.28	0.26	0.02	15.46	14.86	92.31	29.40
14.	Seeds per fruit	298989.40	295783.00	3206.40	70.82	70.44	98.93	144.32
15.	100-seed weight (g)	1.3	1.22	0.08	23.47	22.73	93.81	45.36

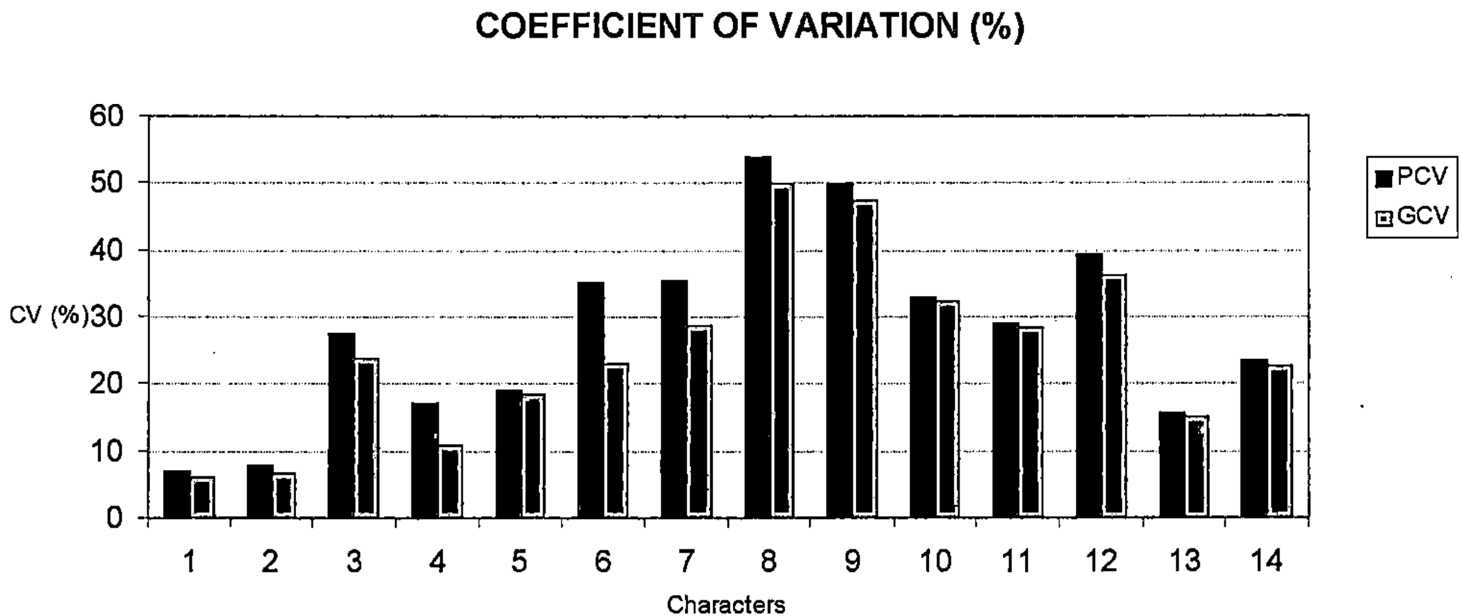


Fig. 1. Coefficient of variation of the characters

1. Days to first male flower opening
2. Days to first female flower opening
3. Node to first male flower
4. Node to first female flower
5. Vine length
6. Branches per plant
7. Fruits per plant
8. Mean fruit weight
9. Fruit yield per plant
10. Fruit length
11. Fruit girth
12. Flesh thickness
13. Drymatter content
14. 100-seed weight

4.2.1.2. Genotypic coefficient of variance

GCV followed a similar trend as that of PCV, indicating less influence of environmental variation. The values of GCV for the various characters are presented in the table 4. Days to first male and female flower had a less GCV of 5.86 and 6.51 respectively. Seeds per fruit had the highest GCV (70.44). The GCV for mean fruit weight and fruit yield per plant were 49.87 and 47.17 respectively.

4.2.2. Heritability (broad sense) and genetic advance (as % of mean)

The heritability estimates recorded for the 15 characters is given in the table 4 and Fig. 2. The highest heritability estimate was observed for seeds per fruit (98.93%). According to the classification suggested by Robinson *et al.* (1949) days to first male and female flower, node to first male flower, vine length, mean fruit weight, fruit yield per plant, fruit length, fruit girth, flesh thickness, dry matter content, seeds per fruit and 100-seed weight had high heritability estimates. Node to first female flower and branches per plant had moderate heritability. The least heritability was for node to first female flower (41.36%).

The genetic advance estimates of the various characters as percentage of mean is given in the table 4 and Fig. 2. The highest estimate of genetic advance was observed for seeds per fruit (144.32%).

According to the classification of Robinson *et al.* (1949), node to first male flower, vine length, branches per plant, mean fruit weight, fruit yield per plant, fruits per plant, fruit length, fruit girth,

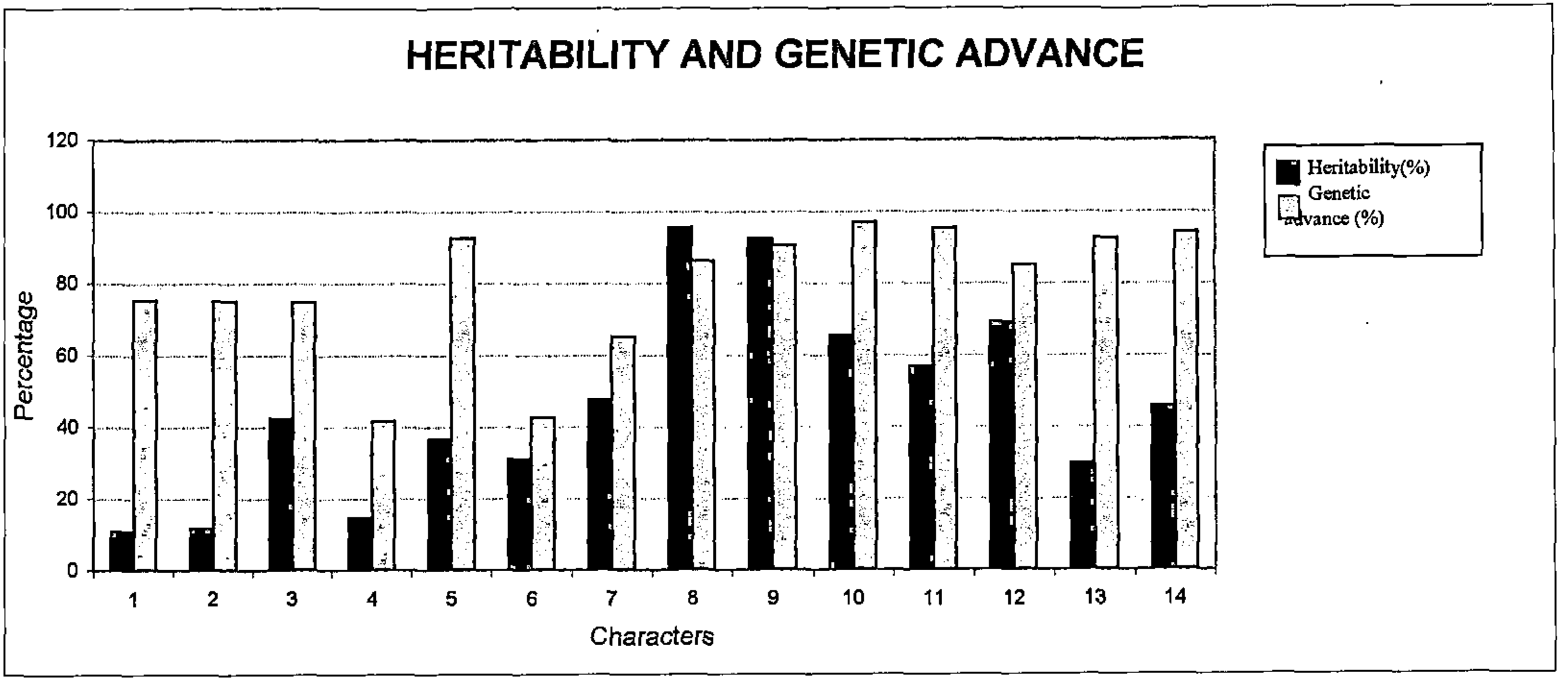


Fig. 2. Heritability and genetic advance estimates of the characters

1. Days to first male flower
2. Days to first female flower
3. Node to first male flower
4. Node to first female flower
5. Vine length
6. Branches per plant
7. Fruits per plant
8. Mean fruit weight
9. Fruit yield per plant
10. Fruit length
11. Fruit girth
12. Flesh thickness
13. Dry matter content
14. 100-seed weight

seeds per fruit, flesh thickness, dry matter content and 100-seed weight had high genetic advance. While days to first male flower, days to first female flower and number of nodes to first female flower had low genetic advance. The lowest genetic advance was observed for days to first male flower (10.48%).

4.3. Correlation analysis

The phenotypic, genotypic and environmental correlations among the various characters were estimated and results are given in the tables 5,6 &7.

4.3.1. Phenotypic correlation coefficient

The phenotypic correlation among the various characters studied is presented in the table 5.

Days to first female flower showed high positive correlation (0.5188) with dry matter content of fruits. It was negatively correlated with fruit girth and flesh thickness. There was positive association for node to first female flower with node to first male flower (0.3732).

Vine length was positively correlated with mean fruit weight (0.3450), fruit length (0.4008) and 100-seed weight (0.3550). High positive association was observed between branches per plant and fruits per plant. There was negative association for branches per plant with 100-seed weight.

Table 5. Estimates of phenotypic correlation coefficients

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
Days to first male flower (X_1)	1.0000																
Days to first female flower (X_2)	0.3722**	1.0000															
Node to first male flower (X_3)	0.3097*	-0.0082	1.0000														
Node to first female flower (X_4)	0.2217	-0.1052	0.3732**	1.0000													
Vine length (X_5)	0.0370	-0.1303	0.1620	-0.2318	1.0000												
Branches per plant (X_6)	0.1527	-0.0232	0.0590	0.2220	-0.2115	1.0000											
Fruits per plant (X_7)	0.2171	0.2220	0.2323	0.0197	-0.2136	0.3069*	1.0000										
Mean fruit weight (X_8)	-0.2933*	-0.2633	-0.1881	-0.2040	0.3450*	-0.1528	-0.5719**	1.0000									
Fruit yield per plant (X_9)	-0.0489	-0.2708	0.0984	-0.0454	0.2619	0.0477	-0.1828	0.8004**	1.0000								
Fruit length (X_{10})	-0.1260	-0.2054	-0.1778	-0.2026	0.4008**	0.0665	-0.5544**	0.6976**	0.5685**	1.0000							
Fruit girth (X_{11})	-0.1824	-0.3468*	-0.1851	-0.2144	0.2913*	-0.0416	-0.5404**	0.7575**	0.6211**	0.5910**	1.0000						
Flesh thickness (X_{12})	-0.2199	-0.3535*	-0.1550	-0.1955	0.1492	-0.0313	-0.4681**	0.6559**	0.6117**	0.7576**	0.7090**	1.0000					
Dry matter content (X_{13})	0.1438	0.5188**	-0.0449	-0.0604	-0.1755	0.1296	0.4283**	-0.5611**	-0.6046**	-0.3553*	-0.6584**	-0.6087**	1.0000				
Seeds per fruit (X_{14})	-0.2735	-0.2878*	-0.2218	-0.1602	0.2151	-0.0276	-0.5379**	0.6162**	0.3745*	0.4295**	0.6692**	0.3916**	-0.3705*	1.0000			
100-seed weight (X_{15})	-0.1978	-0.1430	-0.2501	-0.2142	0.3550*	-0.3152*	-0.4791**	0.5156**	0.2779	0.3124*	0.5820**	0.4164**	-0.4456**	0.3296*	1.0000		
Days to first fruit harvest (X_{16})	-0.0315	0.3023*	-0.0057	-0.1251	-0.2269	-0.0953	0.3996**	-0.2824	-0.1215	-0.4107**	-0.4992**	-0.3240*	0.2596	-0.4332**	-0.1724	1.0000	
Duration of the crop (X_{17})	-0.1976	-0.4216**	0.1752	0.0407	0.1935	-0.1293	-0.2517	0.3060*	0.3041*	0.2323	0.2849	0.2949*	-0.3226*	0.3775**	-0.0803	-0.3205*	1.0000

* significant at 5%

** significant at 1%

Very high negative correlation was seen for fruits per plant with mean fruit weight (-0.5719), fruit length (-0.5544), fruit girth (-0.5404), flesh thickness (-0.4681), seeds per fruit (-0.5379) and 100-seed weight (-0.4791). High positive association was recorded for dry matter content.

Mean fruit weight was positively correlated with fruit yield per plant (0.8004), fruit length (0.6976), fruit girth (0.7575), flesh thickness (0.6559) and seeds per fruit (0.6162) and high negative association was observed with dry matter content (-0.5611).

Fruit yield per plant had negative correlation value with dry matter content (-0.6046). There were positive correlation with fruit length (0.5685), fruit girth (0.6211) and flesh thickness (0.6117). There was very high positive association for fruit length with flesh thickness (0.7576).

Fruit girth was associated negatively with dry matter content and positively with flesh thickness (0.7090) and seeds per fruit (0.6692). Dry matter content was negatively associated with flesh thickness.

4.3.2. Genotypic correlation coefficient

The genotypic correlation among the various characters was studied and the coefficients are given in the table 6.

Days to first male flower was positively correlated with branches per plant while days to first female flower was positively correlated with dry matter content. Node to first male flower was highly associated with node to first female flower (0.8002).

Table 6. Estimates of genotypic correlation coefficients

Character	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
Days to first male flower (X_1)	1.0000																
Days to first female flower (X_2)	0.4597**	1.0000															
Node to first male flower (X_3)	0.3490*	-0.0267	1.0000														
Node to first female flower (X_4)	0.3673*	-0.0406	0.8002**	1.0000													
Vine length (X_5)	0.1042	-0.1670	0.1989	-0.3350*	1.0000												
Branches per plant (X_6)	0.5254**	-0.0300	0.0114	0.5230**	-0.3838**	1.0000											
Fruits per plant (X_7)	0.4329**	0.2711	0.1959	0.3473*	-0.3191*	0.3542*	1.0000										
Mean fruit weight (X8)	-0.3418*	-0.2969*	-0.2350	-0.3544*	0.3895**	-0.2236	-0.7691**	1.0000									
Fruit yield per plant (X_9)	-0.0331	-0.3158*	0.0506	-0.0443	0.2717	0.0456	-0.3488*	0.8445**	1.0000								
Fruit length (X_{10})	-0.1553	-0.2477	-0.1723	-0.3308*	0.4260**	0.0795	-0.6657**	0.7607**	0.6247**	1.0000							
Fruit girth (X_{11})	-0.1989	-0.3910**	-0.1906	-0.3501*	0.3036*	-0.1183	-0.6853**	0.8492**	0.6865**	0.6090**	1.0000						
Flesh thickness (X_{12})	-0.2596	-0.4810**	-0.1765	-0.2847	0.1511	0.0446	-0.6554**	0.7489**	0.6732**	0.8403**	0.7801**	1.0000					
Drymatter content (X_{13})	0.1884	0.6405**	-0.0603	-0.0504	-0.2063	0.2469	0.5182**	-0.6468**	-0.6818**	-0.3902**	-0.7017**	-0.7087**	1.0000				
Seeds per fruit (X_{14})	-0.3091	-0.3212*	-0.2509	-0.2588	0.2189	-0.0572	-0.6576**	0.6791**	0.4054**	0.4389**	0.6845**	0.4307**	-0.3805**	1.0000			
100-seed weight (X_{15})	-0.2299	-0.1760	-0.3326	-0.3559*	0.3700*	-0.4909**	-0.6271**	0.5593**	0.2772	0.3277*	0.6202**	0.4478**	-0.4795**	0.3413*	1.0000		
Days to first fruit harvest (X_{16})	-0.0363	0.3494*	-0.0066	-0.1946	-0.2360	-0.1463	0.4963**	-0.3044*	-0.1279	-0.4178**	-0.5117**	-0.3516*	0.2702	-0.4355**	-0.1780	1.0000	
Duration of the crop (X_{17})	-0.2276	-0.4873**	0.2028	0.0632	0.2013	-0.1984	-0.3126*	0.3299*	0.3202*	0.2363	0.2921*	0.3200*	-0.3358*	0.3796*	-0.0829	-0.3204*	1.0000

* Significant at 5%
** Significant at 1%

Fruits per plant had high negative correlation with mean fruit weight (-0.7691), fruit length (-0.6657), fruit girth (-0.6853), flesh thickness(-0.6554), seeds per fruit (-0.6576) and 100-seed weight (-0.6271). A positive association (0.5182) was seen with dry matter content.

High positive correlation was observed for mean fruit weight with fruit yield per plant (0.8445), fruit length (0.7607), fruit girth (0.8492), flesh thickness (0.7489) and seeds per fruit (0.6791) and negative correlation for dry matter content (-0.6468).

Fruit yield per plant was positively associated with fruit girth (0.6865), fruit length (0.6732) and flesh thickness (0.6732). There was high negative association with dry matter content. Fruit length had high positive association with fruit girth (0.6090) and flesh thickness (0.8403). Fruit girth was negatively associated with dry matter content (-0.7017) and positively associated with flesh thickness (0.7801), seeds per fruit (0.6845) and 100-seed weight (0.6202). While flesh thickness and dry matter content of fruit was negatively associated.

4.3.3. Environmental correlation coefficient

The environmental correlation coefficients for most of the characters were very small. The correlation coefficients obtained are presented in the table 7.

Table 7. Estimates of environmental correlation coefficient

Character	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
Days to first male flower (X_1)	1.0000														
Days to first female flower (X_2)	0.1086	1.0000													
Node to first male flower (X_3)	0.1919	0.0462	1.0000												
Node to first female flower (X_4)	0.0438	-0.2150	-0.1848	1.0000											
Vine length (X_5)	-0.3662*	0.0627	-0.0232	-0.1172	1.0000										
Branches per plant (X_6)	-0.3831**	-0.0164	0.1375	0.0048	0.1392	1.0000									
Fruits per plant (X_7)	-0.2897*	0.1113	0.3215*	-0.3526*	0.2053	0.2691	1.0000								
Mean fruit weight (X8)	-0.0979	-0.1337	0.0013	0.0259	-0.0238	-0.0622	0.0117	1.0000							
Fruit yield per plant (X_9)	-0.1389	-0.0721	0.3607*	-0.0767	0.1602	0.0821	0.4520	0.4814**	1.0000						
Fruit length (X_{10})	0.0713	0.0567	-0.3410*	0.0459	-0.0374	0.1115	-0.2534	0.0558	-0.2550	1.0000					
Fruit girth (X_{11})	-0.1290	-0.1526	-0.2215	0.0313	0.1078	0.2021	-0.0164	-0.1354	-0.2164	0.1733	1.0000				
Flesh thickness (X_{12})	-0.638**	0.1534	-0.0742	-0.0899	0.1437	-0.1971	0.0786	0.1088	0.1856	-0.0485	0.0914	1.0000			
Dry matter content (X_{13})	-0.0969	-0.0975	0.0368	-0.1378	0.1984	-0.1185	0.1670	0.1484	0.2018	0.2580	-0.0116	0.1738	1.0000		
Seeds per fruit (X_{14})	-0.1310	-0.2213	-0.1194	0.0673	0.2004	0.1208	-0.1829	-0.2697	-0.2590	0.0220	0.2186	-0.0778	-0.2381	1.0000	
100-seed weight (X_{15})	-0.0374	0.0358	0.2243	0.0396	0.1523	-0.0282	0.0673	0.1411	0.2945*	0.0078	-0.0749	0.1736	0.0099	0.0304	1.0000

* Significant at 5%.
** Significant at 1%

4.4. Path analysis

Fruit yield per plant was taken as the dependent character and path analysis was done. The component characters selected for the analysis were days to first female flower opening, vine length, mean fruit weight, fruit length, fruit girth, flesh thickness, dry matter content and seeds per fruit. The analysis revealed the direct and indirect effects of various characters on yield as presented in the table 8 and Fig. 3.

The highest direct effect was observed for fruit length followed by flesh thickness, dry matter content, fruit girth, fruits per plant, vine length, seeds per fruit and days to first female flower opening. Days to first female flower, fruits per plant, fruit length and fruit girth had positive direct effects while vine length, flesh thickness, dry matter content and seeds per fruit had negative indirect effects.

Days to first female flower and fruits per plant had the negative total correlation values in spite of their positive direct effects. Vine length, flesh thickness and seeds per fruit had positive correlation estimates and negative direct effects. A positive correlation as well as positive direct effect was noted for fruit length and fruit girth. Dry matter content had both correlation and direct effect negative.

Days to first female flower had a negative correlation coefficient with yield in spite of a positive direct effect. This was mainly attributed to the high negative indirect effects through fruit length (-0.4946) and dry matter content (-0.7746). It had very high positive indirect effect through flesh thickness (0.9299).

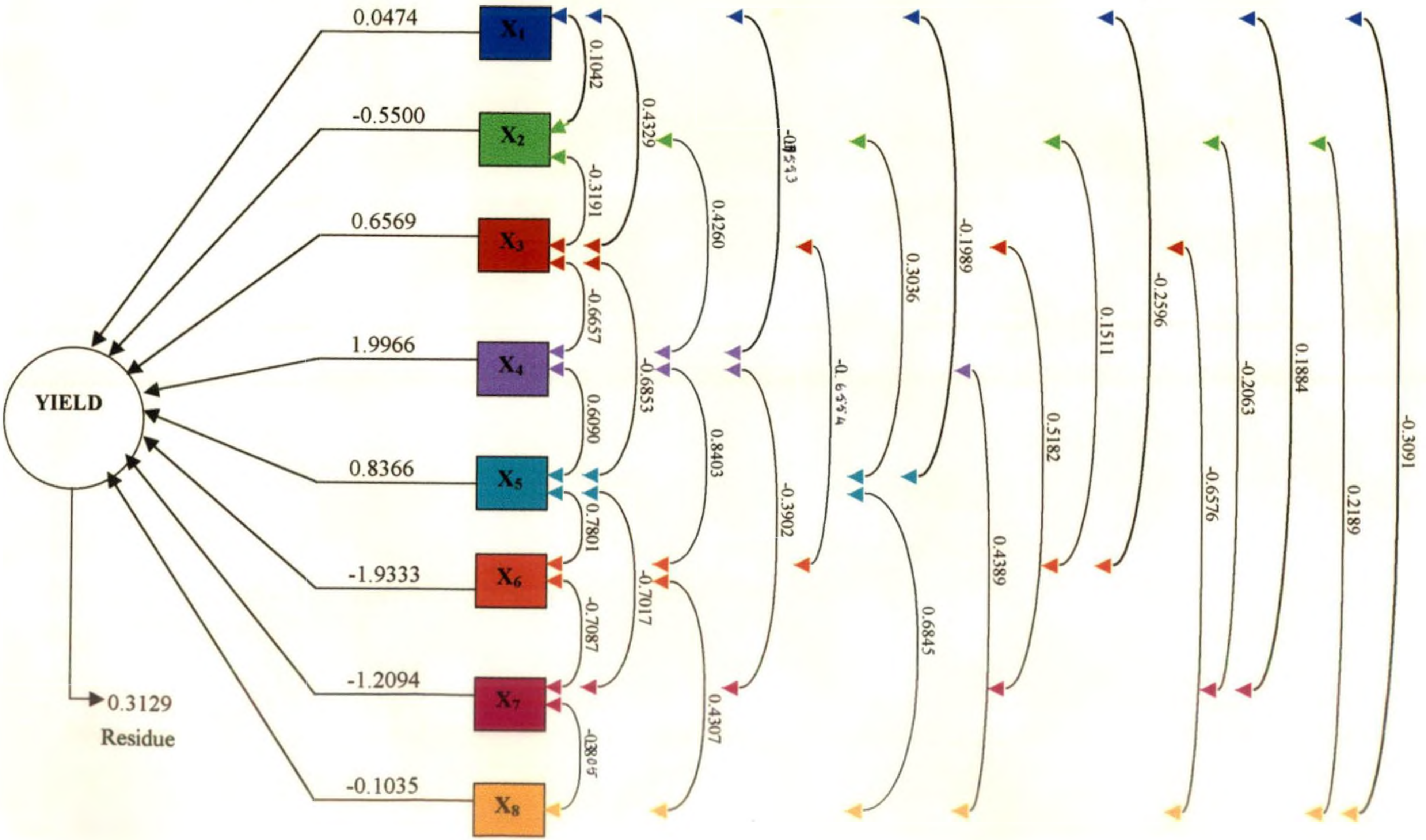
Table 8. Direct and indirect effects of component characters on yield

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Genotypic Correlation
Days to first female flower (X_1)	**0.0474**	0.0919	0.1781	-0.4946	-0.3271	0.9299	-0.7746	0.0332	-0.3158
Vine length (X_2)	-0.0079	**-0.5500**	-0.2096	0.8505	0.2540	-0.2921	0.2495	-0.0227	0.2717
Fruits per plant (X_3)	0.0129	0.1755	**0.6569**	-1.3291	-0.5733	1.2671	-0.6267	0.0680	-0.3487
Fruit length (X_4)	-0.0117	-0.2343	-0.4373	**1.9966**	0.5095	-1.6245	0.4719	-0.0454	0.6248
Fruit girth (X_5)	-0.0185	-0.1670	-0.4502	1.2159	**0.8366**	-1.5081	0.8486	-0.0708	0.6865
Flesh thickness (X_6)	-0.2280	-0.0831	-0.4303	1.6777	0.6526	**-1.9333**	0.8571	-0.0446	0.6731
Dry matter content (X_7)	0.0304	0.1135	0.4303	-0.7791	-0.5870	1.3701	**-1.2094**	0.0394	-0.6817
Seeds per fruit (X_8)	-0.0152	-0.1204	-0.4320	0.8763	0.5727	-0.8327	0.4602	**-0.1035**	0.4054

Residue = 0.3129

Direct effects – diagonal elements
Indirect effects – off diagonal elements

Fig 3. Path diagram



Vine length had a negative direct effect on yield, while the total correlation was positive. A high positive indirect effect was observed through fruit length (0.8505). The character fruits per plant had high indirect effects through fruit length (-1.3291) and flesh thickness (1.2671). The total correlation was negative but there was positive direct effect.

Fruit length had high direct effect on yield (1.9966). It also had high negative indirect effect through flesh thickness. Fruit girth had high negative indirect effect through flesh thickness and positive indirect effect through dry matter content.

There was high negative direct effect for flesh thickness (1.9333) on yield. But the total correlation was positive. This was mainly accounted by the high positive indirect effect through fruit length (1.6777), girth (0.6526) and dry matter content (0.8571).

Dry matter content had a negative direct effect of –1.2094 on yield, while its indirect effect through flesh thickness was very high and positive. The direct effect of seeds per fruit was negative and very less compared to the positive total correlation. There were high indirect effects through fruit length and flesh thickness.

The residual value was 0.3129 indicating that 68 .71% of the variation in yield was contributed by the characters selected for analysis.

4.5. Genetic divergence analysis

The 25 genotypes were subjected to D^2 analysis based on the 15 characters namely, days to first male flower opening, days to first female flower opening, node to first male flower, node to first female flower, vine length, branches per plant, fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth, flesh thickness, drymatter content, seeds per fruit and 100-seed weight.

The genotypes were grouped into 8 clusters using Tocher's method of clustering. The clustering pattern is presented in the table 9.

The cluster III had the highest number of genotypes (8) followed by cluster I (7), II (4) and IV (2). Clusters V, VI, VII and VIII had one genotype each. The cluster I had the genotypes T_1, T_5, T_6, T_{11}, T_{15}, T_{19} and T_{22}. The genotypes T_8, T_{16}, T_{18} and T_{21} were included in the cluster II. The cluster III had T_{12}, T_{13}, T_{14}, T_{17}, T_{20}, T_{23}, T_{24} and T_{25}. The genotypes T_2 and T_3 constituted the cluster IV. The genotype T_9, T_7, T_4 and T_{10} remained as divergent genotypes that cannot be accommodated in any of the clusters and each remained as a separate cluster.

The average inter and intra cluster distances were estimated based on the total D^2 values. The inter and intra cluster distances (D) of the various clusters were worked out and presented in the table10 and Fig. 4. The intracluster distances varied from 0 (clusters V, VI, VII and VIII) to 398.07 (cluster III). The inter cluster distances varied from 189.27 (between clusters VII and VIII) to 2168.61 (between clusters II and IV).

Table 9. Clustering pattern

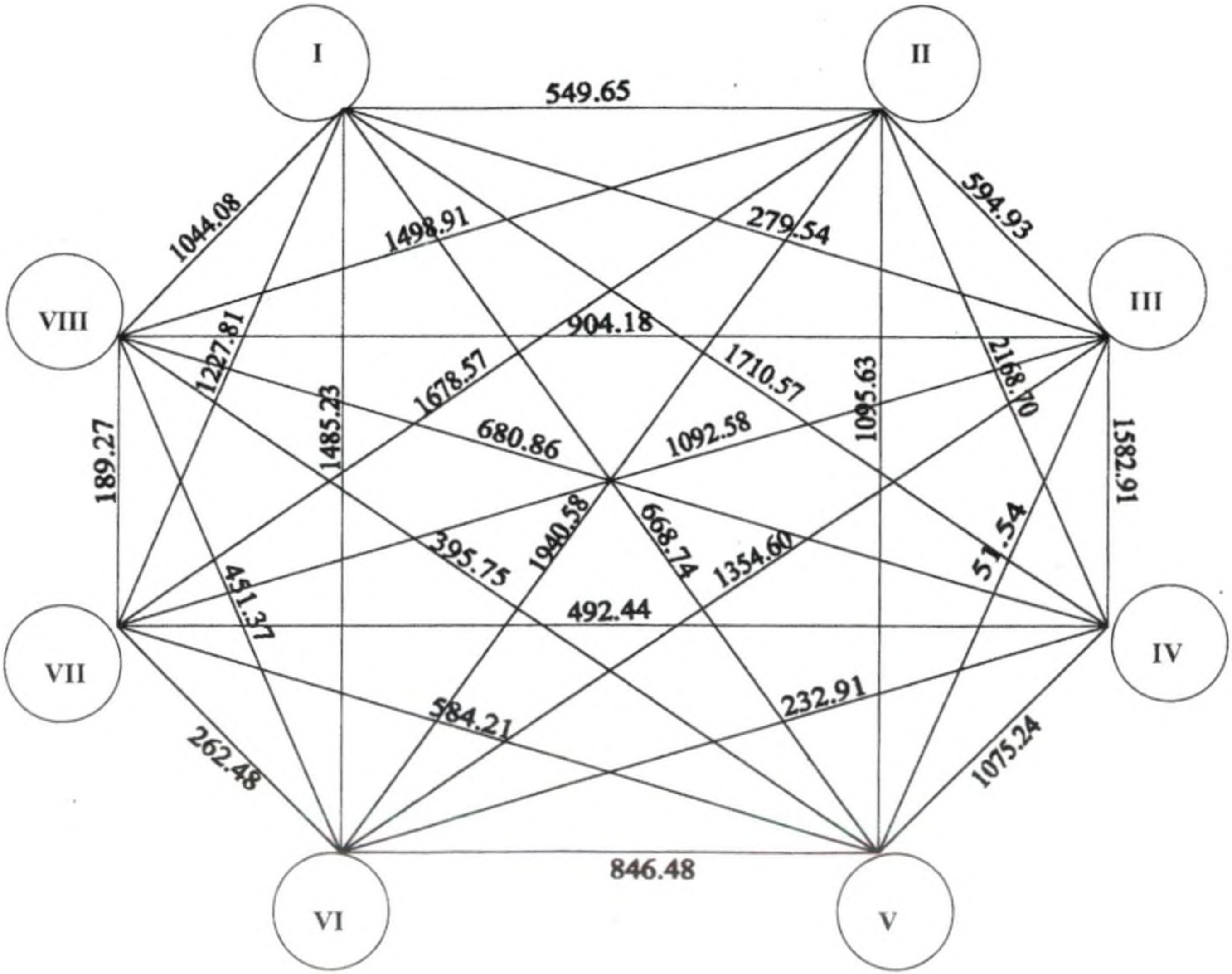
Sl.no	Cluster	Number of genotypes	Genotypes
1.	I	7	T_1, T_5, T_6, T_{11}, T_{15}, T_{19}, T_{22}
2.	II	4	T_8, T_{16}, T_{18}, T_{21}
3.	III	8	T_{12}, T_{13}, T_{14}, T_{17}, T_{20}, T_{23}, T_{24}, T_{25}
4.	IV	2	T_2, T_3
5.	V	1	T_9
6.	VI	1	T_7
7.	VII	1	T_4
8.	VIII	1	T_{10}

Table 10. Average intercluster and intracluster distances

	I	II	III	IV	V	VI	VII	VIII
I	**90.08**	549.65	279.54	1710.57	668.74	1485.23	1227.81	1044.09
II		**132.45**	594.93	2168.70	1095.63	1940.58	1678.57	1489.91
III			**398.07**	1582.91	510.54	1354.60	1092.58	904.18
IV				**92.38**	1075.24	232.91	492.44	680.86
V					**0**	846.48	584.21	395.75
VI						**0**	262.48	451.37
VII							**0**	189.27
VIII								**0**

Diagonal elements – intracluster values
Off diagonal elements – inter cluster values

Fig. 4. Cluster diagram



The cluster IV had the greatest distance from cluster I, followed by clusters VI, VII, VIII, V, II and III. The cluster II was at the greatest distance from IV, followed by VI, VII, VIII, V, III and I. The maximum distance of cluster III was from cluster IV, followed by VI, VII, VIII, II, V and I. The cluster IV was at the maximum distance from II, followed by I, III, V, VIII, VII and VI. The cluster V had the greatest distance from II followed by IV, VI, I, VII, III and VIII. The cluster VI was at the greatest distance from II followed by I, III, V, VIII, VII and IV. The cluster VII was at maximum distance from II followed by I, III, V, IV, VI and VIII. The cluster VIII had the greatest distances from II followed by I, III, IV, VI, V and VII.

The cluster means for each character is presented in the table11 and illustrated in metroglyph as depicted in Fig. 5. The data reveals that character seeds per fruit is contributing maximum towards divergence. Comparatively lesser variation was observed for the characters days to first male and female flower production. The percentage of contribution of the various characters is presented in the table12 and Fig. 6.

Table 11. Cluster means of the various characters

Clusters	Days to first male flower opening	Days to first female flower opening	Node to first male flower	Node to first female flower	Vine length	Branches per plant	Fruits per plant	Mean fruit weight	Fruit yield per plant	Fruit length	Fruit girth	Flesh thickness	Dry matter content	100-seed weight	Seeds per fruit
I	59.30	65.11	17.80	22.11	10.84	1.86	4.62	3.39	12.73	25.75	47.15	3.04	3.40	4.53	553.81
II	62.10	69.83	15.89	22.42	8.90	2.17	6.42	1.27	7.38	14.13	32.18	1.28	4.13	3.53	157.92
III	57.08	64.10	14.99	19.36	10.99	1.50	3.96	5.75	18.64	28.28	55.78	3.75	3.19	5.35	643.75
IV	58.25	64.33	13.38	18.61	11.08	1.67	3.67	6.73	6.73	31.20	68.28	4.02	3.11	4.57	1946.67
V	57.00	59.93	15.38	21.17	12.32	1.00	4.00	6.73	21.56	23.00	52.30	2.23	3.00	5.31	1061.67
VI	56.96	60.43	13.65	20.22	10.27	2.33	3.33	6.29	19.78	23.43	74.27	3.17	3.06	4.97	1760.00
VII	57.17	64.33	14.34	22.33	12.00	2.33	3.67	6.53	17.75	28.77	69.73	2.97	3.35	6.40	1543.33
VIII	59.00	68.67	13.63	19.33	10.31	1.33	2.33	6.11	12.37	24.43	69.53	3.13	3.49	6.75	1386.67
Mean	58.35	64.59	14.88	20.69	9.55	1.77	4.00	5.35	14.61	24.87	58.65	2.95	3.34	5.18	1131.73
SD	1.78	3.59	1.49	1.52	1.13	0.49	1.18	1.98	5.66	5.19	14.44	0.86	0.36	1.04	634.55
CV	3.09	5.35	9.97	7.32	11.79	27.49	29.42	36.92	38.70	20.88	24.62	29.18	10.85	20.08	56.07

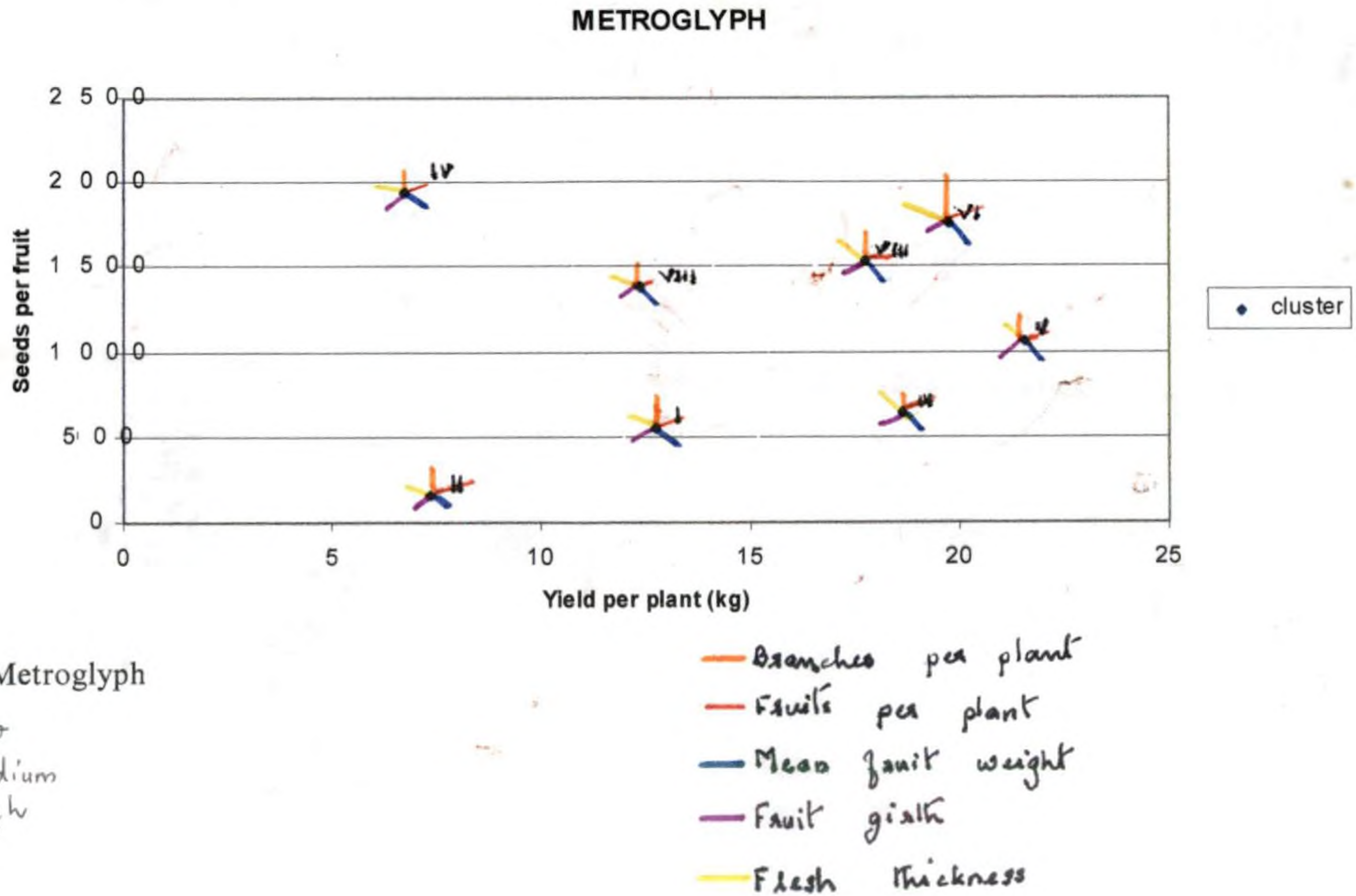


Fig. 5. Metroglyph

— Low
— Medium
— High

Table12. Contribution of individual character to total divergence

Sl.No.	Character	% of contribution
1.	Days to first male flower	1
2.	Days to first female flower	2
3.	Node to first male flower	3
4.	Node to first female flower	2
5.	Vine length	4
6.	Branches per plant	8
7.	Fruits per plant	9
8.	Mean fruit weight	11
9.	Fruit yield per plant	12
10.	Fruit length	6
11.	Fruit girth	7
12.	Flesh thickness	9
13.	Dry matter content	3
14.	Seeds per fruit	17
15.	100-seed weight	6

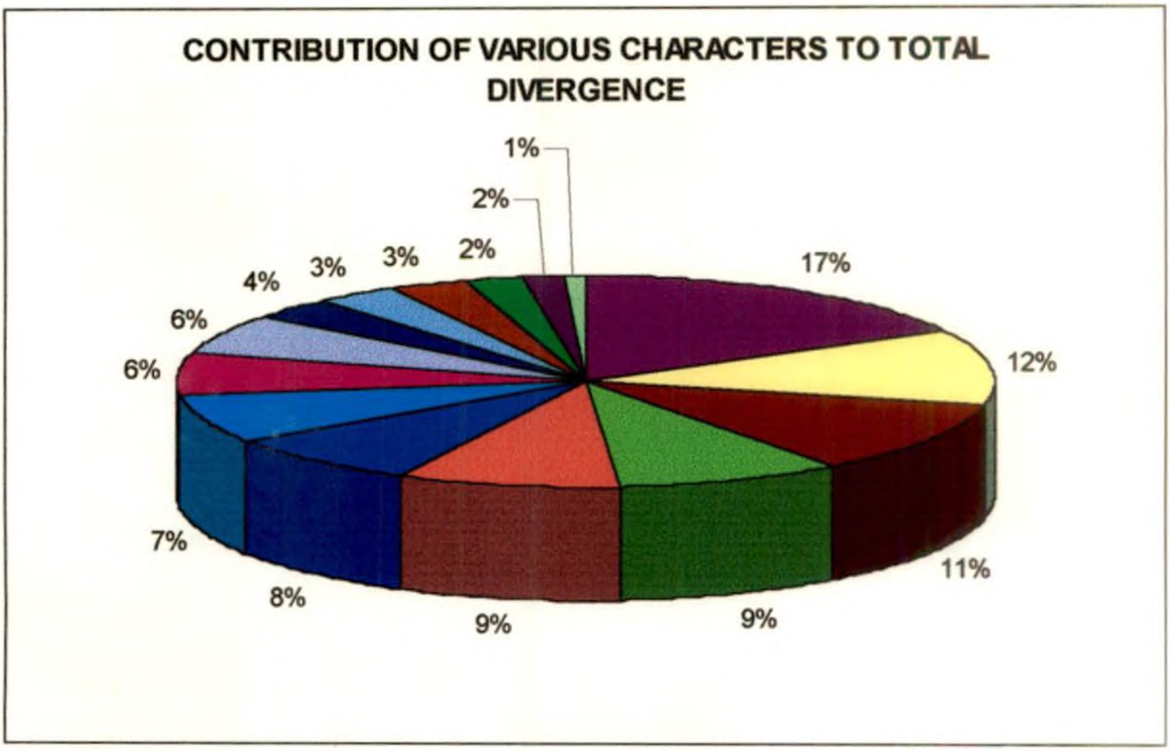


Fig. 6. Contribution of various characters

- Seeds per fruit
- Fruit yield per plant
- Mean fruit weight
- Fruits per plant
- Flesh thickness
- Branches per plant
- Fruit girth
- Fruit length
- 100-seed weight
- Vine length
- Node to first male flower
- Dry matter content
- Days to first female flower
- Node to first female flower
- Days to first male flower

4.6. Selection index

Selection index for the genotypes was computed based on the fifteen characters namely days to first male flower opening (X_1), days to first female flower opening (X_2), node to first male flower (X_3), node to first female flower (X_4), vine length (X_5), branches per plant (X_6), fruits per plant (X_7), mean fruit weight (X_8), fruit yield per plant (X_9), fruit length (X_{10}), fruit girth (X_{11}), flesh thickness (X_{12}), dry matter content (X_{13}), seeds per fruit (X_{14}) and 100-seed weight (X_{15}). The selection index worked out was as follows:

$$I = 3.713426x_1 + 0.5064513x_2 + 2.80411x_3 + 0.1843356x_4 - 4.140824x_5 - 11.27325x_6 + 13.61144x_7 + 22.09674x_8 - 2.46018x_9 + 0.9324364x_{10} + 0.4510095x_{11} + 7.184066x_{12} + 7.107639x_{13} + 0.9864799x_{14} + 0.4901273x_{15}$$

Accordingly selection index values were worked out and presented in the table13 in the descending order. The genotypes T_2 and T_3 ranked first with the highest index values. The minimum estimates were recorded for T_{16}, T_{21} and T_{18}.

Table 13. Selection indices arranged in descending order

Sl.no.	Genotypes	Selection index values
1.	T_3	7330.02
2.	T_2	7120.22
3.	T_7	6568.23
4.	T_4	5978.42
5.	T_{10}	5540.66
6.	T_9	4527.83
7.	T_5	4186.48
8.	T_1	3779.66
9.	T_{13}	3528.37
10.	T_{24}	3404.73
11.	T_{20}	3382.19
12.	T_{25}	3308.51
13.	T_{17}	3284.99
14.	T_{14}	3230.54
15.	T_{23}	3158.54
16.	T_{12}	3136.76
17.	T_{22}	2930.24
18.	T_{15}	2644.39
19.	T_{11}	2466.09
20.	T_{19}	2412.12
21.	T_6	2327.40
22.	T_8	2067.35
23.	T_{16}	1744.28
24.	T_{21}	1553.63
25.	T_{18}	1528.06

DISCUSSION

5. DISCUSSION

The primary aim of a plant breeding programme is to evolve superior genotypes with high yield, superior quality, resistance to pest and diseases and other desirable attributes. The success of crop improvement programme aimed at the production of superior varieties depends solely on the selection of suitable genotypes to be used as parents in the hybridization programme. Selection based on yield and its components could be more efficient than yield alone (Evans, 1978).

Very little work on genetic aspects has been done in ashgourd, which is a commonly cultivated vegetable crop of Kerala. The first step for this is to assess the existing genetic variability in the crop, which will enable to identify the suitable types. Hence this study has been conducted and the results obtained are discussed below.

5.1. Mean performance

Days to first male and female flower was minimum for T_{24}. Nodes to produce the first female flower was minimum for T_3 and T_{25}. Maximum fruits were obtained from T_{18} and T_{21}. Highest mean fruit weight was for T_{14}. A wide range of 0.80 to 7.62 was noticed for this character. Fruit yield per plant was maximum for T_{20}, which was on par with T_{22}. Maximum fruit length was seen for T_5 and T_7 had the highest fruit girth. The flesh thickness was highest for T_{20}.

The classification of genotypes into poor, medium and better groups indicated normality of the data for almost all the characters in the material under study. The genotypes T_2, T_3 and T_4 were better for most of the characters, while T_6, T_{15}, T_{16} and T_{21} were poor in most of the characters.

5.2. Genetic parameters

5.2.1. Coefficient of variation

The basic information which a breeder usually requires as a pre-requisite to any breeding programme of a particular crop species, is the extend of variability present in the available germplasm. Since the observed variability in a population is the sum of variation arising due to genotypic and environmental effects, knowledge on the nature and magnitude of genetic variation contributing to gain under selection is essential (Allard, 1960).

Highly significant differences for days to first male and female flower, nodes to first male and female flower, vine length, branches per plant, fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth, flesh thickness, dry matter content, seeds per fruit and 100-seed weight among the twenty-five ashgourd accessions were observed. The existence of wide variation for several characters in ashgourd was reported by George (1981), Hamid *et al.* (1989) and Menon (1998). Highest PCV and GCV were observed for seeds per fruit are in conformity with results of Rajendran and Thamburaj (1994) in watermelon, Sureshbabu (1989) and Babu *et al.* (1996) in pumpkin and Mariappan and Pappiah (1990) in cucumber.

In this study high PCV was recorded for mean fruit weight, fruit yield per plant, flesh thickness, branches per plant and fruits per plant. High values of PCV reported for fruits per plant is in agreement with the findings of Shibukumar (1995) in watermelon and Mohanty and Mishra (1999) in pumpkin.

High GCV was observed for fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth and flesh thickness which indicates that there exists high genetic variability and better scope for improvement of these characters through selection.

The high GCV obtained in this study for fruits per plant is in agreement with the findings of Gopalakrishnan (1979) and Kumaran *et al.* (1997) in pumpkin, Vahab (1989) in bittergourd, Varghese and Rajan (1993) in snakegourd and Shibukumar (1995) in watermelon. GCV was high for mean fruit weight (Swamy *et al.*, 1985 in muskmelon, Babu *et al.*, 1996 in pumpkin; Gayathri, 1997 in cucumber), fruit yield per plant (Sureshbabu, 1989 in pumpkin; Singh *et al.*, 1992 in muskmelon; Rajendran and Thamburaj, 1994 in watermelon; Menon, 1998 in ashgourd and Iswaraprasad, 2000 in bittergourd), fruit length (Ram *et al.*, 1996 in pumpkin, watermelon, cucumber, muskmelon, bittergourd and bottlegourd; Iswaraprasad, 2000 in bittergourd) and fruit girth (Pynadath, 1978 in snakegourd; Ram *et al.*, 1996 in pumpkin, watermelon, cucumber, muskmelon, bittergourd and bottlegourd).

Comparatively low coefficient of variation was observed for the characters of earliness such as days to first male flower and days to first female flower indicating presence of low variability and thus limiting the scope for further improvement through selection. Similar results were reported by George (1981) in ashgourd, Vahab (1989) in bittergourd and Gayathri (1997) in cucumber for days to first female flower and Sureshbabu (1989) in pumpkin, Ram *et al.* (1996) in muskmelon and Gayathri (1997) in cucumber for days to first male flower. High variation for days to first male and female flower were noted by Pynadath (1978) in snakegourd and Ram *et.al.* (1996) in pumpkin, watermelon, cucumber, bottlegourd and bittergourd.

5.2.2. Heritability and genetic advance

Information on heritability and estimates of genetic advance that could be obtained in the next cycle of selection are of vital importance to the breeder in deciding the appropriate method of breeding.

High heritability estimates were recorded for all characters except node to first female flower, which had moderate heritability. Heritability was maximum for seeds per fruit followed by fruit length, fruit girth, 100-seed weight, dry matter content, vine length, fruit yield and fruits per plant.

High heritability for fruit yield per plant in the present study was in agreement with the findings of Swamy *et al.* (1985) in muskmelon; Rastogi and Deep (1990a) in cucumber; Paiva (1994) in spineless gherkin; Singh *et al.* (1996) in bottlegourd; Joseph (1999) in ivygourd and Iswaraprasad (2000) in bittergourd. On the contrary, low heritability for fruit yield per plant was reported by Pynadath (1978) in snakegourd; Sureshbabu (1989) in pumpkin and Wehner and Cramer (1996) in cucumber.

High estimates of heritability for fruits has been reported earlier by George (1981) in ashgourd; Paiva (1994) in spineless gherkin and Singh *et al.* (1996) in bottlegourd. High heritability for fruit weight was observed by George (1981) in ashgourd; Swamy *et al.* (1985) in muskmelon; Borthakur and Shadeque (1990) in pumpkin; Marriappan and Pappiah (1990) in cucumber; Rajendran and Thamburaj (1994) in watermelon and Iswaraprasad (2000) in bittergourd.

As in the present study moderate heritability was reported for node to first female flower by Mohanty and Mishra (1999) in pumpkin. ,

High genetic advance was noted for node to first male flower, vine length, branches per plant, fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth, flesh thickness, dry matter content, seeds per fruit and 100-seed weight. However days to first male and female flower and node to female flower recorded low genetic advance. The present findings are supported by earlier reports of high genetic advance for yield per plant (George, 1981 in ashgourd; Anitha, 1998 in ridgegourd; Menon, 1998 in ashgourd and Deepthy, 2000 in melon). Seeds per fruit had the highest genetic advance as recorded by Sureshbabu (1989) in pumpkin.

High estimates of genetic advance for average fruit weight was supported by George (1981) in ashgourd, Rajendran and Thamburaj (1994) in watermelon, Menon (1998) in ashgourd and Iswaraprasad (2000) in bittergourd.

High heritability and high genetic advance of characters is indicative of additive gene action suggesting the possibility of genetic improvement of those characters through selection. The characters node to male flower, vine length, fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth, flesh thickness, 100-seed weight, seeds per fruit and dry matter content had high heritability coupled with high genetic advance.

Similar results were reported for mean fruit weight (George, 1981 in ashgourd, Rastogi and Deep, 1990a and Prasad and Singh, 1992 in cucumber, Kumaran *et al.*, 1997 in pumpkin, Deepthy, 2000 in melon and Iswaraprasad, 2000 in bittergourd), fruits per plant (Sharma and Dharkar, 1990 in bottlegourd, Chaudhary *et al.*, 1991 in bittergourd, Rajendran and Thamburaj, 1994 in watermelon, Anitha, 1998 in ridgegourd, Deepthy, 2000 in melon and Iswaraprasad, 2000 in bittergourd) and yield per plant (Singh *et al.*, 1992 in pointedgourd, Mathew, 1996 in snakegourd, Gayathri, 1997 in cucumber, Menon, 1998 in ashgourd, Mohanty and Mishra, 1999 in pumpkin, Deepthy, 2000 in melon and Iswaraprasad, 2000 in bittergourd).

High heritability and low genetic advance of characters indicates dominant gene action suggesting the possibility of genetic improvement through hybridization breeding programmes. In the present study, high heritability and low genetic advance was noted for days to first male and female flower. The same results were reported by Varghese and Rajan (1993) in snakegourd for days to first male flower and by Anitha (1998) in ridgegourd for days to first female flower.

5.3. Correlation studies

A knowledge on the degree of association among quantitative characters would help the breeder to pinpoint 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 the yield.

In the present study yield per plant showed strong positive genotypic correlation with mean fruit weight, fruit length, fruit girth, flesh thickness and seeds per fruit. Negative correlation was seen for days to first female flower, fruits per plant and dry matter content.

Similar results of genotypic correlation with yield were reported for mean fruit weight by Pynadath (1978) in snakegourd, George (1981) in ashgourd, Borthakur and Shadeque (1994) in pumpkin, Dhaliwal *et al.* (1996) in muskmelon and Menon (1998) in ashgourd, fruit length by Singh *et al.* (1987) in parwal, Milotary *et al.* (1991) in cucumber, Saika *et al.* (1995) in cucumber, Paranjape and Rajput (1995) in bittergourd and Joseph (1999) in ivygourd, fruit girth by Abusaleha and Dutta (1988) in cucumber, Gayathri (1997) in cucumber, Joseph (1999) in ivygourd and Rao *et al.* (2000) in ridgegourd and flesh thickness (Prasad and Singh, 1992 in cucumber, Shibukumar, 1995 in watermelon and Dhaliwal *et al.*, 1996 in muskmelon).

Negative correlation was reported for days to first female flower in cucumber by Abusaleha and Dutta (1988) and in ridgegourd by Rao *et al.* (2000).

The association analysis based on correlation coefficients of components with yield will not give a true picture of the relative cause and effects of each of the components to final yield. Hence an assessment of the merit of each character by analyzing the direct and indirect effects of each character towards yield, using path analysis gives valuable information in selecting the character for crop improvement.

Days to first female flower, fruits per plant fruit length and fruit girth had positive direct effects, while vine length, flesh thickness, dry matter content and seeds per fruit had negative direct effects. For selection of genotypes those characters with positive direct effects are useful.

The maximum positive direct effect on yield was shown by fruit length followed by fruit girth, fruits per plant and days to first female flower. Both fruit length and fruit girth had high positive direct effect and genetic correlation. The characters fruits per plant and days to first female flower had positive direct effects but negative genetic correlation.

High direct effect on yield were observed for fruit length by Abusaleha and Dutta (1988) in cucumber, Mathew (1999) in bottlegourd and Zhang *et al.* (1999) in cucumber, for fruit girth by Pynadath (1978) in snakegourd, Gayathri (1997) in cucumber and Mathew (1999) in bottlegourd and fruits per plant by Ramachandran (1978) in bittergourd, Shibukumar

(1995) in watermelon, Kumaran *et al.* (1998) in pumpkin and Joseph (1999) in ivygourd.

Highest negative direct effect was noted for flesh thickness followed by dry matter content and vine length. Seeds per fruit had very less direct effect. Vine length, flesh thickness and seeds per fruit had positive genotypic correlation. High negative direct effect of vine length on yield was suggested by George (1981), Shibukumar (1995) and Kumar and Singh (1998).

From the present study it is evident that selection based on the characters fruit length and fruit girth can be effective for improving yield of the crop.

5.4. Genetic divergence

The importance of genetic diversity of parents in hybridisation programme has been emphasized by many workers. The more diverse the parents within a reasonable range, higher would be the chances of improving the characters in question. Mahalanobis D^2 statistic 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.

5.4.2. Clustering of genotypes

Following Mahalanobis D^2 statistic (Mahalanobis, 1936), the 25 genotypes were grouped into 8 clusters. The maximum number of genotypes (8) were included in cluster III, followed by cluster I (7), cluster II (4), cluster IV (2). The clusters V, VI, VII and VIII had only one genotype in them.

Maximum divergence was shown between the clusters II and IV, while the minimum divergence was between clusters VII and VIII. The intracluster distance was highest for the cluster III.

The cluster means were highest in cluster II for characters days to anthesis, node to flower, fruits per plant and dry matter content. While the cluster means for mean fruit weight and fruit yield per plant were highest in cluster V. Cluster IV exhibited highest mean value for fruit length.

Seeds per fruit contributed maximum to the total divergence followed by fruit yield per plant, mean fruit weight, fruits per plant and flesh thickness. Contribution to total divergence by seeds per fruit (Parhi *et al.*, 1993 in bittergourd), yield per plant (Ramachandran *et al.*, 1981 in bittergourd; Rios *et al.*, 1997 in pumpkin) and fruits per plant (Ramachandran *et al.*, 1981 in bittergourd) were earlier reported.

5.4.1. Ecogeographic diversity Vs genetic diversity

Clustering pattern was not related to the geographical similarities as each cluster contained genotypes from various localities. The cluster IV had 2 genotypes, T_2 and T_3, which were from Wayanad and Idukki respectively. Similarly genotypes from various places were grouped into one cluster. This indicated the absence of influence of ecogeographical diversity on genetic diversity. Such results were earlier reported by Vahab and Gopalakrishnan (1993), Mathew (1996) and Verma and Sachan (2000).

5.5. Selection index

Selection of genotypes based on a suitable index is highly efficient in any breeding programme. An estimation of discriminant function based on reliable and effective characters is a valuable tool for the practical plant breeder.

In the present study, selection index for the genotypes was computed on the fifteen characters namely, days to first male and female flower, node to first male and female flower, vine length, branches per plant, fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth, flesh thickness, dry matter content, seeds per fruit and 100-seed weight.

The grouping of genotypes by selection indices followed almost the same pattern as their clustering pattern in the D^2 analysis. The genotypes in the cluster IV i.e., T_2 (Wayanad local-1) and T_3 (Idukki local-1) topped the list, while the genotypes T_8, T_{16}, T_{21} and T_{18} came together which formed the cluster II.

The maximum selection index values were obtained for T_2 (Wayanad local-1) and T_3 (Idukki local-1). In another classification of genotypes based on their mean values for the 15 characters also these genotypes appeared to be superior.

Selection of genotypes from clusters II and IV as parents for hybridization works is likely to give more heterotic hybrids. The characters fruit length and fruit girth can be used as the criteria for selection of genotypes since they are found to have high direct effect on yield of the plant. There is a high scope of improvement for yield through selection since there exists high variation for the character and it has high heritability and genetic advance.

SUMMARY

6. SUMMARY

The present study was conducted in the Department of Plant Breeding, College of Agriculture, Vellayani, during the period of 1999-2001. This study was conducted with the objective of estimating the genetic diversity, the role of genetic constitution in the expression of the characters and the degree and pattern of association between the characters in a collection of ashgourd genotypes.

From different agro climatic regions, 25 genotypes of ashgourd were raised in Randomised Block Design with 3 replications. Observations were recorded on various biometric characters namely, days to first male and female flower, node to first male and female flower, vine length, branches per plant, fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth, flesh thickness, dry matter content, seeds per fruit and 100-seed weight.

Significant difference existed among the genotypes for almost all the characters as revealed by Analysis of Variance. Days to first male and female flower was minimum for Kottayam local-3. Node to the first female flower was minimum for Idukki local-1 and Kottayam local-4.

Maximum fruits were obtained from Idukki local-4 and Thiruvananthapuram local-2. Highest mean fruit weight was for Allepey local-1. A wide range of 0.80 to 7.62 was noticed for this character. Fruit yield per plant was maximum for KAU local, which was on par with Kottayam local-2. Maximum fruit length was seen for Tamilnadu local-1 and Wayanad local-2 had the highest fruit girth. The flesh thickness was highest for KAU local.

The classification of genotypes into poor, medium and better groups indicated normality of the data for almost all the characters in the material under study. Wayanad local-1, Idukki local-1 and Bangalore local-1 performed better for most of the characters, while Kozhicode local-1, Idukki local-2, Thiruvananthapuram local-1 and Thiruvananthapuram local-2 were poor in most of the characters.

In this study high PCV was recorded for mean fruit weight, fruit yield per plant, flesh thickness, branches per plant and fruits per plant. High GCV was observed for fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth and flesh thickness which indicates high genetic variability and better scope for improvement of these characters through selection. Comparatively low coefficient of variation was observed for days to first male and female flower indicating low variability and thus limiting the scope for further improvement through selection.

High heritability estimates were recorded for all characters except node to first female flower, which had moderate value. Heritability was maximum for seeds per fruit followed by fruit length, fruit girth, 100-seed weight, dry matter content, vine length, fruit yield per plant and number of fruits per plant.

High genetic advance was noted for node to first male flower, vine length, branches per plant, fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth, flesh thickness, dry matter content, seeds per fruit and 100-seed weight, while days to first male and female flower and node to female flower recorded low genetic advance.

Node to male flower, vine length, fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth, flesh thickness, 100-seed weight, seeds per fruit and dry matter content had high heritability coupled with high genetic advance. In the present study, high heritability and low genetic advance was noted for days to first male and female flower.

In the present study yield per plant showed strong positive genotypic correlation with mean fruit weight, fruit length, fruit girth, flesh thickness and seeds per fruit. High negative correlation was seen for days to first female flower, fruits per plant and dry matter content.

Days to first female flower, fruits per plant and fruit girth had positive direct effects, while vine length, flesh thickness, dry matter content and seeds per fruit had negative direct effects.

The maximum positive direct effect on yield was shown by fruit length followed by fruit girth, fruits per plant and days to first female flower. Both fruit length and fruit girth had high positive direct effect and genetic correlation. The characters fruits per plant and days to first female flower had positive direct effects but negative genetic correlation.

Following Mahalanobis D^2 statistic, the 25 genotypes were grouped into 4 clusters. Maximum genotypes (8) were included in cluster III, followed by cluster I (7), cluster II (4), cluster IV (2). The clusters V, VI, VII and VIII had only one genotype each.

Maximum divergence was shown between the clusters II and IV, while it was minimum between VII and VIII. The intracluster distance was highest for the cluster III. Seeds per fruit contributed maximum to the total divergence followed by fruit yield per plant, mean fruit weight, fruits per plant and flesh thickness. Clustering pattern was not related to the geographical similarities as each cluster contained genotypes from various localities.

Maximum selection index values were obtained for Wayanad local-1 and Idukki local-1. The grouping of genotypes by selection indices followed almost the same pattern as their clustering pattern in the D^2 analysis. The genotypes in the cluster IV i.e., Wayanad local-1 and Idukki local-1 topped the list, while Kozhicode local-1, Idukki local-2, Thiruvananthapuram local-1 and Thiruvananthapuram local-2 came together which formed the cluster II.

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* Original not seen

EVALUATION OF GENETIC DIVERGENCE IN ASHGOURD (*Benincasa hispida* Cogn.)

By

LOVELY B.

ABSTRACT OF THE THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN AGRICULTURE
(PLANT BREEDING AND GENETICS)
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

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KERALA

2001

ABSTRACT

A research programme was carried out at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 1999-2001 with the objective of assessing the genetic diversity present in a population of ashgourd genotypes. Twenty-five genotypes were evaluated adopting randomized block design with 3 replications. Genetic parameters, association among the characters, direct and indirect effects of characters on yield, D^2 values and selection indices were estimated.

Analysis of variance revealed significant differences for almost all the characters. Genotypic and phenotypic coefficients of variation were high for mean fruit weight, fruit yield per plant, flesh thickness and fruits per plant. Node to first male flower, vine length, fruits per plant, mean fruit weight, fruit yield per plant, fruit length, fruit girth, flesh thickness, 100-seed weight, seeds per fruit and dry matter content had high heritability coupled with high genetic advance. However high heritability and low genetic advance was noted for days to first male and female flower.

High direct effect of days to first female flower, fruits per plant fruit length and fruit girth on yield indicate that selection based on the above components result in the improvement of yield per plant. Mahalanobis D^2 analysis clustered the 25 genotypes into 8 groups with genotypes from different eco-geographic locations being grouped in the same clusters. The genetic distance was maximum between II and IV, while the minimum

divergence was between clusters VII and VIII. The character seeds per fruit contributed maximum to the total divergence. In future breeding programmes selection of parents from clusters II and IV for hybridization is likely to give the most heterotic hybrids.

Fruit length and fruit girth can be used as the criteria for selection of genotypes since they had high direct effect on yield of the plant. There is a high scope of improvement for yield through selection since there exists high variation for the character along with high heritability and genetic advance.