STUDIES ON GENETIC DIVERGENCE, VARIABILITY PARAMETERS AND CHARACTER ASSOCIATION IN BOTTLE GOURD

(Lagenaria siceraria (Mol) Stand L)

By

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CERTIFICATE

Miss **VARAKALA SUCHITRA** has satisfactorily prosecuted the course of research and that the thesis entitled **"STUDIES ON GENETIC DIVERGENCE, VARIABILITY PARAMETERS AND CHARACTER ASSOCIATION IN BOTTLE GOURD (*Lagenaria siceraria* (Mol) Stand L.)"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for degree of any university.

Date : 6·11·20
Place : Tirupati

Dr. K.HARIBABU
(Major Advisor)

CERTIFICATE

This is to certify that the thesis entitled "**STUDIES ON GENETIC DIVERGENCE, VARIABILITY PARAMETERS AND CHARACTER ASSOCIATION IN BOTTLE GOURD (*Lagenaria siceraria* (Mol) Stand L.)**" submitted in partial fulfillment of the requirements for degree of **Master of Science in Agriculture** of the **Acharya N.G.Ranga Agricultural University,** Hyderabad, is a record of the bonafide research work carried out by **Miss VARAKALA SUCHITRA** under my guidance and supervision. The subject of the thesis has been approved by the **Student's Advisory Committee.**

No part of the thesis has been submitted for any other degree or diploma or has been published. The published part has been fully acknowledged. The author of the thesis has duly acknowledged all assistance and help received during the course of investigations.

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(Suchitra)

SYMBOLS AND ABBRIEVATIONS

cm	:	Centimeter
cv	:	Coefficient of variation
GA	:	Genetic Advance
GCV	:	Genotypic coefficient of variation
g	:	Gram
h2(b)	:	Heritability in broad sense
ha	:	Hectare
kg	:	Kilogram
no	:	Number
%	:	Per cent
PCV	:	Phenotypic coefficient of variation
GV	:	Genetic variance
PV	:	Phenotypic variance

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DECLARATION

I **VARAKALA SUCHITRA** here by declare that the thesis entitled **"STUDIES ON GENETIC DIVERGENCE, VARIABILITY PARAMETERS AND CHARACTER ASSOCIATION IN BOTTLE GOURD (*Lagenaria siceraria* (Mol) Stand L.)"** submitted to Acharya N.G.Ranga Agricultural University, for the Degree of **Master of Science in Agriculture** is the result of original work done by me. I also declare that the material contained in this thesis has not been published earlier.

Date :

(VARAKALA SUCHITRA)

ABSTRACT

Author	: **V.SUCHITRA**
Title of the thesis	: **STUDIES ON GENETIC DIVERGENCE, VARIABILITY PARAMETERS AND CHARACTER ASSOCIATION IN BOTTLE GOURD (*Lagenaria siceraria* (Mol) Stand L).**
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The present investigation consisting of twenty four diverse genotypes of bottle gourd (*Lagenaria siceraria* (Mol) Stand L.) was carried out to study genetic divergence, variability, heritability and genetic advance, GA as per cent of mean, character association and path coefficient analysis of thirteen quantitative characters. The experiment was laid out at horticultural garden, S.V. Agricultural College, Tirupati in a randomized block design with three replications during *rabi* 1999-2000. The data were recorded on thirteen quantitative characters viz., days to female / male flowers, number of node at which first male / female flower appeared, fruit length, fruit diameter, fruit weight, number of seeds per fruit, seed weight, fruit flesh thickness, number of fruits per vine, yield per vine and vine length.

Genetic divergence studies revealed that the twenty four genotypes of bottle gourd were grouped into five different clusters based on earliness, fruit weight, shape of fruit and yield. For clustering pattern Mahalanobsis's D^2 statistic, was used which would be a

powerful tool in measuring the genetic divergence. The genotypes PSPL, Indo American, Warad, IC-92330, Pratik, Arka Bahar were identified as the best genotypes.

The analysis of genetic parameters revealed higher genotypic coefficient of variation, heritability, GA as per cent of mean for yield per vine, vine length indicating that simple selection could be practiced for improving these characters.

Character association studies indicated the strong positive correlation of fruit weight, number of fruits per vine, fruit length with fruit yield and also among themselves. Path coefficient analysis revealed the importance of fruit weight, number of fruits per vine, vine length and fruit length in formulating selection criterion for effective improvement of fruit yield.

Introduction

CHAPTER – I

INTRODUCTION

Bottle gourd or white flowered gourd (*Lagenaria siceraria* (mol) Stand L.) is a cosmopolitan cucurbitaceous vegetable grown successfully in tropical and subtropical regions. It is extensively grown in India and is cultivated almost universally throughout the year. Although bottle gourd does not rank high in nutritional value, but by virtue of volume consumed, it contributes significantly to dietary in take of vitamins (Vit. A,B,C), minerals (0.5%) such as calcium, iron, potassium, phosphorus and carbohydrates (2.9%), proteins (0.25%) and fats (0.5%). Bottle like shape of the fruit and its use as a contains of wines and spirits in the past gave it the common name of bottle gourd.

The fruits in the green stage are used as vegetables and also for preparation of some sweets and pickles. The dried hard shell of the fruit is used as water jugs, domestic utensils, for making musical instruments, floats for fishing nets and for indoor decoration.

The fruit pulp, tender vines and leaves have many medicinal values. It is having cooling effects and prevents constipation. The decotion of leaves mixed with sugar is given against jaundice. The pulp of the fruit is applied to the sores in burning feet.

Its popularity is due to its versatility and the variety it lends to our diet. Though it was originated in Indian sub-continent, its diversity has not been adequately exploited. To meet the stringent demands of both fresh market and processing industry, there is a need to boost the productivity and quality aspects of present day bottle gourd cultivars.

Under tropical conditions, bottle gourd being a cucurbit produces a large number of male flowers, when compared to female flowers and the yields are quite low. In this large family (cucurbitaceae), practically every type of sex expression is noticed. Modern forms of bottle gourd were secondary polyploids derived from an ancestor with a basic chromosome number n= 11

Its cross-pollinated nature and monoecious behaviour have resulted in a large variation in several qualitative and quantitative characters and also it is more suitable for exploitation of heterosis. As the flower is large and sturdy, manual manipulation is quite convenient for effective crosses. Yet very little attention has so far been given for genetic improvement of this crop. With this background the present study, was designed to formulate future breeding strategy of the crop with following objectives.

1. To study the nature and magnitude of genetic diversity using mahalanobis's D^2 statistic technology for future breeding programme.
2. To evaluate the mean performance of different lines/varieties for yield and yield attributes.
3. To estimate variability parameters for quantitative characters.
4. To study association between yield and yield attributing characters for deciding selection criteria.
5. To estimate direct and indirect effects of yield attributes on yield parameters.

Review of literature

CHAPTER – II

REVIEW OF LITERATURE

An attempt was made to critically review the literature of past research work done in relevance to the objectives of research programme in bottle gourd (*Lagenaria siceraria* (Mol) Stand L.) under the following headings:

2.1 Genetic divergence
2.2 Genetic parameters
2.3 Character association
2.4 Path coefficient analysis

2.1 GENETIC DIVERGENCE

Bottle gourd, like other cucurbitaceous crops was reported enough variability for high yield potential. This type of variation was because of the complex nature of yield which is dependent on a number of intra and inter genetic interactions (Sidhu and Brar 1985). The importance of genetic diversity in crop plants was first realized by Darwin (1857).

Developments in quantitative genetics had a substantial contribution in the development of techniques to identify the genetically diverse parents for hybridization programme aimed at combining desirable genes from several sources. Multivariate D^2 analysis was found to be the best technique to classify the genotypes on the basis of genetic distance between the characters.

2.1.1 Mahalanobis's D^2 analysis (grouping of clusters by D^2 statistic)

Mahalanobis's D^2 analysis is an effective tool in quantifying the degree of divergence at genetic level and provides a quantitative measure of association between geographic and genetic diversity based on generalized distance (Mahalanobis, 1936).

Sidhu and Brar (1985) studied genetic divergence analysis using Mahalanobis's D^2 technique and grouped 28 populations of water melon into 7 clusters. They observed that the average fruit weight contributed the maximum towards genetic divergence followed by number of fruits which contributed 51.32 per cent of the divergence in watermelon.

Wahab and Gopalakrishnan (1993) grouped 50 genotypes of bitter gourd into 5 clusters based on D^2 values. Their study revealed that the grouping pattern of the genotypes was not always directly associated with the geographic diversity. With the help of inter cluster distance values (D) the cluster diagram showing the inter cluster relationship was prepared. The same group consisted of genotypes of different source/origin and the lines of same origin/source fell into different groups also.

Sureshbabu *et al.* (1996) reported wide genetic variability among the 50 genotypes of pumpkin as revealed by D^2 analysis and grouped them into 5 clusters based on genetic distance. Clusters showing the largest genetic distance showed the maximum divergence.

The striking diverse features like growth habit, larger fruit size, greater fruit number and fruit weight were responsible for placing ridge gourd cultivar CO-1 as a lone entry into a cluster (Varalaxmi, 1992).

2.2 GENETIC PARAMETERS

The exploitation of genetic variability of quantitative traits generated through hybridization is the sole cause of improvement in any plant breeding programme. Knowledge on the magnitude of genotypic and phenotypic variability present in any crop species plays a vital role in formulating a successful breeding programme. Estimation of genetic variability alone cannot indicate the possible improvement achieved through selection, but it should be used in conjunction with heritability and genetic advance.

The magnitude of heritability, the most important aspect of genetic constitution of breeding material, determines the degree of success in a selection programme. Heritability measures the relative amount of heritable portion of variability. Genetic advance under selection gives an idea about how much of the genetic gain could be obtained with the selection for a character. High heritability for the character is not always an indication of high genetic gain (Vishnuswarup and Chagle, 1962) but the character with high heritability coupled with high genetic advance could successfully be improved by direct selection (Paul, 1978). *Therefore the estimates of genetic variability, heritability and genetic advance had an immense value in identifying the superior genotypes.*

2.2.1 Variability

Genetic variability for yield and yield components is essential in the base population for successful crop improvement (Allard, 1960). Yield and yield components are quantitative characters and are polygenically inherited which are greatly influenced by environment. Partitioning of observed variability into heritable and non-heritable components is essential to get a true indication of the genetic variation of the trait. Genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance (GA) are commonly used in describing the variability and genetics of a character.

2.2.2 Genotypic and phenotypic variance

A brief review of literature on genotypic and phenotypic variance in different cucurbits is given under

S.No.	Character	Range	Crop	Reference
1.	Days to first male flower	High	Pumpkin	Mohanty and Mishra (1999)
		Low	Cucumber	Mariappan and Pappiah (1990)
			Sponge gourd	Panwar *et al*, (1977)
		High	Musk melon	Vijay (1987) Molina *et al*, (1989)
2.	Days to first female flower	High	Musk melon	Deol *et al.* (1981)
		Low	Pumpkin	Goplakrishnan *et al*, (1980)
			Cucumber	Mariappan and Papaiah (1990)
		High	Pumpkin	Mohanty and Mishra (1999)
			Musk melon	Molina *et al*, (1989)
3.	Number of fruits / vine	High	Pumpkin	Borthakur and Shadeque (1990)
			Ridge gourd	Krishnaprasad and Singh (1989)
			Bottle gourd	Maurya and Singh (1994)
			Musk melon	Molina *et al*, (1989)
			Sponge gourd	Panwar *et al*, (1977)
			Pumpkin	Sendurkumaran *et al.* (1997)
			Bitter gourd	Singh *et al.* (1977)
			Musk melon	Vijay (1987)
			Cucumber	Mariappan and Papaiah (1990)
		Low	Musk melon	Deol *et al.* (1981)
			Pumpkin	Mohanty and Mishra (1999)
			Musk melon	Parrini (1965)
4.	Average fruit weight	High	Pumpkin	Sendurkumaran *et al.* (1997)
			Musk melon	Vijay (1987) Molina *et al*, (1989)
			Cucumber	Mariappan and Papaiah (1990)
		Low	Pumpkin	Mohanty and Mishra (1999)

5.	Fruit diameter	High	Musk melon	Molina *et al*, (1989)
			Cucumber	Rastogi and Aryadeep (1990) Solanki and Seth (1980b)
		Low	Sponge gourd	Panwar *et al*, (1977)
			Ridge gourd	Sahni *et al* (1987)
6.	Fruit flesh thickness	High	Pumpkin	Mohanty and Mishra (1999)
			Muskmelon	Molina *et al*, (1989)
		Low	Cucumber	Mariappan and Papaiah (1990)
7.	No.of seeds per fruit	High	Muskmelon	Molina *et al*, (1989)
			Cucumber	Mariappan and Papaiah (1990)
			Pumpkin	Sendurkumaran *et al.* (1997)
8.	Seed weight	High	Cucumber	Mariappan and Papaiah (1990)
			Muskmelon	Molina *et al*, (1989)
9.	Vine length	High	Ridge gourd	Krishnaprasad and Singh (1989
			Pumpkin	Mohanty and Mishra (1999)
			Cucumber	Mariappan and Papaiah (1990)
			Muskmelon	Molina *et al*, (1989) Vijay (1987)
10.	Yield per vine	High	Sponge gourd	Arora *et al.* (1983)
			Round melon	Dahiya *et al* (1989)
			Muskmelon	Deol *et al.* (1981)
			Ridge gourd	Krishnaprasad and Singh (1989)
			Bottle gourd	Maurya and Singh (1994)
			Pumpkin	Mohanty and Mishra (1999)
			Muskmelon	Molina *et al*, (1989)
			Sponge gourd	Panwar *et al*, (1977)
			Pumpkin	Sendurkumaran *et al.* (1997)
			Bitter gourd	Singh *et al.* (1977)
			Ridge gourd	Sahni *et al* (1987)

Phenotypic and genotypic coefficients of variation

S.No.	Character	Range	Crop	Reference
1.	Days to first female flower	High PCV High GCV	Cucumber	Krishnaprasad and Singh (1989)
			Sponge gourd	Panwar *et al*, (1977)
		Moderate PCV& GCV	Pumpkin	Mohanty and Mishra (1999)
		Low PCV Low GCV	Muskmelon	Deol *et al.* (1981)
			Bitter gourd	Mangal *et al* (1981)
			Pumpkin	Sureshbabu *et al.* (1996)
			Ridge gourd	Narsimharao (1997)

2.	Days to first male flower	Low PCV Low GCV	Pumpkin	Sureshbabu *et al.* (1996)
			Ridge gourd	Narsimharao (1997)
3.	No.of node at which first female flowering appeared	High PCV High GCV	Bottle gourd	Sharma and Dhankar (1990)
			Ridge gourd	Narsimharao (1997)
		Low PCV Low GCV	Pumpkin	Sureshbabu *et al.* (1996) Narsimharao (1997)
4.	No.of node at which first male flowering	High PCV High GCV	Ridge gourd	Varalaxmi *et al.* (1995) Narsimharao (1997)
5.	No.of fruits per vine	High PCV High GCV	Pumpkin	Borthakur and Shadeque (1990)
			Round melon	Dahiya *et al.* (1989)
			Muskmelon	Deol *et al.* (1981)
			Pumpkin	Gopalakrishnan *et al.* (1980)
			Muskmelon	Kalloo *et al* (1983)
			Ridge gourd	Krishnaprasad and Singh (1989)
			Water melon	Laltaprasad *et al* (1988)
			Cucumber	Krishnaprasad and Singh (1992)
			Spine gourd	Maharana *et al* (1995)
			Bottle gourd	Maurya and Singh (1994)
			Bitter gourd	Mangal *et al* (1981)
			Ribbed gourd	Reddy and Rao (1984)
			Ridge gourd	Sahni *et al.* (1987) Narsimharao (1997)
			Pumpkin	Sendurkumaran *et al.* (1997)
			Bitter gourd	Singh *et al.* (1977)
			Ridge gourd	Varalaxmi *et al.* (1995)
			Snake gourd	Vargheese and Rajan (1993)
			Musk melon	Vijay (1987)
		High PCV Low GCV	Sponge gourd	Panwar *et al.* (1977)
		Low PCV Low GCV	Cucumber	Solanki and Seth (1980b)

6.	Fruit weight	High PCV High GCV	Round melon	Dahiya *et al* (1980)
			Musk melon	Deol *et al.* (1981)
			Pumpkin	Doijode and Sulladmath (1986)
			Watermelon	Laltaprasad *et al* (1988)
			Bitter gourd	Mangal *et al.* (1981)
			Pumpkin	Mohanty and Mishra (1999)
			Ribbed gourd	Reddy and Rao (1984)
			Pumpkin	Sendurkumaran *et al.* (1997)
				Sureshbabu *et al* (1996)
			Ridge gourd	Varalaxmi *et al* (1995)
		Low PCV Low GCV	Spine gourd	Maharana *et al.* (1995)
7.	Fruit diameter	Low PCV Low gcv	Sponge gourd	Panwar *et al* (1977)
			Ribbed gourd	Reddy and Rao (1984)
			Ridge gourd	Narsimharao (1997)
8.	Fruit length	High PCV High GCV	Bitter gourd	Singh *et al.* (1997)
9.	Fruit flesh thickness	High PCV High GCV	Musk melon	Vijay (1987)
				Kalloo *et al* (1983)
10.	No.of seeds per fruit	High PCV High GCV	Water melon	Laltaprasad *et al* (1988)
			Cucumber	Mariappan and Pappiah *et al* (1997)
			Pumpkin	Sendurkumaran *et al.* (1997)
				Sureshbabu *et al.* (1996)
			Watermelon	Thakur and Nandpuri (1974)
			Ridge gourd	Varalaxmi *et al* (1995)
11.	Seed weight		Watermelon	Laltaprasad *et al* (1988)
			Cucumber	Mariappan and Pappiah *et al* (1997)
12.	Vine length		Pumpkin	Borthakur and Shadeque (1990)
				Mohanty and Mishra (1999)
			Bottle gourd	Sharma and Dhankar (1990)
			Muskmelon	Deol *et al* (1981)

13.	Yield per vine		Sponge gourd	Arora *et al* (1983)
			Round gourd	Dahiya *et al* (1989)
			Muskmelon	Dcol *et al* (1981) Kalloo *et al.* (1983)
			Bitter gourd	Katiyar *et al* (1996)
			Ridge gourd	Krishnaprasad and Singh (1989)
			Cucumber	Krishnaprasad and Singh (1992)
			Watermelon	Laltaprasad *et al.* (1988)
			Spine gourd	Maharana *et al.* (1995)
			Bitter gourd	Mangal *et al* (1981)
			Bottle gourd	Maurya and Singh (1994)
			Pumpkin	Mohanty and Mishra (1999)
			Sponge gourd	Panwar *et al* (1977)
			Cucumber	Rastogi and Aryadeep (1990)
			Pumpkin	Sendurkumaran *et al.* (1997)
			Bitter gourd	Singh *et al.* (1977)
			Ridge gourd	Varalaxmi *et al* (1995)
			Muskmelon	Vijay (1987)
			Ridge gourd	Narsimharao (1997)

2.2.3 Heritability (H) and Genetic Advance (GA)

Heritability as described by Smith (1936) is the ratio expressed as percentage of variance component due to additive (fixable) gene effects (σ^2A) to the sum of additive (σ^2A), deminance (σ^2D) and epistatic (σ^2E) gene effects". Heritability in broad sense may be defined as the ratio of genetic variance to phenotypic variance (Lush, 1948), characters with high estimates of heritability are of great importance to the plant breeder as it will be enable the plant breeder to formulate criteria based on phenotypic performance. If heritability of a character is very high, selection for the character is fairly easy. This is because there would be a close correspondence between genotype and phenotype due to a relatively smaller contribution of environment to the phenotype. But for character with low heritability, selection may be considerably difficult due to masking effect of environment on the genotype effects.

Genetic advance is the expected genetic gain or improvement in the next generation by selecting the superior individuals under a certain amount of selection pressure. Chhonkar *et al*. (1979) reported that heritability estimates and genetic advance were more valid for selection than heritability estimates alone. It was observed that a greater amount of genetic advance may be expected if the heritability is chiefly due to additive gene action. It was further stated that high heritability do not necessarily increase genetic advance. If heritability is coupled with high genetic advance, it indicates that the character is chiefly governed by additive genes and will be most effect for selection and further utilization in breeding programmes.

A brief review of literature on heritability and genetic advance in different cucurbits is given under

S.No.	Character	Range	Crop	Reference
1.	Days to first male flower	High H High GA	Sponge gourd	Arora *et al* (1983)
			Muskmelon	Kalloo *et al*. (1983)
			Cucumber	Mariappan and Pappiah (1990)
			Muskmelon	Daljitsingh and Nandpuri (1978) Vijay (1987)
			Sponge gourd	Panwar *et al*. (1977)
		Medium H Medium GA	Bottle gourd	Maurya and Singh (1994)
		High H Low GA	Snake gourd	Varghese and Rajan (1993)
			Pumpkin	Sendurkumaran *et al*. (1997) Gopalakrishnan *et al*. (1980)
		Low H Low GA	Bitter gourd	Singh *et al*., (1977)

2.	Days to first female flower	High H High GA	Sponge gourd	Arora *et al.* (1983)
			Sponge gourd	Panwar *et al.* (1977)
			Muskmelon	Kalloo *et al.* (1983)
				Daljitsingh and Nandpuri (1978)
			Cucumber	Mariappan and Pappiah (1990)
			Bitter gourd	Suribabu *et al.* (1986)
			Bottle gourd	Sharma and Dhankar (1990)
			Muskmelon	Vijay (1987)
		Medium H Medium GA	Bottle gourd	Maurya and Singh (1994)
		Medium H Low GA	Muskmelon	Deol *et al.* (1981)
		High H Low GA	Ridge gourd	Krishnaprasad and Singh (1989)
			Bitter gourd	Mangal *et al* (1981)
			Pumpkin	Sureshbabu *et al* (1996) Sendurkumaran *et al.* (1997)
			Bitter gourd	Singh *et al.* (1997)
			Pumpkin	Gopalakrishnan *et al* (1980)
3.	Number of node at which first male flower appeared	High H High GA	Ridge gourd	Varalaxmi *et al* (1995)
			Bitter gourd	Rajput *et al.* (1996)
			Ridge gourd	Sahni *et al.* (1987) Narsimharao (1997) Thakur and Choudhury (1965)
			Sponge gourd	Arora *et al.* (1983)
			Ridge gourd	Krishnaprasad and Singh (1989)
4.	No.of node at which first female flower appeared	High H High GA	Watermelon	Laltaprasad *et al.* (1988)
			Bottle gourd	Maurya and Singh (1994)
			Cucumber	Prasad and Singh (1993)
			Bottle gourd	Sharma and Dhankar (1990) Singh *et al.* (1996)
			Ridge gourd	Varalaxmi *et al* (1995)
			Bitter gourd	Rajput *et al* (1996)
			Pumpkin	Sendurkumaran *et al.* (1997)
			Ridge gourd	Sahni *et al* (1987) Thakur and Choudhury (1965)
			Sponge gourd	Arora *et al.* (1983)
			Pumpkin	Sureshbabu *et al.* (1996)
			Ridge gourd	Krishnaprasad and Singh (1989)

6.	Fruit weight	High H High GA	Pumpkin	Borthakur and Shadeque (1990)
			Muskmelon	Chhonkar *et al*. (1979)
			Watermelon	Thakur and Nandpuri (1974)
				Sidhu and Brar (1978)
			Muskmelon	Deol *et al*. (1981)
			Pumpkin	Doijode and Sulladmath (1986)
				Gopalakrishnan *et al* (1980)
			Cucumber	Krishnaprasad and Singh (1989) Rastogi and Aryadeep (1990)
			Watermelon	Thakur and Nandpuri (1974)
			Ridge gourd	Varalaxmi *et al* (1995)
			Ridge gourd	Sahni *et al*. (1987)
			Cucumber	Mariappan and Pappiah (1990)
			Bitter gourd	Kattiyar *et al*. (1996)
				Rajput *et al*. (1996)
				Mangal *et al*. (1981)
			Watermelon	Laltaprasad *et al*. (1988)
			Ribbed gourd	Reddy and Rao (1984)
			Cucumber	Solanki and Seth (1980b)
			Muskmelon	Kalloo and Dixit (1983)
			Watermelon	Sidhu *et al*. (1977a)
			Roundmelon	Dahiya *et al*. (1989)
7.	Fruit diameter	High	Sponge gourd	Arora *et al* (1983)
			Cucumber	Krishnaprasad and Singh (1992)
			Water melon	Sidhu and Brar (1978)
			Bottle gourd	Ghevaria *et al*. (1995)
			Cucumber	Mariappan and Pappiah (1990)
			Watermelon	Laltaprasad *et al* (1998)
			Pointed gourd	Singh *et al*. (1985)
			Bitter gourd	Rajput *et al*. (1996)
		High-H	Ridge gourd	Krishnaprasad and Singh (1992)
		Medium-H Medium-GA	Bitter gourd	Singh *et al*. (1977)
		Low-H Low-GA	Sponge gourd	Panwar *et al*. (1997)
			Ribbed gourd	Reddy and Rao (1984)
			Ridge gourd	Sahni *et al*. (1987)

8.	Fruit length	High-H High-GA	Cucumber	Krishnaprasad and Singh (1992)
			Radish	Lal and Srivastava (1975)
			Sponge gourd	Panwar *et al.* (1997)
			Ridge gourd	Thakur and Choudhury (1965)
				Varalaxmi *et al.* (1995)
			Cucumber	Mariappan and Pappiah (1990)
			Bottle gourd	Prasad and Prasad (1979)
			Water melon	Laltaprasad *et al* (1998)
			Bottle gourd	Ghevaria *et al.* (1995)
			Sponge gourd	Prasad *et al.* (1984)
			Pointed gourd	Singh *et al.* (1985) Singh *et al.* (1986)
			Ridge gourd	Krishnaprasad and Singh (1989)
			Bitter gourd	Singh *et al.* (1977)
			Sponge gourd	Arora *et al.* (1983)
			Snake gourd	Vargheese and Rajan (1993)
		Low H Low GA	Ridge gourd	Sahni *et al.* (1987)
9.	Fruit flesh thickness	High H High GA	Pumpkin	Borthakur and Shadeque (1990)
			Muskmelon	Chhonkar *et al.* (1979) Vijay (1987)
			Cucumber	Krishnaprasad and Singh (1992)
		High H Low GA	Muskmelon	Deol *et al.* (1981)
10.	Number of seeds per fruit	High H High GA	Pumpkin	Doijode and Sulladmath (1986)
			Watermelon	Thakur and Nandpuri (1974)
			Ridge gourd	Varalaxmi *et al.* (1995)
			Cucumber	Mariappan and Puppiah (1990)
			Water melon	Laltaprasad *et al.* (1988)
			Pumpkin	Sureshbabu *et al.* (1996) Sendurkumaran *et al.* (1997)
			Bitter gourd	Suribabu *et al.* (1986)
			Pumpkin	Gopalakrishnan *et al.* (1980)
11.	Seed weight	High H High GA	Ridge gourd	Varalaxmi *et al.* (1995)
			Cucumber	Mariappan and Pappiah (1990)
			Watermelon	Laltaprasad *et al.* (1988) Rajedrân (1989)
			Pumpkin	Suresh Babu *et al.* (1996)

12.	Vine length	High H High GA	Sponge gourd	Arora *et al.* (1983)
				Panwar *et al* (1977)
			Muskmelon	Chhonkar *et al.* (1979)
			Pumpkin	Borthakur and Shadeque (1990)
			Cucumber	Krishnaprasad and Singh (1992)
			Bottle gourd	Singh *et al.* (1996)
				Sharma and Dhankar (1990)
			Ridge gourd	Varalaxmi *et al.* (1995)
			Pumpkin	Sendurkumaran *et al.* (1997)
				Gopalakrishnan *et al.* (1980)
				Krishnaprasad and Singh (1989)
		High H Low GA	Muskmelon	Deol *et al.* (1981)
			Cucumber	Rastogi and Aryadeep (1990)
		Low H	Ridge gourd	Krishnaprasad and Singh (1989)
13.	Yield/vine	High H High GA	Ridge gourd	Krishnaprasad and Singh (1989)
			Spine gourd	Maharana *et al.* (1998)
			Pumpkin	Mangal *et al.* (1979)
			Cucumber	Rastogi and Aryadeep (1990)
			Bottle gourd	Singh *et al.* (1996)
				Sharma and Dhankar (1990)
			Bitter gourd	Singh *et al.* (1977)
			Ridge gourd	Varalaxmi *et al.* (1995)
			Muskmelon	Vijay (1987)
			Watermelon	Lalta Prasad *et al.* (1988)
			Ribbed gourd	Reddy and Rao (1984)
			Pumpkin	Sendurkumaran *et al.* (1997)
			Bottle gourd	Rajanarayan *et al.* (1996)
			Pointed gourd	Singh *et al.* (1985)
			Ridge gourd	Singh *et al.* (1986)
				Narsimharao (1997)
			Cucumber	Solanki and Seth (1980b)
		High H Low GA	Sponge gourd	Arora *et al.* (1983)
			Snake gourd	Vargheese and Rajan (1993)
			Muskmelon	Deol *et al.* (1981)
		Medium H High GA	Sponge gourd	Panwar *et al.* (1977)
		Medium H Medium GA	Cucumber	Krishnaprasad and Singh (1992)
		Low M	Watermelon	Thakur and Nandpuri (1974)
		Low GA	Bottle gourd	Maurya and Singh (1994)
				Sharma *et al.* (1983)
			Musk melon	Kallo and Dixit (1983)
			Water melon	Sidhu *et al.* (1977)
			Brinjal	Singh *et al.* (1976)
			Bottle gourd	Ghevaria *et al.* (1995)

2.2.4 Genetic advance as a % of mean

S.No.	Character	Range	Crop	Reference
1.	Days to first female flower	Low	Bitter gourd	Mangal *et al.* (1981)
2.	Node at first female flower	Low	Bottle gourd	Sharma and Dhankar (1990)
3.	Number of fruits per vine	High	Pumpkin	Gopalakrishnan *et al.* (1980)
			Bitter gourd	Singh *et al.* (1977)
4.	Fruit weight	High	Watermelon	Laltaprasad *et al.* (1988)
			Ribbed gourd	Reddy and Rao (1984)
5.	Vine length	Low	Cucumber	Rastogi and Aryadeep (1990)
6.	Yield/vine	High	Bitter gourd	Singh *et al.* (1977)

2.3 CHARACTER ASSOCIATION

Genetic improvement of yield is the primary concern to the plant breeder. Yield is a complex character and is highly influenced by the environment. On the contrary, yield component traits are not only less complex and simply inherited but also influenced much less due to environmental deviations. Thus, selection based on the component characters has been considered to be more effective as compared to direct selection for yield (Grafiucs, 1956). Knowledge on the association of yield components with yield is of permanent importance while aiming at improvement in yield.

It is essential to have knowledge of genetic correlation among the factors contributing to the yield in order to affect selection of yield component characters.

A brief review of literature on association of component characters with fruit yield is presented here under

S.No.	Character	Type of association	Crop	Reference
1.	Days to first female flowering	Positive significant	Watermelon	Tikka *et al.* (1974)
			Muskmelon	Vijay (1987)
		Negative significant	Bitter gourd	Mangal *et al.* (1981)
			Sponge gourd	Panwar *et al.* (1977)
			Muskmelon	Deol *et al.* (1981)
			Bitter gourd	Khattra *et al.* (1994)
			Ridge gourd	Narsimharao (1997)
2.	Days to first male flowering	Positive significant	Bottle gourd	Rajnarayan *et al.* (1996)
3.	Number of node at which first female flower appeared	Positive significant	Cucumber	Prasuna and Rao (1989) Choudhury and Mandal (1987) Prasuna and Rao (1989) Abusaleha and Dutta (1988)
			Pumpkin	Mangal *et al.* (1979)
			Ash gourd	Vikrampuri *et al.* (1984)
			Ridge gourd	Krishnaprasad and Singh (1989) Pal and Vani (1986) Sahni *et al.* (1985) Thakur and Choudhury (1965) Kodam *et al.* (1992) Varalaxmi and Reddy (1994)
			Sponge gourd	Panwar *et al.* (1977)
			Bitter gourd	Ramachandran *et al.* (1978) Srivastava and Srivastava (1976) Mangal *et al.* (1981) Lavande and Patil (1989) Khattra *et al.* (1994) Singh *et al.* (1977)
			Bottle gourd	Singh *et al.* (1996) Prasad *et al.* (1993) Rajnarayan *et al.* (1996) Tyagi (1972) Murali *et al.* (1986) Singh *et al.* (1996)
			Watermelon	Singh and Singh (1988) Sidhu and Brar (1981)
			Muskmelon	Vijay (1987)
			Pointed gourd	Singh *et al.* (1993) Singh *et al.* (1986).
		Positive non-significant	Cucumber	Haribabu (1985) Krishnaprasad and Singh (1992)
			Ridge gourd	Narasimha Rao (1997)
			Muskmelon	Swamy *et al.* (1984)

5.	Fruit weight	Positive significant	Bitter gourd	Lawande and Patil (1989) Parhi *et al*. (1995) Ramachandran *et al*. (1978) Khattra *et al*. (1994)
			Ridge gourd	Kadam *et al*. (1992) Varalaxmi and Reddy (1994) Narasimha Rao (1997)
			Cucumber	Prasuna and Rao (1989) Haribabu (1985) Krishnaprasad and Singh (1992) Choudhuri and Mandal (1987)
			Bottle gourd	Prasad *et al*. (1993) Murali *et al*. (1986) Rajanarayan *et al*. (1996)
			Watermelon	Sidhu and Brar (1981) Tikka *et al*. (1974)
			Pumpkin	Mangal *et al*. (1981) Rana *et al*. (1985)
			Pointed gourd	Sarkar *et al*. (1999) Singh *et al*. (1986)
			Muskmelon	Swamy *et al*. (1984) Chhonkar *et al*. (1979) Deol *et al*. (1981) Vijay (1987)
			Ashgourd	Vikrama puri *et al*. (1984)
			Ribbed gourd	Thamburaj (1973)
6.	Fruit diameter	Positive significant	Ridge gourd	Varalaxmi and Reddy (1994)
			Cucumber	Krishnaprasad and Singh (1992)
				Abusaleha and Dutta (1988)
			Bottle gourd	Tyagi (1972)
			Ridge gourd	Narasimha Rao (1997)
			Bitter gourd	Mangal *et al*. (1981)

7.	Fruit length	Positive significant	Bitter gourd	Ramachandran *et al.* (1978)
			Ridge gourd	Varalaxmi and Reddy (1994) Thakur and Choudhury (1965)
			Cucumber	Krishnaprasad and Singh (1992) Ahusaleha and Dutta (1988)
			Ridge gourd	Sahni *et al.* (1985)
			Cucumber	Choudhury and Mandal (1987)
			Parwal	Singh *et al.* (1987)
			Bitter gourd	Parhi *et al.* (1995)
			Bottle gourd	Tyagi (1972)
			Ridge gourd	Kodam *et al.* (1992)
8.	Fruits flesh thickness	Positive significant	Pumpkin	Rana *et al.* (1985)
			Muskmelon	Vijay (1987)
		Positive non-significant	Cucumber	Krishnaprasad and Singh (1992) Abusaleha and Dutta (1988)
			Muskmelon	Swamy *et al.* (1984)
			Cucumber	Haribabu (1985)
9.	Number of seeds per fruits	Positive significant	Pointed gourd	Sarkar *et al.* (1999)
			Ribbed gourd	Thamburaj (1973)
			Bottle gourd	Tyagi (1972)
			Bitter gourd	Parhi *et al.* (1995)
10.	Seed weight	Positive significant	Bottle gourd	Tyagi (1972)
			Muskmelon	Swamy *et al.* (1984)
11.	Vine length	Positive significant	Bitter gourd	Parhi *et al.* (1995) Lawande and Patil (1989) Ramachandran *et al.* (1978)
			Cucumber	Choudhury and Mandal (1987) Krishnaprasad and Singh (1992)
			Muskmelon	Chhonkar *et al.* (1979)
			Ridge gourd	Krishnaprasad and Singh (1989) Kadam *et al.* (1992) Sahni *et al.* (1985)
			Pumpkin	Mangal *et al.* (1979)
			Bottle gourd	Murali *et al.* (1986)
			Pointed gourd	Sarkar *et al.* (1999)
			Watermelon	Tikka *et al.* (1974) Laltaprasad *et al.* (1988)
			Ash gourd	Vikramapuri *et al.* (1984)
		Negative	Pointed gourd	Singh et al. (1986)

2.4 PATH COEFFICIENT ANALYSIS

Path coefficient analysis, a statistical device developed by Wright (1934) helps in partitioning of the correlation coefficients into direct and indirect effects of independent variable and dependent variable. As yield is influenced by several factors, selection based on simple correlation without taking into consideration between the component characters is not effective. Hence path analysis is of much importance in any plant breeding programme, correlation in combination with path analysis would give a better insight into cause and effect relationship between different pairs of characters. Dewey and Lu (1959) and Frakes (1961) demonstrated the utility of path coefficient analysis in plant selection and since then its application has been extended to almost to every crop.

The available literature on path coefficient analysis is furnished here in a tabular form.

S.No.	Character	Positive direct effect on yield	Negative direct effect on yield
1.	Days to first male flower	Parhi *et al.* (1995)	Vijay (1987)
2.	Days to first female flower	Narasimharao (1997) Krishnaprasad and Singh (1989) Singh and Singh (1988) Tikka *et al.* (1974) Rajanarayan (1996)	Vijay (1987)
3.	Number of node at which first female flower appeared	Varalaxmi and Reddy (1994)	Vijay (1987)

4.	No.of fruits	Sarkar *et al.* (1999) Vijay (1987) Ramachandran *et al.* (1978) Srivastava and Srivastava (1976) Thamburaj *et al.* (1978) Kondal Raj *et al.* (1984) Vikrampuri *et al.* (1984) Choudhury and Mandal (1987) Abusalehe and Dutta (1988) Prasuna and Rao (1989) Pandita *et al.* (1990) Rajanarayan *et al.* (1996) Singh *et al.* (1993) Narsimharao (1997)	
5.	Fruit weight	Tikka *et al.* (1974) Vijay (1987) Ramachandran *et al.* (1978) Thamburaj *et al.* (1978) Kondalraj *et al.* (1984) Narsimharao (1997) Vikram puri *et al.* (1984) Sahni *et al.* (1985) Choudhury and Mandal (1987) Prasuna and Rao (1989) Parhi *et al.* (1995) Rajanarayan *et al.* (1996) Singh *et al.* (1993) Gopalakrishnan *et al.* (1980) Krishnaprasad and Singh (1992) Rana *et al.* (1985) Sarkar *et al.* (1999) Singh and Singh (1988)	

7.	Fruit diameter	Parhi *et al.* (1995) Sarkar *et al.* (1999) Choudhury and Mandal (1987)	Vijay (1987)
8.	Fruit length	Krishnaprasad and Singh (1992) Abusaleha and Dutta (1988) Varalaxmi and Reddy (1994) Parhi *et al.* (1998) Choudhury and Mandal (1987) Sahni (1985)	Ramachandran *et al.* (1978)
9.	Flesh thickness	Gopalakrishnan *et al.* (1980) Rana *et al.* (1985) Vijay (1987)	
10.	Number of seeds/fruit	Parhi *et al* (1995)	Vijay (1987)
11.	Vine length	Gopalakrishnan *et al.* (1980) Krishnaprasad and Singh (1989) Ramachandran *et al.* (1978) Varalaxmi and Reddy (1994) Sahni (1985)	Vijay (1987)

2.4.1 Path coefficient analysis (Indirect effects)

Indirect effects of days to male flower through

Character	Positive indirect effect	Negative indirect effect
Fruit weight	Vijay (1987)	
Number of fruits	Vijay (1987)	
Vine length		Vijay (1987)

Indirect effect of node at which male flower appeared through

Character	Positive indirect effect	Negative indirect effect
Node at which female flower appeared	Krishnaprasad and Singh (1992)	
Fruit weight	-	Krishnaprasad and Singh (1992)
Fruit length	-	Krishnaprasad and Singh (1992)
Fruit diameter	-	Krishnaprasad and Singh (1992)
No.of fruits per vine	-	Krishnaprasad and Singh (1992)
Flesh thickness	-	Krishnaprasad and Singh (1992)

Indirect effects of days to first female flower through

Character	Positive indirect effect	Negative indirect effect
Fruit weight	Tikka *et al* (1974) Singh and Singh (1988)	Krishnaprasad and Singh (1992)
No.of fruits per vine		Sing and Singh (1988) Krishnaprasad and Singh (1992)
Vine length	Tikka *et al.* (1974)	Krishnaprasad and Singh (1992)

Indirect effect of node at which first female flower appeared through

Character	Positive indirect effect	Negative indirect effect
Fruit weight	Krishnaprasad and Singh (1992) Singh and Singh (1988) Gopalakrishnan *et al.* (1980)	
Fruit length		Krishnaprasad and Singh (1992)
No.of fruits length		Krishnaprasad and Singh (1989) Singh and Singh (1988)
Vine length	Krishnaprasad and Singh (1989)	

Indirect effect of fruit weight through

Character	Positive	Negative
Days to female flower	Singh and Singh (1988) Tikka *et al.* (1974)	Krishnaprasad and Singh (1992)
Fruit length	Krishnaprasad and Singh (1992)	Sarkar *et al.* (1999) Ramachandran *et al.* (1978)
Fruit diameter	Sarkar *et al.* (1999) Krishnaprasad and Singh (1992)	
No.of fruits per vine	Vijay (1987) Ramachandran *et al.* (1978)	Rana *et al.* (1985) Gopalakrishnan *et al.* (1980) Krishnaprasad and Singh (1992) Sarkar *et al.* (1999) Singh and Singh (1988)
Vine length	Sarkar *et al.* (1999) Ramachandran *et al.* (1978)	Vijay (1987) Krishnaprasad and Singh (1992)

Indirect effects of fruit length through

Character	Positive	Negative
Fruit weight	Sarkar *et al.* (1999) Krishnaprasad and Singh (1992) Ramachandran *et al.*(1978) Gopalakrishnan *et al.* (1980)	
Number of fruits per vine	Gopalakrishnan *et al.* (1980)	Ramachandran *et al.*(1978) Sarkar *et al.* (1999) Mangal *et al.* (1981)
Vine length		Ramachandran *et al.*(1978) Sarkar *et al.* (1999) Krishnaprasad and Singh (1992)

Indirect effects of number of fruits through

Character	Positive	Negative
Fruit weight	Vijay (1987) Krishnaprasad and Singh (1992) Ramachandran *et al.* (1978)	Sarkar *et al.* (1999) Singh and Singh (1988)
Fruit length	Rajput *et al.* (1991) Ramachandran *et al.* (1978) Sarkar *et al.* (1999)	
Fruit diameter	Rajput *et al.* (1991)	Sarkar *et al.* (1999)
Fruits flesh thickness	Rana *et al.* (1985)	
Vine length	Ramachandran *et al.* (1978)	Sarkar *et al.* (1999) Krishnaprasad and Singh (1992) Vijay (1987)

Indirect effects of vine length through

Character	Positive	Negative
Fruit weight	Ramachandran *et al*. (1978) Vijay (1987) Sarkar *et al*. (1999) Tikka *et al*. (1974)	Krishnaprasad and Singh (1992)
Fruit length		Ramachandran *et al*. (1978) Sarkar *et al*. (1999) Krishnaprasad and Singh (1992)
No.of fruits per vine	Ramachandran *et al*. (1978) Vijay (1987) Sarkar *et al*. (1999) Krishnaprasad and Singh (1992)	
Vine length	Vijay (1987)	

A brief review of literature on association among yield component traits

Character	Type of association	Crop	Reference
Days to flowering with			
No.of fruits/vine	Negative significant	Cucumber	Krishnaprasad and Singh (1992)
		Bottle gourd	Murali *et al.* (1986)
		Sponge gourd	Panwar *et al.* (1977)
		Watermelon	Singh and Singh (1988)
	Positive significant	Muskmelon	Daljitsingh and Nandpuri (1978)
Fruit weight	Negative	Ribbed gourd	Reddy and Rao (1984)
Fruits flesh thickness	Negative significant	Cucumber	Krishnaprasad and Singh (1992)
Yield	Negative significant	Muskmelon	Daljitsingh and Nandpuri (1978)
		Cucumber	Krishnaprasad and Singh (1992)
		Bottle gourd	Murali *et al.* (1986)
		Ribbed gourd	Reddy and Rao (1984)
Node at which first female flower appeared with			
Days to first male flower	Positive non-significant	Sponge gourd	Arora *et al.* (1983)
Days to first female flower	Positive non-significant	Sponge gourd	Arora *et al.* (1983)
Number of fruits/vine	Negative	Cucumber	Krishnaprasad and Singh (1992)
Fruit weight	Negative	Ribbed gourd	Reddy and Rao (1984)
Fruit length	Positive significant	Cucumber	Krishnaprasad and Singh (1992)
Fruit diameter	Positive significant	Cucumber	Krishnaprasad and Singh (1992)
Yield/vine	Negative	Ribbed gourd	Reddy and Rao (1984)

Number of fruits with			
Days to flowering	Positive significant	Bitter gourd	Singh *et al*. (1977)
	Negative significant	Sponge gourd	Panwar *et al*. (1977)
		Pumpkin	Mangal *et al*. (1981)
Fruit weight	Positive and Significant	Cucumber	Solanki and Seth (1980)
		Ribbed gourd	Reddy and Rao (1984)
		Bottle gourd	Murali *et al*. (1986)
	Negative significant	Cucumber	Haribabu (1985)
		Cucumber	Prasanna and Rao (1989)
Fruit length	Positive significant	Bitter gourd	Singh *et al*. (1977)
Vine length	Positive significant	Pumpkin	Mangal *et al*. (1979)
		Bottle gourd	Murali *et al*. (1986)
		Pumpkin	Rana *et al*. (1985)
		Cucumber	Solanki and Seth (1980a)
	Negative non significant	Muskmelon	Deol *et al*. (1981)
		Pointed gourd	Sarkar *et al*. (1999)
Yield	Positive significant	Sponge gourd	Panwar *et al*. (1977)
		Pointed gourd	Sarkar *et al*. (1999)
		Ribbed gourd	Reddy and Rao (1984)
		Bitter gourd	Singh *et al*. (1977)
		Cucumber	Smith *et al*. (1978)
	Negative	Muskmelon	Deol *et al*. (1981)
Number of seeds/fruit	Positive significant	Bottle gourd	Tyagi (1972)

Fruit weight with			
Days to first female flower	Positive Significant	Watermelon	Singh and Singh (1988)
Number of fruits per vine	Positive Significant	Watermelon	Ramachandran and Gopalakrishnan (1979)
Fruit length		Pumpkin	Gopalkrishnan *et al*. (1980)
		Cucumber	Krishnaprasad and Singh (1992)
		Pumpkin	Mangal *et al*. (1981)
		Ribbed gourd	Thamburaj (1973)
Fruit diameter	Positive Significant	Cucumber	Krishnaprasad and Singh (1992)
		Ribbed gourd	Thamburaj (1973)
		Muskmelon	Molina *et al*. (1989)
		Pumpkin	Gopalakrishnan *et al*. (1980)
Fruit flesh thickness	Positive Significant	Muskmelon	Swamy et al (1984)
		Pumpkin	Gopalkrishnan et al (1989)
		Cucumber	Krishnaprasad and Singh (1992)
		Muskmelon	Molina et al (1989)
		Muskmelon	Daljitsingh and Nandpuri (1978)
		Watermelon	Singh and Singh (1988)
		Muskmelon	Deol *et al*. (1981)
Number of seeds	Positive significant	Pumpkin	Gopalakrishnan *et al*. (1980)
		Ribbed gourd	Thamburaj (1973)
		Pumpkin	Doijode and Sulladmath (1986)

Seed weight	Positive significant	Pumpkin	Doijode and Sulladmath (1986)
		Muskmelon	Narsimharao (1984)
		Pumpkin	Gopalakrishnan *et al.* (1980)
Yield./vine	Positive significant	Cucumber	Krishnaprasad and Singh (1992)
		Sponge gourd	Panwar *et al.* (1977)
		Muskmelon	Daljitsingh and Nandpuri (1978)
		Bitter gourd	Ramachandran *et al.* (1978)
	Positive non-significant	Ribbed gourd	Thamburaj (1973)
Fruit length with			
Days to flowering	Positive significant	Bitter gourd	Singh *et al.* (1977)
Number of fruits	Positive significant	Bitter gourd	Singh *et al.* (1977)
	Negative significant	Ridge gourd	Krishnaprasad and Singh (1989)
Fruit weight	Positive significant	Bitter gourd	Ramachandran *et al.* (1978)
		Snake gourd	Thamburaj *et al.* (1978)
		Ribbed gourd	Reddy and Rao (1984)
Fruit diameter	Positive significant	Bitter gourd	Mangal *et al.* (1981)
		Sponge gourd	Panwar *et al.* (1977)
	Negative significant	Snake gourd	Thamburaj *et al.* (1978)
No.of seeds	Positive significant	Bitter gourd	Mangal *et al.* (1981)
		Bottle gourd	Tyagi (1972)
	Positive non-significant	Ribbed gourd	Thamburaj (1973)
Seed weight	Positive significant	Bottle gourd	Tyagi (1972)

Yield/vine	Positive significant	Ridge gourd	Krishnaprasad and Singh (1989)
		Sponge gourd	Panwar *et al.* (1977) Singh *et al.* (1977)
		Ribbed gourd	Thamburaj (1973) Reddy and Rao (1984) Singh *et al.* (1987)
Fruit diameter with			
Fruit length	Positive significant	Ridge gourd	Krishnaprasad and Singh (1989)
		Bitter gourd	Mangal *et al.* (1981)
Number of seeds/fruit	Positive significant	Pointed gourd	Sarkar *et al.* (19 99)
		Bottle gourd	Tyagi (1972)
	Positive non-significant	Ribbed gourd	Thamburaj (1973)
Yield /vine	Positive significant	Ridge gourd	Krishnaprasad and Singh (1989)
		Pointed gourd	Sarkar *et al.* (1999)
	Positive non-significant	Sponge gourd	Arora *et al.* (1983)
		Ribbed gourd	Thamburaj (1973) Reddy and Rao (1984)
Flesh thickness	Positive significant	Cucumber	Krishnaprasad and Singh (1992)
Vine length	Negative significant	Bottle gourd	Tyagi (1972)
Fruit flesh thickness with			
Fruit weight	Positive significant	Muskmelon	Deol *et al.* (1981)
		Pumpkin	Rana *et al.* (1985)
Fruit length	Non-significant	Muskmelon	Deol *et al.* (1981)
Vine length	Negative significant	Pumpkin	Rana *et al.* (1985)

Yield/vine	Positive significant	Muskmelon	Daljitsingh and Nandpur (1978)
Number of seeds with			
Seed weight	Positive significant	Bottle gourd	Tyagi (1972)
Seed weight with			
Fruit weight	Positive significant	Ribbed gourd	Thamburaj (1973)
Fruit length	Positive significant	Ribbed gourd	Thamburaj (1973)
Number of seeds	Positive significant	Ribbed gourd	Thamburaj (1973)
Vine length with			
Days to first male flower	Positive non significant	Sponge gourd	Arora *et al.* (1983)
Days to first female flower	Positive non significant	Sponge gourd	Arora *et al.* (1983)
Number of fruits/vine	Positive non-significant	Bitter gourd	Ramachandran *et al.* (1978)
		Cucumber	Solanki and Seth (1980a)
Fruit weight	Positive significant	Muskmelon	Chhonkar *et al.* (1979)
		Cucumber	Solanki and Seth (1980a)
Fruit length	Positive significant	Bitter gourd	Ramachandran *et al.* (1978)
No.of seeds	Positive significant	Bottle gourd	Tyagi (1972)
Seed weight	Negative		
Yield/vine	Positive	Pumpkin	Gopalakrishnan *et al.* (1980)
	Positive non-significant	Cucumber	Haribabu (1985) Solanki and Seth (1980a)

Materials and Methods

CHAPTER – III

MATERIAL AND METHODS

The present investigations on "Studies on genetic divergence, variability parameters and character association in bottle gourd (*Lagenaria siceraria* (Mol.) Stand L.) were carried during *rabi* season (December 1999 to April 2000) at the horticultural garden, S.V. Agricultural College, Tirupati which is situated at an altitude of 182.9 m above mean sea level, on 13.27° N latitude and 79.36° E longitude. The meteorological data recorded during the period of experiment is presented in appendix.

3.1 Material

Twenty four lines/varieties of bottle gourd collected from diverse sources were used for the study. Varieties include both long and round types. The details of the genotypes are furnished in Table 1.

3.2 Methods

3.2.1 Field plot technique

The experiment was laid out in a randomized block design with three replications. Each replication consists of twenty four rows and each row has six pits with a spacing of 2.75 x 1 m and finally maintaining one plant per pit. Cultivation practices including fertilizer application and plant protection measures were followed as per recommendations for the crop recommended by Choudhury (1967).

Table 1: Details of twenty four genotypes of bottle gourd

S.No.	Genotype	Source	Salient features
1.	Ganesh	Ganaga Cauveri Seed Pvt. Ltd. Hyderabad	Lengthy vines, long fruits
2.	MGH-8	Mahyco-Maharastra Hybrid Seeds Co., Ltd., Jalna	Short to medium vines long fruits
3.	Doodhee	Santosh Seed Pvt. Ltd., Hyderabad	Short vines, long fruits
4.	Pusa Meghdoot	Mahyco-Maharastra Hybrid Seeds Co Ltd. Jalna	Trimonoecious, crooked necked long fruits, medium vines
5.	Vipul – 7	Ankur Seeds Pvt. Ltd. Nagpur	Long vines, medium sized fruits
6.	Avinasi Local	Avinasi Local Seed Market, T N	Lon green fruits – long vines
7.	Pusa Summer Prolific Long	Prithvi Seeds Pvt. Ltd. Hyderabad	Medium to long vines, fruits long
8.	Warad	Mahyco-Maharastra Hybrid Seeds Co. Ltd. Jalna	Medium vines, long fruits
9.	Pusa Naveen	Paras Seeds Hindustan Lever Limited, Delhi	Short vines, long fruits
10.	Indo-American	Avinasi Local Seed Market, Tamilnadu	Round green fruits, long vines
11.	Arka Bahar	IIHR, Bangalore	Long vines, Long fruits
12.	Indian 1720	Indo American Hybrid Seeds, Bangalore	Short vines, long fruits
13.	MGH-9	Mahyco-Maharastra Hybrid Seeds Company Limited, Jalna	Short vines, long fruits
14.	Swathi	Sungro Seeds Pvt. Ltd. Delhi	Medium vines, long fruits
15.	NLG Long	Nalgonda Local Seed Market Nalgonda, AP	Long green fruits, long vines
16.	Shramika	Bejo sheetal seeds Pvt. Ltd. Jalna	Short vines, long fruits
17.	Pallavi	Zoden Samen Seeds, Aurangabad	Short vines – Long fruits
18.	Pratik	Arkur Seeds Pvt Ltd. Nagpur	Medium to long vines, Medium fruits
19.	Satur	Avinasi Local Seed Market, Tamil Nadu	Round green big fruits, long vine
20.	HYD Round	Hyderabad Local Seed Market, AP	Medium vines, small round fruits
21.	MLG Local	Miryalaguda Local Seed Market, AP	Short-medium vines, short fruits
22.	IC-92330	ICAR, New Delhi	Medium-long vines medium sized fruits
23.	Nadhaswaram	Nalgonda Local Seed Market, Nalgonda, AP	Medium-long vines medium fruits
24.	SRP-1	Suryapet Local Seed Market, AP	Medium to long vines, medium round fruits yellowish green

3.2.2 Details of cultivation

The experimental field was thoroughly ploughed and prepared well. After layout, shallow pits were dug at a spacing of 2.75 x 1m. At the time of preparation of pits well decomposed FYM was incorporated @ 2 kg per pit. Seed were dibbled @ 4 per pit on December 8th 1999. Later thinning was done leaving one plant per pit. Fertilizers were applied one month after sowing @ 11 g of N, 7 g of P are 7 g of K per pit by way of Ammonium sulphate, Super phosphate, Muriate of potash. The experimental plots were irrigated as and when necessary and need based plant protection measures were also takenup to control the pests and diseases.

3.2.3 Observations recorded

Observations were recorded on five randomly tagged plants. The mean of the values of the five plants was utilized for statistical analysis. Observations were recorded on the following characters.

3.2.3.1 Number of node at which first male flower appeared

The node number at which the first male flower appeared was noted, counting its position from the base of the vine including the cotyledenary node

3.2.3.2 Days to first male flower

The number of days taken for the opening of the first male flower on the vine from the date of sowing in each treatment was recorded.

3.2.3.3 Number of node at which first female flower appeared

The node number at which the first female flower appeared was noted, counting its position from the base of the vine including the cotyledonary node.

3.2.3.4 Day to first female flower

The number of days taken for the opening of the first female flower on the vine from the date of sowing in each treatment was recorded.

3.2.3.5 Number of fruits per vine

The number of the marketable fruits harvested from each vine were totaled and recorded as the total number of marketable fruits per vine by number.

3.2.3.6 Weight of the fruit (kg)

Average fruit weight was obtained by dividing the weight of the fruits obtained per plant with number of plants in each treatment.

3.2.3.7 Fruit diameter (cm)

The diameter of the fruit was measured by at the maximum girth of the fruit after attaining marketable size.

3.2.3.8 Length of the fruit (cm)

The length of the fruit was measured from the stalk end to tip of fruit after attaining marketable size.

3.2.3.9 Fruit flesh thickness (cm)

Thickness of edible flesh was measured with a scale by taking central portion excluding the rind.

3.2.3.10 Number of seeds per fruit

Fruits after attaining maximum size are harvested and seeds are extracted and the number of seeds per fruit was counted.

3.2.3.11 Weight of thousand seeds

One thousand seeds taken for each treatment were weighed and average was worked out and expressed in grams.

3.2.3.12 Vine length (m)

The length of the main vine was measured from base of the plant to the tip of the main vine at the end of crop duration.

3.2.3.13 Yield per vine (kg)

All the marketable fruits per plant were harvested and weighed in each harvest, and recorded as total yield per vine.

3.3 Biometrical analysis

The treatment means obtained for each character were subjected to the following statistical analysis

1. Analysis of variance
2. Estimation of genetic divergence by using Mahalanobis's D^2 analysis
3. Grouping of clusters by D^2 statistic
4. Estimation of genotypic variance
5. Estimation of phenotypic variance

6. Estimation of Phenotypic and Genotypic coefficients of variation
7. Heritability (Broad sense)
8. Genetic advance
9. Correlation coefficients
10. Path coefficient analysis

3.3.1 Analysis of variance

The means of the observations recorded from five plants for each treatment in each replication were subjected to statistical scrutiny as proposed by Panse and Sukhatma (1957) as follows.

$$Y_{ij} = \mu + g_i + r_j + e_{ij}$$

Where,

Y_{ij} = Phenotypic observation in i^{th} genotype and j^{th} replication

μ = General mean

g_i = Effect of i^{th} genotype

r_i = Effect of j^{th} replication

e_{ij} = Random error associated with i^{th} genotype and j^{th} replication

3.3.2 Anova

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F ratio
Replication	(r-1)	RSS	M_r	$\frac{Mr}{Me}$
Treatments	(g-1)	VSS	M_v	$\frac{Mv}{Me}$
Error	(r-1)(g-1)	ESS	M_e	
Total	rg-1			

Where,

r = Number of Replications

t = Number of Genotypes

Mr = Mean sum of squares due to replications

Mv = Mean sum of squares due to genotypes

Me = Mean sum of squares due to error

The test of significance was carried-out by referring to F table value given by Fisher and Yates (1967).

3.3.3 Genetic Divergence

The data collected on different characters were analysed through Mahalabobis's generalized distance (D^2) statistic following procedure given by Rao (1952). The mean values of uncorrelated linear combinations Y_1 to Y_{13} were computed by substituting respective values of characters measured as

$$D^2_{ij} = P\sum_{t=1}(Y_{it} - Y_{jt})$$

Where,

Y_{it} = Uncorrelated mean value of i[th] genotype for 't' character

Yjt = Uncorrelated mean value of j[th] genotype for 't' character

D^2_{ij} = D^2 value between i[th] and j[th] genotype

Variances were calculated for all the 13 characters investigated and test of significance was done. Analysis of covariance for the character pairs was estimated on the basis of mean values. A dispersion table was prepared from the estimates. After testing the differences between genotypes for each of the characters, a simultaneous test of significance of differences between the mean values of a number of correlated variables was done by using 'V' statistic, which in turn utilizes Wilk's λ Criterion (Wilk, 1932). The sum of squares and sum of products of error and error plus variety variance – covariance matrix were used for this purpose.

The estimates of λ (Wilk's Criterion) were done using the following formula.

$$\lambda = \frac{(E)}{(E+V)}$$

Where,

(E) = Determinant of error matrix

(E+V) = Determinant of error + variances matrix

The significance of λ was tested by

$$X^2_{pq} = V = -m \log_e \lambda$$

Where,

m = (n-P+q+1)/2 with pq degrees of freedom

n = degrees of freedom of error + varieties

p = Number of characters

q = Number of genotypes –1

$\log_e \lambda = 2.3407 \ \log_{10} \lambda$

3.3.3.1 Grouping of clusters by D^2 statistics

Grouping of the genotypes into different clusters was done by using Tocher's method as described by Rao (1952). The criterion used in clustering by this method is that any two variables belonging to the same cluster should at least on an average show a smaller D^2 value among themselves than those belonging to two different clusters.

The first step in grouping the genotypes into different clusters was to arrange the genotypes in order to know their relative distance from each other. For this purpose D^2 values of all the possible combinations in each genotype were arranged in increasing order of the magnitude in a tabular form as described by Singh and Chowdhury (1977). To start with, two closely associated genotypes with the lowest D^2 values were selected and third type which has the smallest average D^2 from the first two genotypes were added. Then comes the nearest fourth genotype with smallest average D^2 and so it goes on. At certain stage, when it was felt that after adding a particular variety, there was an abrupt increase in the average D^2 value, then that variety was not considered for inclusion in that cluster. Thus, the process was continued till all the genotypes are included in one or the other cluster.

3.3.4 Genotypic variance

Genotypic variance is calculated according to the formulae given by Lush (1940).

$$\text{Genotypic variance} = V_g = \frac{M_1 - M_2}{r}$$

3.3.5 Phenotypic variance

It is also calculated according to the formulae given by Lush (1940)

Phenotypic variance $= V_{ph} = M_1 - V_g + V_e$

3.3.6 Phenotypic coefficient of variation (pcv)

PCV is calculated as suggested by Burton (1953) and expressed in per cent

$$PCV = \frac{(\text{Phenotypic variance})^{1/2}}{\text{General Mean}} \times 100$$

3.3.7 Genotypic coefficient of variation (GCV)

GCV is calculated as suggested by Burton (1953) and expressed in per cent.

$$GCV = \frac{(\text{Genotypic variance})^{1/2}}{\text{General Mean}} \times 100$$

3.3.8 Heritability (Broad sense)

Heritability in broad sense was calculated according to Robinson (1966) and expressed in per cent.

$$h^2(BS) = \frac{V_g}{V_{ph}} \times 100$$

3.3.9 Genetic advance

Genetic advance was worked out based on the formula given by Johnson et al, (1955).

$$\text{Genetic advance (GA)} = \frac{V_g}{V_{ph}} \times 100 \times K \times (V_{ph})^{1/2}$$

Where,

K = Selection differential at 5 per cent

Selection intensity (2.06)

$$\text{Genetic advance as per cent of mean} = \frac{GA}{\text{Grand mean}} \times 100$$

3.3.10 Correlation coefficient

Analysis of covariance was done in a similar method as that of analysis of variance. The error sum of products (mean sum of products for replication x genotypes) was used as environmental covariance. The phenotypic and genotypic covariances were derived as detailed for phenotypic and genotypic variances. The variance and covariance components were utilized to calculate the phenotypic, genotypic and environmental correlation coefficients (Johnson *et al*, 1955) as follows.

$$r_p = \frac{P\ cov\ 1.2}{(PV_1.PV_2)^{1/2}}$$

$$r_g = \frac{G\ cov\ 1.2}{(GV_1.GV_2)^{1/2}}$$

$$r_e = \frac{E\ cov\ 1.2}{(EV_1.EV_2)^{1/2}}$$

Where

- r_p, r_g, r_e are phenotypic, genotypic and environmental correlation coefficients

  $PCOV_{1.2}$, $GCOV_{1.2}$ and $ECOV_{1.2}$ are phenotypic, genotypic and environmental covariances respectively between the characters 1 and 2.

- PV_1, GV_1 and EV_1 are phenotypic, genotypic and environmental variances respectively for the first character.
- PV_2, GV_2 and EV_2 are phenotypic, genotypic and environmental variances respectively for the second character.

3.3.11 Path coefficient analysis

Path coefficient analysis as applied by Dewey and Lu (1959) was used to partition the genotypic correlation coefficients into direct and indirect effects. The path coefficients were obtained by solving the simultaneous equation for thirteen variables.

Results

CHAPTER-IV

RESULTS

Twenty four genotypes of bottle gourd were evaluated for variability, genetic divergence, character association and path analysis for thirteen characters viz., days to male flower, days to female flower, node at which first male flower appeared, node at which first female flower appeared, number of fruits per vine, fruit weight, fruit length, fruit diameter, fruit flesh thickness, number of seeds per fruit, thousand seed weight, vine length and yield per vine. The data collected on these characters were used for bio-metrical studies. The results obtained from these investigation are furnished in this chapter.

4.1 MEAN PERFORMANCE

The data recorded on thirteen characters were subjected to analysis of variance and presented in the Table 2. The treatment differences among the twenty four genotypes were significant for all the characters studied and the mean performance of these genotypes is presented in Table 3.

4.1.1 Days to first male flower

The time taken for the first male flower to appear ranged from 41.78 days to 69.61 days with a general mean of 53.76 days. Among all the genotypes SRP-1 had taken less number of days (41.78) for the first male flower whereas NLG-local took more number of days (69.61). Eleven genotypes were earlier in flowering when compared to mean number of days to first male flower (Table 3).

Table 2 : Analysis of variance for thirteen characters for twenty four genotypes of bottle gourd

S.No.	Character	Replications	Treatments	Error
1.	Degrees of freedom	2	23	46
2.	Number of node at which first male flower appeared	0.62	39.07	2.63
3.	Days to first male flower	35.18	238.40	57.84
4.	Number of node at which first female flower appeared	17.44	285.71	33.65
5.	Days to first female flower	117.80	520.58	141.45
6.	Fruit length	1.87	452.04	13.26
7.	Fruit diameter	1.95	12.34	3.94
8.	Fruit weight	0.08	0.80	0.05
9.	No.of seeds per fruit	3368.16	79166.39	3507.47
10.	Thousand seed weight	71.41	7484.38	1119.37
11.	Fruit flesh thickness	1.32	8.11	1.90
12.	No.of fruits per vine	0.10	1.82	0.09
13.	Yield per vine	0.03	30.77	0.32
14.	Vine length	0.33	10.47	0.25

Table 3 : Mean performance of twenty four genotypes for thirteen quantitative characters in bottle gourd

Name of the Genotype	No.of node at which first male flower appeared	Days to First Male Flower	No.of node at which first female flower appeared	Days to First Female Flower	Fruit Length (cm)	Fruit diameter (cm)	Fruit Weight (kg)	No.of Seeds per fruit	Thousand Seed Weight (g)	Fruit Flesh thickness (cm)	No.of Fruits per Vine	Vine Length (m)	Corre-lations with yield
Ganesh	6.99	44.30	12.30	52.16	59.68	9.93	2.16	687.64	248.38	7.27	3.25	2.57	6.92
MGH-8	5.94	44.44	12.30	53.93	50.57	9.36	2.15	661.57	249.53	6.98	3.31	2.95	6.97
Doodhee	6.36	64.26	8.80	62.46	40.11	9.99	1.37	363.95	289.49	6.69	3.07	1.41	4.26
Puso meghdoor	6.00	45.66	12.76	54.30	66.59	8.86	1.80	411.02	318.65	5.94	3.93	3.36	7.05
Vipul-7	6.96	57.53	10.90	60.90	39.66	10.10	1.73	541.96	285.44	7.43	3.85	7.19	6.66
Avinasi local	11.68	64.89	17.21	68.86	53.90	14.58	2.77	950.40	321.87	10.33	2.66	11.58	7.48
PSNL	6.13	55.16	6.00	53.06	52.16	9.57	1.86	437.06	280.92	6.34	5.07	3.73	9.32
Warad	6.91	44.10	12.28	51.94	51.69	9.23	2.22	485.03	331.19	6.85	3.42	3.52	7.35
Pusa naveen	5.93	51.30	7.00	57.16	31.95	9.65	1.40	530.82	223.63	7.21	3.04	1.33	4.54
Indo American	18.35	58.80	34.40	64.62	21.16	15.47	1.42	383.21	303.31	12.63	2.45	9.66	3.27
Arkabahar	6.73	56.66	9.76	61.20	45.53	9.63	1.73	352.19	240.29	7.26	3.41	6.45	5.86
Indom-1720	6.40	54.56	6.83	53.76	37.10	10.06	1.58	348.62	330.32	6.94	3.14	3.97	4.66
MGH-9	6.53	44.58	13.00	52.41	43.57	8.76	1.43	578.55	330.76	6.35	3.95	2.56	5.79
Swathi	7.02	45.09	13.83	55.16	54.48	10.10	2.18	471.52	289.09	7.52	3.14	3.76	6.52
NLG_local	17.72	69.61	43.00	93.33	50.58	9.52	1.94	616.36	300.93	7.20	2.61	12.29	5.02
Shramika	6.25	43.39	14.02	53.66	49.36	9.64	2.04	496.25	358.60	8.35	3.30	2.81	6.61
Pallavi	6.83	45.40	12.61	53.80	47.21	9.26	1.76	410.75	270.12	6.71	2.74	2.83	5s.11
Protik	8.16	50.06	22.51	54.63	40.05	9.71	1.53	492.22	247.03	7.21	4.10	5.51	6.51
Sathur_local	11.03	63.90	17.25	86.83	32.98	16.37	3.02	581.59	330.55	11.71	2.44	11.28	7.40
HYD_round	7.69	58.23	23.66	81.33	19.75	10.23	0.75	296.19	245.88	9.12	2.00	3.50	1.80
MLG_local	6.30	53.96	13.90	68.96	36.57	8.95	0.98	391.93	216.51	6.94	3.05	3.21	2.98
IC-92330	6.01	63.39	17.41	62.90	38.37	10.92	1.52	261.66	369.74	8.07	1.82	5.60	2.90
Nadhaswaram	14.11	69.27	33.98	95.44	40.05	10.33	1.39	175.41	334.92	7.64	3.42	4.72	4.86
SRP-1	8.20	41.78	31.80	65.13	17.06	10.96	1.16	320.15	164.07	7.74	1.55	2.93	2.74
G.mean	8.34	53.76	16.98	63.25	42.50	10.46	1.75	476.92	286.72	7.77	3.11	4.95	5.52

Table 4: Mean performance of twenty four genotypes for thirteen quantitative characters in bottle gourd genotypes

S.No.	Character	Mean	Range	
			Minimum	Maximum
1.	Number of node at which first male flower appeared	8.34	5.50	66.20
2.	Days to first male flower	53.76	41.50	70.50
3.	Number of node at which first female flower appeared	16.98	5.80	96.80
4.	Days to first female flower	63.25	23.80	100.00
5.	Fruit length	42.50	16.50	69.13
6.	Fruit diameter	10.46	1.95	16.54
7.	Fruit weight	1.75	0.66	469.98
8.	No.of seeds per fruit	476.92	156.45	971.08
9.	Thousand seed weight	286.72	11.66	386.09
10.	Fruit flesh thickness	7.77	2.51	12.71
11.	No.of fruits per vine	3.11	1.66	5.21
12.	Yield per vine	4.95	1.73	9.39
13.	Vine length	5.52	1.32	12.51

4.1.2 Days to first female flower

The genotype Warad has taken 51.94 days and the genotype Nadhaswaram took 95.44 days to first female flower. Fifteen genotypes were earlier in flowering of first female flower (Table 3) when compared to mean number of days to first female flower i.e., 63.25 days.

4.1.3 Number of node at which first male flower appeared

The genotype MGH-8 had produced male flower on lowest node number (5.9) whereas the genotype Indo American has produced its first male flower on the highest node number (18.35) and the mean of number of nodes at which first male flower appeared was 8.34.

4.1.4 Number of node at which first female flower appeared

The range for node at which first female flower appeared was from 6.0 to 43.0. The genotype PSPL produced its female flower on lowest node number (6.00) and the genotype NLG-local produced its female flower on highest node number (43.00) whereas general mean was 16.98.

4.1.5 Number of fruits per plant

The number of fruits per vine ranged from 1.55 to 5.07. The maximum number of fruits (5.07) per vine was recorded in PSPL where as the minimum (1.55) in genotype SRP-1. Thirteen genotypes exceeded the general mean in case of number of fruits per vine i.e, 3.11.

4.1.6 Fruit weight (kg)

The genotype Sathur Local recorded maximum fruit weight (3.02 kg) and the genotype HYD-Round recorded minimum fruit weight (0.7523 kg) where as ten genotypes exhibited more fruit weight than the mean weight (1.75 kg).

4.1.7 Fruit length (cm)

The genotype Pusa Meghdoot recorded longest fruit length (66.59 cm) and the genotype SRP-1 exhibited shortest fruit length of 17.06 cm. Twelve genotypes have shown greater fruit length than the general mean value of the genotypes (42.50 cm).

4.1.8 Fruit diameter (cm)

Fruit diameter ranged from 8.7 to 16.37 cm and the genotype MGH-9 recorded less fruit diameter whereas the genotype Sathur Local recorded highest fruit diameter. Five genotypes recorded greater fruit diameter than the general mean (10.46 cm).

4.1.9 Fruit flesh thickness (cm)

The range of fruit flesh thickness varied from 5.94 to 12.64 cm and the minimum flesh thickness was recorded by the genotype Pusa Meghdoot whereas maximum flesh thickness was noticed in the genotype Indo American while six genotypes recorded greater flesh thickness when compared to general mean of 7.77 cm.

4.1.10 Number of seeds per fruit

Maximum number of seeds per fruit was noticed in the genotype Avinasi Local (950.40) and the genotype Nadhaswaram showed minimum number of seeds per fruit (175.41), while twelve genotypes have shown less number of seeds per fruit than the general mean of 476.92.

Table 5 : Analysis of variance for dispersion in twenty four genotypes of bottle gourd

Source of variation	Degrees of freedom	Mean squares
Varieties	23	1.82335D+19**
Error	45	2.86159D-03
Total	68	6.16722D+18

** Significant at 1% level

4.1.11 Thousand seed weight (g)

Among 24 genotypes IC-92330 recorded maximum seed weight (369.74) while SRP-1 exhibited minimum seed weight (164.07 g). Nine genotypes showed lesser seed weight when compared to mean seed weight of 286.72 g.

4.1.12 Vine length (m)

Maximum length of the vine was recorded in the genotype NLG-Local (12.29 m) whereas minimum vine length was recorded in the genotype Pusa Naveen (1.33 m), seven genotypes has recorded more length of the vine than the general mean vine length (4.950 m).

4.1.13 Fruit yield per vine (kg)

The fruit yield per vine ranged from 1.80 to 9.32 kg. Observations on yield per vine revealed that the genotype PSPL produced maximum yield per vine of (9.32 kg) followed by Avinasi Local (7.48 kg) and Sathur Local (7.40 kg). Whereas HYD-round recorded minimum yield per vine (1.8 kg). Thirteen genotypes exhibited more yield per vine than the general mean value of 5.52 kg.

4.2 GENETIC DIVERGENCE

Twenty four genotypes of bottle gourd were quantitatively assessed by adopting Mahalanobis's D^2 static using yield and its component characters.

4.2.1 Test with Wilk's criterion and analysis of variance for dispersion of genotypes

Wilk's V (Statistic) criterion was used to test the significant differences between the genotypes based on the pooled effects of all the characters. The significance of

V (Statistic) values was tested by X^2 at 299 degree of freedom. The V statistic value (2451.98267^{**}) was highly significant indicating that the genotypes differed significantly when all the characters were considered simultaneously.

The analysis of variance of dispersion of twenty four genotypes is presented in Table 4. The significance of genotypes clearly indicated the significant pooled effect of all the characters studied between different genotypes. Hence, further analysis was made to estimate D^2 values.

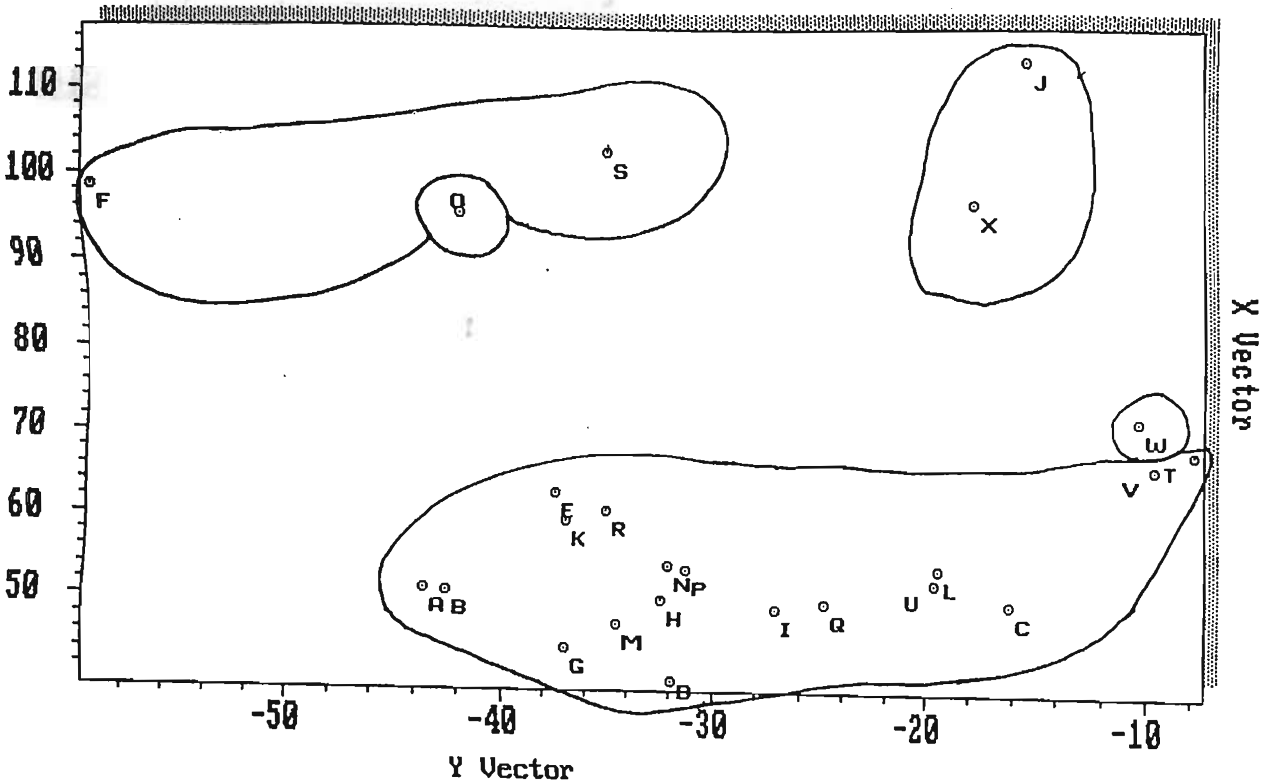
4.2.2 Mahalabobis's D^2 values

The mean values of twenty four genotypes [$(X_1) - (X_2)$] were transformed into standardized uncorrelated mean values [$(Y_1) - (Y_2)$]. The D^2 values were computed for all the possible 24 (24-1)/2= 276 pairs of genotypes. The highest D^2 value of 7737.38 was observed between the genotypes NLG-Long and HYD-Round where as the lowest D^2 value of 38.54 was recorded between the genotypes Ganesh and MGH-8.

4.2.3 Grouping of genotypes

All the twenty four genotypes of bottle gourd were grouped into five clusters using the Tocher's method (Rao, 1952). The distribution of the genotypes into clusters is presented in the Table 5. Cluster I included the maximum number of 18 genotypes. Cluster III and IV comprised two genotypes each while the clusters II and V included one genotype each.

Fig 2: Clusters formed by Tocher's method in bottle gourd genotypes



GENOTYPES

A. Ganesh
B. MGH-8
C. Doodhee
D. Pusa Meghdoot
E. Vipul-7
F. Avinasi Local
G. PSPL
H. Warad
I. Pusa Naveen
J. Indo American
K. Arka Bahar
L. Indam-1720
M. MGH-9
N. Swathi
O. NLG Local
P. Shramika
Q. Pallavi
R. Pratik
S. Sathur Local
T. HYD Round
U. MLG Local
V. IC-92330
W. Nadhaswaram
X. SRP-1

4.2.4 Cluster means for various characters

The cluster means for each of the thirteen characters are presented in Table 7. Considerable differences between the clusters were observed for most of the characters studied.

4.2.4.1 Number of node at which first male/female flower appeared

The genotypes in cluster I recorded minimum cluster mean values of 6.704 and 12.88 while cluster IV exhibited maximum cluster mean values of 18.0 and 43.33 for number of node on which male and female flowers appeared respectively.

4.2.4.2 Days to male/female flowering

The genotypes in cluster I took minimum days for both male (51.29) and female (58.09) flower initiation. Where as genotypes in cluster V took maximum days (69.66) to produce first male flower. Similarly the genotypes in cluster II took maximum of 95.66 days to first female flower initiation.

4.2.4.3 Fruit length (cm)

Minimum fruit length was recorded in the genotypes of cluster IV (23.16) and the genotypes of cluster V recorded maximum cluster mean values of (50.66) for fruit length.

4.2.4.4 Fruit diameter

The genotypes of cluster I and IV has recorded minimum cluster mean values of 9.66 and maximum of 16.16 in cluster IV for fruit diameter.

Table 6: Cluster composition of twenty four genotypes of bottle gourd (Tocher's method)

Cluster	No. of genotypes	Name of the genotypes
I	18	Ganesh, MGH-8, Warad, Swathi, Shramika, MGH-9, Pallavi , Pratik, Pusa Naveen Arka Bahar, Vipul-7, MLG-Local, Indam-1720, PSPL, Pusa Meghdoot, Doodhe HYD-Round , IC 92330
II	1	Nadhaswaram
III	2	Avinasi Local, Satur Local
IV	2	Indo American, SRP-1
V	1	NLG-Local

Table 8 : Cluster means for thirteen characters in twenty four genotypes of bottle gourd (By Tocher's method)

	Character												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Cluster 1	6.70	51.29	12.88	58.09	44.88	9.66	1.68	467.74	284.77	7.11	3.24	5.70	3.63
Cluster 2	14.33	69.33	34.00	95.66	40.00	10.33	1.33	175.33	335.00	8.00	3.00	5.00	4.66
Cluster 3	11.50	64.50	17.33	78.00	43.16	15.50	3.00	766.00	326.16	11.00	2.66	7.16	11.50
Cluster 4	15.33	61.33	41.33	81.00	23.16	16.16	1.50	430.16	281.50	12.50	2.33	3.50	7.00
Cluster 5	18.00	69.66	43.33	93.66	50.66	9.66	2.00	616.33	301.00	7.00	2.66	5.00	12.33

Characters

1. No.of node at which first male flower appeared
2. Days to first male flower
3. No.of node at which first female flower appeared
4. Days to first female flower
5. Fruit length
6. Fruit diameter
7. Fruit weight
8. No.of seeds per fruit
9. Thousand seed weight
10. Fruit flesh thickness
11. No.of fruits per vine
12. Yield per vine
13. Vine length

4.2.4.5 Fruit weight

The genotypes in cluster II showed lowest cluster mean values (1.33) whereas cluster III showed maximum value (3.0) for fruit weight.

4.2.4.6 Number of seeds per fruit

The genotypes in cluster II recorded minimum (175.33) and cluster III recorded maximum (766.00) cluster mean values for number of seeds per fruit.

4.2.4.7 Thousand seed weight

Minimum cluster mean value was recorded for the genotypes in cluster IV (281.5) while maximum for cluster II (335.00) for the character thousand seed weight.

4.2.4.8 Fruit flesh thickness

Maximum cluster mean values was observed for genotypes in cluster IV (12.50) and minimum for the genotypes in cluster V (7.0cm) for fruit flesh thickness.

4.2.4.9 Number of fruits per vine

The genotypes in cluster IV recorded minimum cluster means values (2.33) and the genotypes in cluster I recorded maximum cluster mean values (3.24) for number of fruits per vine.

4.2.4.10 Yield per vine

The genotypes in cluster III recorded maximum cluster mean value (7.16) and minimum cluster mean value (3.50) for the genotypes in cluster IV for yield per vine.

4.2.4.11 Vine length

The cluster mean for vine length was maximum (12.33 m) for the genotypes in cluster V and minimum (3.63 m) for the genotypes in cluster I.

4.2.5 Relative contribution of characters towards diversity

The relative contribution of thirteen characters towards diversity is presented in Table 8 and Fig 1. The more the number of times that each of the thirteen characters appeared in first rank, the more it contributes towards diversity.

The character, length of the main vine contributed maximum (30.80%) towards diversity by taking first rank 85 times followed by three characters viz., number of node at which first female flower appeared, number of seeds per fruit, fruit flesh thickness whose contribution towards diversity was 14.13 per cent with 39 times ranking first while yield per vine contributed towards diversity to a tune of 12.68 per cent with 35 times ranking first. Whereas the character days to first male flower was responsible for diversity to three times of only 1.09 per cent.

4.2.6 Cluster distances

With the help of values, a cluster diagram was constructed Fig. 2. Showing the relationship between the different populations. The greatest distance between two clusters exited between cluster I and cluster IV (60.150) indicating the greatest divergence. The least distance was recorded between clusters I and cluster II indicating least genetic divergence among the five clusters formed.

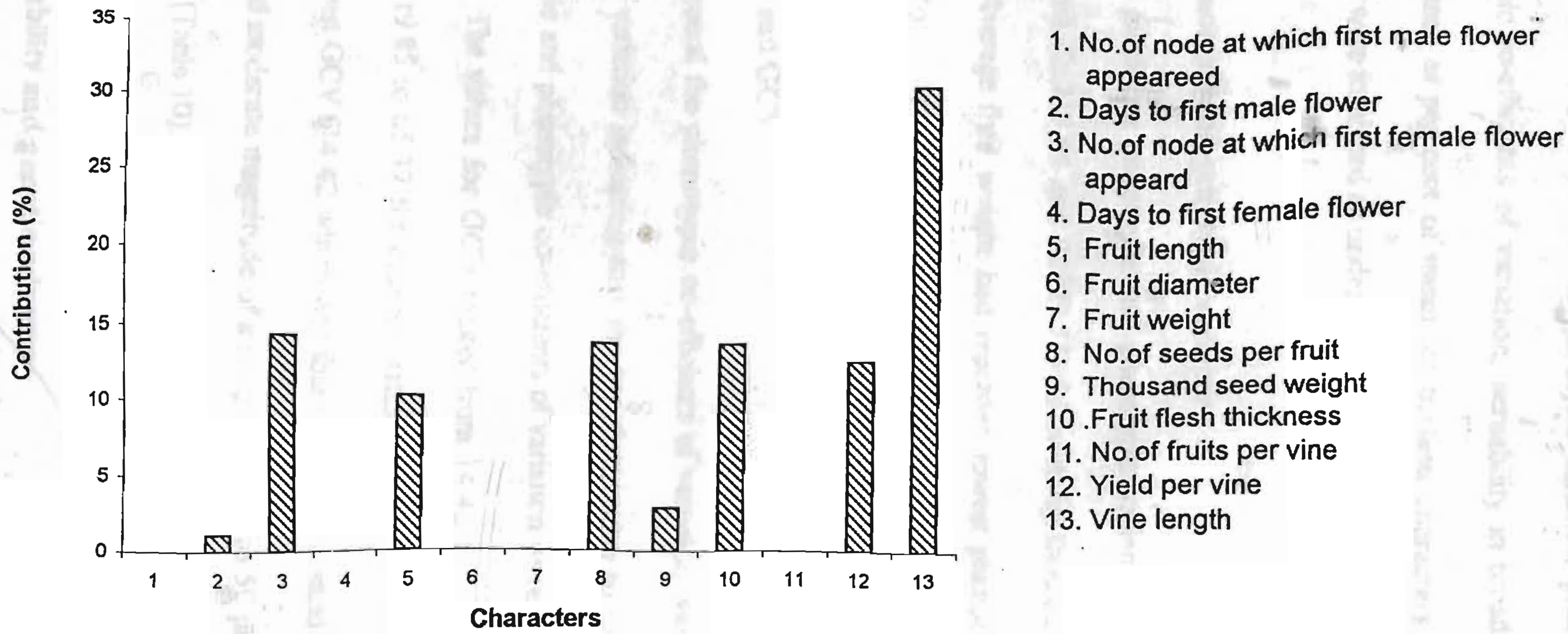
Table 7 : Inter-cluster and Intra-cluster (diagonal) average of D^2 values of twenty four genotypes of bottle gourd (Tocher's method)

Cluster	I	II	III	IV	V
I	24.44	36.38	56.88	60.15	56.48
II		0.00	56.32	46.21	45.19
III			29.77	44.84	44.83
IV				35.56	50.09
V					0.00

Table 9 : Contribution of different quantitative characters to diversity in bottle gourd genotypes

S.No.	Character	Times ranked first	Contribution (%)
1.	Number of node at which first male flower appeared	0	0.00
2.	Days to first male flower	3	1.09
3.	Number of node at which first female flower appeared	39	14.13
4.	Days to first female flower	0	0.00
5.	Fruit length	28	10.14
6.	Fruit diameter	0	0.00
7.	Fruit weight	0	0.00
8.	No.of seeds per fruit	39	14.13
9.	Thousand seed weight	8	2.90
10.	Fruit flesh thickness	39	14.13
11.	No.of fruits per vine	0	0.00
12.	Yield per vine	35	12.68
13.	Vine length	85	30.80

Fig 1: Contribution of different quantitative characters to diversity in bottle gourd genotypes



4.2.7 Variability parameters

The variability estimates as genotypic variance, phenotypic variance, phenotypic and genotypic co-efficients of variation, heritability in broad sense, genetic advance and genetic advance as per cent of mean for thirteen characters in twenty four genotypes of bottle gourd were furnished as under.

4.2.8 Phenotypic and genotypic variance

The maximum genotypic and phenotypic variance was recorded for number of seeds per fruit (25219.64 and 28727.11) followed by thousand seed weight (2121.66 and 3241.04). Average fruit weight had recorded lowest phenotypic and genotypic variance (0.25 and 0.30).

4.2.9 PCV and GCV

In general the phenotypic co-efficients of variation were higher than genotypic co-efficients of variation indicating that the variation is due to the influence of environment. The genotypic and phenotypic co-efficients of variation were highest for vine length (64.35 and 65.37). The values for GCV ranged from 14.42 to 64.35 while the values of PCV ranged from 19.85 to 65.37 for different rates. Among the traits days to first male flower recorded lowest GCV (14.42 which was followed by thousand seed weight. The GCV and PCV exhibited moderate magnitude of a range from 20 to 50 per cent and 25 to 45 per cent respectively (Table 10).

4.2.10 Heritability and genetic advance

The estimates of heritability and genetic advance for various characters are presented in Table 11 and Fig. 4.

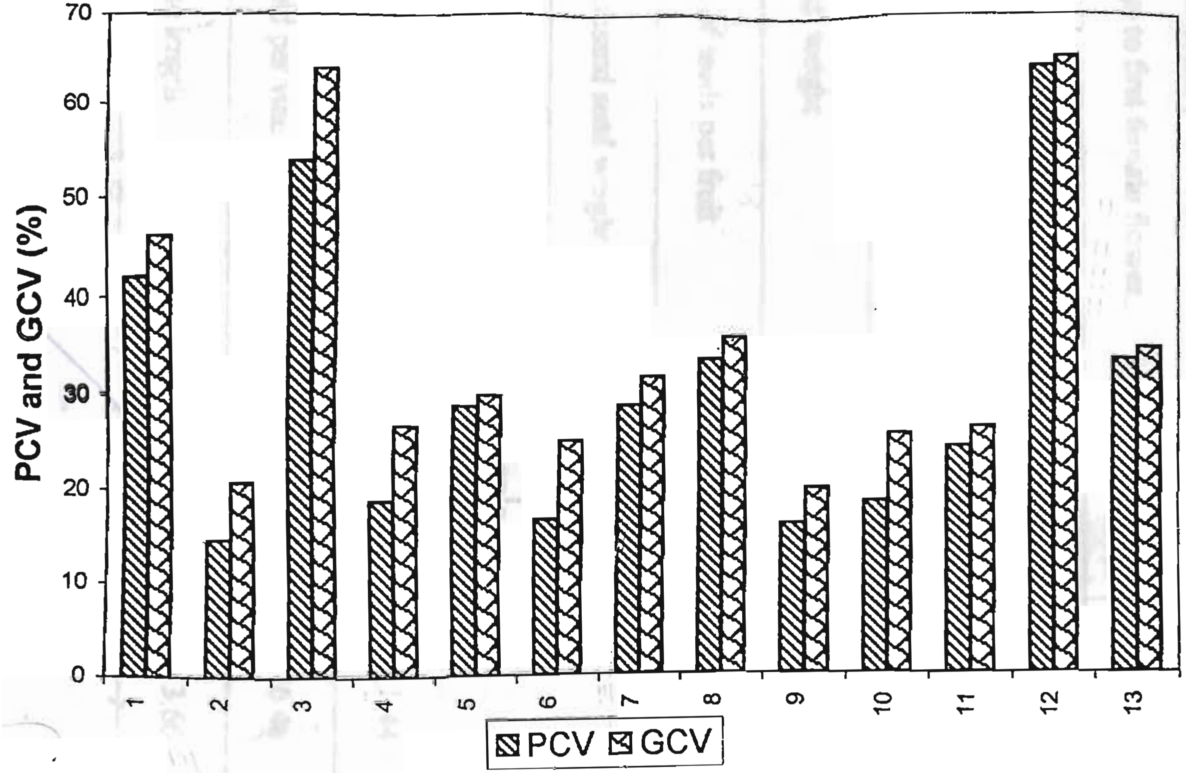
Table 10: Estimates of genotypic and phenotypic variance in bottle gourd genotypes

S.No.	Character	Genetic variance	Phenotypic variance
1.	Number of node at which first male flower appeared	12.14	14.78
2.	Days to first male flower	60.18	118.03
3.	Number of node at which first female flower appeared	84.01	117.67
4.	Days to first female flower	126.37	267.83
5.	Fruit length	146.26	159.52
6.	Fruit diameter	2.80	6.74
7.	Fruit weight	0.25	0.30
8.	No.of seeds per fruit	25219.64	28727.11
9.	Thousand seed weight	2121.66	3241.04
10.	Fruit flesh thickness	2.06	3.97
11.	No.of fruits per vine	0.57	0.67
12.	Yield per vine	10.15	10.47
13.	Vine length	3.40	3.66

Table 11: Estimates of PCV, GCV for various characters in bottle gourd genotypes

S.No.	Character	Genotypic coefficient of variation	Phenotypic coefficient of variation
1.	Number of node at which first male flower appeared	41.75	46.06
2.	Days to first male flower	14.42	20.20
3.	Number of node at which first female flower appeared	53.97	63.88
4.	Days to first female flower	17.77	25.87
5.	Fruit length	28.44	29.77
6.	Fruit diameter	15.98	24.80
7.	Fruit weight	28.60	31.57
8.	No.of seeds per fruit	33.29	35.53
9.	Thousand seed weight	16.06	19.85
10.	Fruit flesh thickness	18.50	25.65
11.	No.of fruits per vine	24.31	26.30
12.	Yield per vine	64.35	65.37
13.	Vine length	33.38	34.61

genotypes

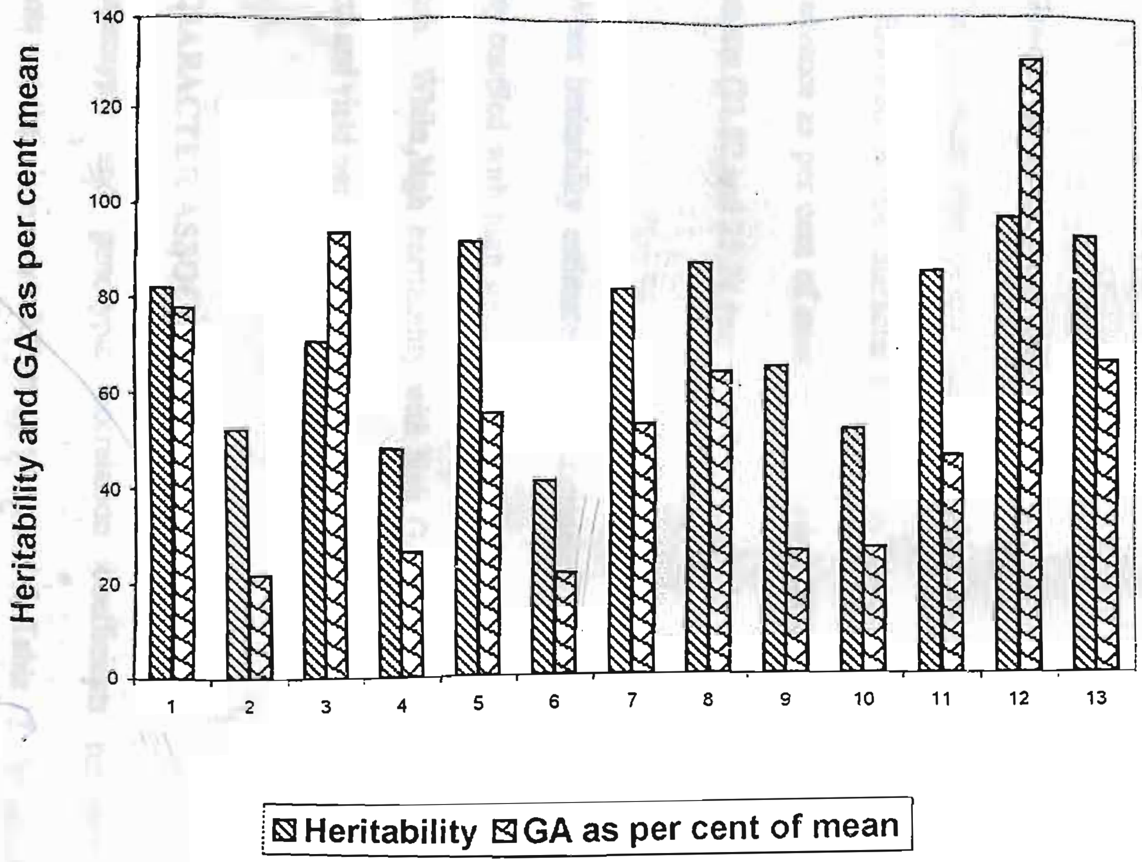


1. No.of node at which first male flower appeareed
2. Days to first male flower
3. No.of node at which first female flower appeard
4. Days to first female flower
5, Fruit length
6. Fruit diameter
7. Fruit weight
8. No.of seeds per fruit
9. Thousand seed weight
10 .Fruit flesh thickness
11. No.of fruits per vine
12. Yield per vine
13. Vine length

Table 12: Estimates of Heritability, Genetic advance and Genetic advance as per cent of mean for various characters in bottle gourd genotypes

S.No.	Character	Heritability (BS) (%)	Genetic advance	Genetic advance as per cent of mean
1.	Number of node at which first male flower appeared	82.17	6.50	77.97
2.	Days to first male flower	50.99	11.41	21.22
3.	Number of node at which first female flower appeared	71.40	15.95	93.95
4.	Days to first female flower	47.18	15.90	25.14
5.	Fruit length	91.68	23.85	56.11
6.	Fruit diameter	41.53	2.22	21.21
7.	Fruit weight	82.07	0.93	53.38
8.	No.of seeds per fruit	87.79	306.52	64.27
9.	Thousand seed weight	65.46	76.77	26.77
10.	Fruit flesh thickness	52.04	2.13	27.49
11.	No.of fruits per vine	85.48	1.44	46.31
12.	Yield per vine	96.91	6.46	130.51
13.	Vine length	93.03	3.66	66.33

Fig 4 : Estimates of Heritability, Genetic advance as per cent mean for various character in bottle gourd genotypes



1. No.of node at which first male flower appeareed
2. Days to first male flower
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6. Fruit diameter
7. Fruit weight
8. No.of seeds per fruit
9. Thousand seed weight
10 .Fruit flesh thickness
11. No.of fruits per vine
12. Yield per vine
13. Vine length

4.2.11 Heritability

The highest heritability estimate in broad sense was observed for vine length (96.91%) followed by yield per vine (93.03%), fruit length (91.68%) where as least value (41.53%) for heritability was recorded for fruit diameter.

4.2.12 Genetic advance

Among the characters, studied, the highest genetic advance was noticed in number of seeds per fruit (306.52) followed by thousand seed weight (76.77%). All the remaining characters recorded lower values of genetic advance which were less than 20 per cent.

4.2.13 Genetic advance as per cent of mean

The character vine length displayed highest genetic advance as per cent of mean (130.51) followed by the character first female flowering node (93.95%). However low genetic advance as per cent of mean was recorded for both, days to first male flower and fruit diameter (21.22 and 21.21 respectively).

When heritability estimates were considered along with genetic advance, higher heritability coupled with high genetic advance was observed for number of seeds per fruit, fruit length. While high heritability with high GA as per cent of mean was recorded in vine length and yield per vine.

4.3 CHARACTER ASSOCIATION

Phenotypic and genotypic correlation coefficients between yield and its components and their inter correlation are presented in Table 12. In general the genotypic correlations were slightly higher than the phenotypic correlations.

4.3.1 Association between yield and its components

4.3.1.1 Days to first male flower

Association of this character with yield per vine was not appreciable and it had a negative correlation both phenotypically (-0.047) with fruit yield and genotypically (-0.32).

4.3.1.2 Days to first female flower

Association of this character with yield per vine was also not appreciable and it also exhibited a phenotypic negative correlation with fruit yield (-0.14) but a negative and a significant genotypic correlation (-0.48*).

4.3.1.3 Number of node at which first male flower appeared

This character showed negative but a non-significant correlation with yield per vine (-0.0803).

4.3.1.4 Number of node at which first female flower appeared

This character also had recorded negative and non-significant phenotypic correlation (-0.27) but a negative and significant genotypic correlation with yield (-0.49*).

4.3.1.5 Fruit length

Influence of this character on fruit yield was positive and highly significant both in case of phenotypic (0.74**) and genotypic (0.73**) correlation.

4.3.1.6 Fruit diameter

Fruit diameter recorded a non significant phenotypic association (0.1198) and a negative genotypic correlation (-0.1141) with yield.

4.1.3.7 Number of seeds per fruit

This character displayed a positive and a highly significant both phenotypic and genotypic associations with fruit yield respectively.

4.1.3.8 Fruit weight

Fruit weight expressed positive and highly significant correlation with fruit yield both at phenotypic (0.76**) and genotypic (0.76**) levels.

4.1.3.9 Thousand seed weight

The phenotypic (0.3267) and genotypic (0.2455) correlation between thousand seed weight and fruit yield there were positive and non-significant.

4.1.3.10 Fruit flesh thickness

Influence of this character on fruit yield is negative and non-significant both at phenotypic (-0.01) and at genotypic (-0.27) levels.

4.1.3.11 Number of fruits per vine

It has shown positive and highly significant association with yield both at phenotypic (0.71**) and genotypic (0.70**) levels.

4.1.3.12 Vine length

Vine length recorded positive and non significant association and with yield both at phenotypic (0.15) and genotypic (0.11) levels.

4.1.4 Inter correlation among yield components

4.1.4.1 Days to first male flower

Days to first male flower had positive and highly significant correlation at phenotypic level with number of node at which first male and female flower appeared (0.62** and 0.52** respectively) days to first female flowering (0.8312), fruit diameter (0.62**), fruit flesh thickness (0.58**), vine length (0.59**) and negative correlation with fruit length (-0.06), number of fruits per vine (-0.01). While it showed positive and highly significant association only at genotypic level with days to first female flower (0.69**), and vine length (0.68**). It recorded a negative correlation with fruit length (-0.3414), fruit weight (-0.11), number of seeds per fruit (-0.20) and number of fruits per vine (-0.36), where as its association with other characters was non significant.

4.1.4.2 Days to first female flower

This character showed positive and highly significant correlation at phenotypic level with fruit diameter (0.59**), fruit flesh thickness (0.60**) and vine length (0.53**) and at genotypic level it has exhibited positive and highly significant association only with vine length (0.61**) and negative and significant association with fruit length (-0.49*) and number of fruits per vine (-0.63*)

4.1.4.3 Number of node of which first male flower appeared

It has recorded a positive and highly significant correlation both at phenotypic level and genotypic levels with days to first male flower (0.62**, 0.55**), number of node at which first female flower appeared (0.83**, 0.83**), days to first female flower (0.69**, 0.68*), fruit diameter (0.61**, 0.58**) and vine length (0.73**, 0.75**) and it has showed

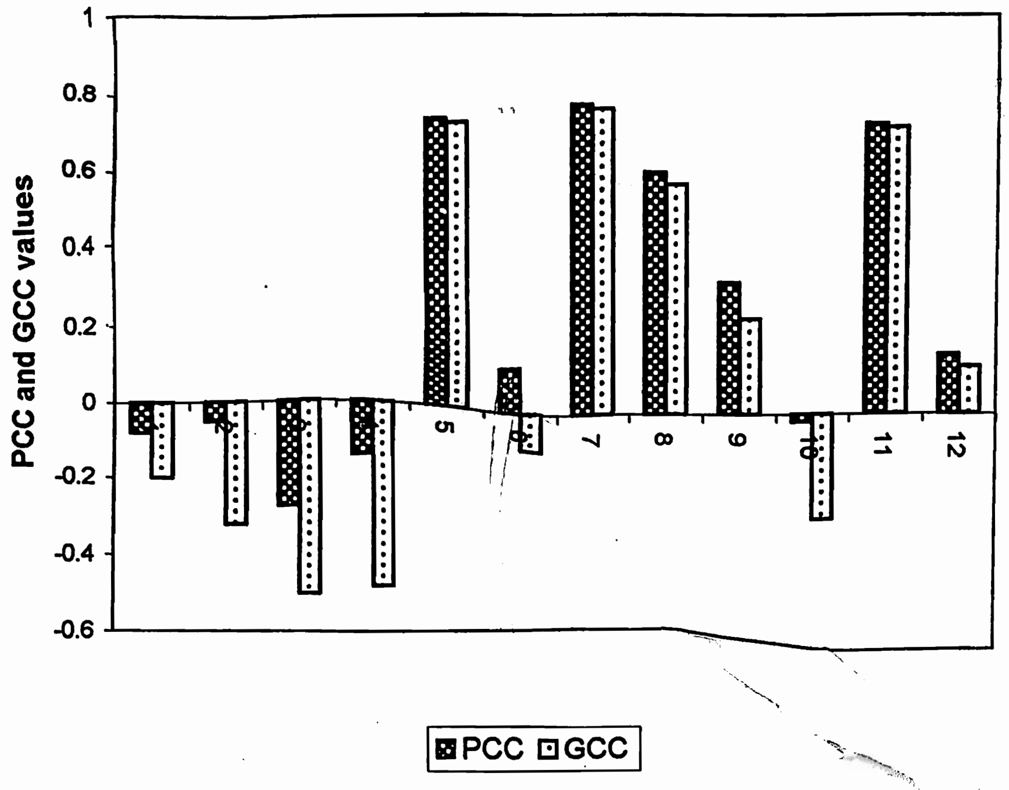
Table 13 : Phenotypic and Genotypic correlation coefficients among thirteen characters in twenty four genotypes in bottle gourd

Character	No.of node at which first male flower appeared	Days to First Male Flower	No.of node at which first female flower appeared	Days to First Female Flower	Fruit Length	Fruit Diameter	Fruit Weight	No.of Seeds per Fruit	Thousand Seed Weight	Fruit Flesh Thickness	No.of Fruits per Vine	Vine Length	Yield per Vine
No.of node at which first male flower appeared		0.6277**	0.8396**	0.6951**	-0.1422	0.6096**	0.1948	0.1408	0.2883	0.6483**	-0.1721	0.7358**	-0.0803
Days to first male flower	0.5535**		0.5285**	0.8312**	-0.0592	0.6249**	0.1804	0.0944	0.4723*	0.5804**	-0.0124	0.5904**	-0.0475
No.of node at which first female flower appeared	0.8367**	0.2722		0.7557**	-0.2322	0.4790*	-0.0185	-0.0463	0.1657	0.5420**	-0.2810	0.5138**	-0.2747
Days to first female flower	0.6821**	0.6963**	0.6615**		-0.1529	0.5960**	0.1315	0.0360	0.3082	0.6008**	-0.1650	0.5314**	-0.1415
Fruit length	-0.2767	-0.3414	-0.4482*	-0.4980*		-0.1518	0.5724**	0.4885*	0.3868	-0.2588	0.5749**	-0.0229	0.7408**
Fruit diameter	0.5502**	0.2407	0.1531	0.1484	-0.5395**		0.4988*	0.3348	0.4092*	0.9524**	-0.1505	0.6206**	0.1198
Fruit weight	0.0653	-0.1171	-0.2802	-0.1800	0.5528**	0.3787		0.7004**	0.4715*	0.3820	0.1951	0.4767*	0.7667**
No.of seeds per Fruit	0.0145	-0.2026	-0.2776	-0.3100	0.4489*	0.1329	0.6815**		0.1159	0.2676	0.2238	0.4142*	0.6006**
Thousand seed weight	0.1120	0.1703	-0.1678	-0.1191	0.3106	0.0362	0.3614	-0.0869		0.3816	0.2156	0.3124	0.3267
Fruit flesh thickness	0.5841**	0.2059	0.2938	0.2296	-0.6218**	0.9229**	0.1939	0.0533	0.0243		-0.2414	0.6060**	-0.0163
No.of fruits per vine	-0.3648	-0.3680	-0.5824**	-0.6336**	0.5608**	-0.6863**	0.0898	0.1289	0.0611	-0.7132**		-0.1855	0.7157**
Vine Length	0.7576**	0.6833**	0.5133*	0.6104**	-0.0658	0.7811**	0.4703*	0.3908	0.2828	0.6930**	-0.2643		0.1521
Yield per Vine	-0.2033	-0.3224	-0.4978*	-0.4811*	0.7347**	-0.1141	0.7649**	0.5717**	0.2455	-0.2742	0.7073**	0.1162	

Phenotypic (Upper diagonal)
Genotypic (Lower diagonal)

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

Fig 5: Phenotypic and Genotypic correlation coefficients between yield per vine and component characters in bottle gourd genotypes



1. No.of node at which first male flower appeareed
2. Days to first male flower
3. No.of node at which first female flower appeard
4. Days to first female flower
5, Fruit length
6. Fruit diameter
7. Fruit weight
8. No.of seeds per fruit
9. Thousand seed weight
10 .Fruit flesh thickness
11. No.of fruits per vine
12. Vine length

negative correlation with fruit length (-0.14, -0.27), number of fruits per vine (-0.17, -0.36), while it showed non significant correlation with remaining characters.

4.1.4.4 Number of node at which first female flower appeared

This character showed a positive and highly significant phenotypic correlation with days to first female flowering (0.75**), fruit diameter (0.47*), fruit flesh thickness (0.54**) and vine length (0.51*). It showed positive and significant genotypic correlation with days to first female flower (0.66**), and vine length (0.51*). Where as it showed a negative and highly significant association with fruit length (-0.44*) and number of fruits per vine (-0.58**).

4.1.4.5 Fruit length

Fruit length exhibited a positive and significant association with fruit weight (0.57**, 0.55**), number of seeds per fruit (0.48*, 0.44*), number of fruits per vine (0.57**, 0.56**), both at phenotypic and genotypic levels.

Fruit length exhibited a highly significant and negative correlation with fruit diameter (-0.53**) and fruit flesh thickness (-0.62**) at genotypic level. While correlation between fruit length and vine length showed a negative relationship both at genotypic and phenotypic levels.

4.1.4.6 Fruit diameter

This character possessed positive and significant association with fruit diameter (0.49*), thousand seed weight (0.40*), fruit flesh thickness (0.95*) and vine length (0.62**) at phenotypic level. At genotypic level it exhibited positive and significant correlation with fruit flesh thickness (0.92**) and vine length (0.78**) and negative but highly significant correlation with number of fruits per vine (-0.68**).

4.1.4.7 Fruit weight

Positive and significant association of fruit weight was recorded with number of seeds per fruit (0.70**, 0.68**) and vine length (0.47*, 0.47*) both at phenotypic and genotypic levels. It exhibited negative correlation with number of node at which first female flower appeared (-0.02, -0.28) both at phenotypic and genotypic levels. While it showed a negative correlation with days to first male flower (-0.11) and days to first female flower (-0.18) at phenotypic level only.

4.1.4.8 Number of seeds per fruit

A significant and positive association of number of seeds per fruit was observed with fruit length (0.48*, 0.44*) and fruit weight (0.70**, 0.68**) both at phenotypic and genotypic levels. While it exhibited positive association with vine length (0.41*) at phenotypic level only.

4.1.4.9 Thousand seed weight

It did not exhibit significant association with any of the characters at genotypic level but at phenotypic level it exhibited a positive and significant association with days to first male flower (0.47*), fruit diameter (0.40*) and fruit weight (0.47*), thousand seed weight. But it did not show negative correlation with any of the characters at phenotypic level.

a negative association at both phenotypic and genotypic levels with fruit length (-0.92, -0.06) and number of fruits per vine (-0.18, -0.26).

4.1.5 PATH COEFFICIENT ANALYSIS

Path coefficients analysis facilitates the partitioning of correlation coefficients into direct and indirect effects of various characters on fruit yield. It provides an effective means of finding out direct and indirect causes of association and presents a critical examination of the specific forces acting to produce a given correlation and measures the relative importance of each causal factor. The path coefficient analysis of different characters on yield based on phenotypic and genotypic correlations in twenty four genotypes of bottle gourd are presented in Tables 14 & 15.

4.1.6 Direct effect

Average fruit weight registered the highest positive direct effect on yield per plant i.e. 0.6831 and 1.0255 at phenotypic and genotypic levels respectively, followed by number of fruits per vine (0.5889 and 0.5902) and vine length (0.1236 and 0.0582). On the other hand, highest negative direct effect was registered by fruit diameter (-0.2640) followed by days to first female flower (-0.1936) and fruit length (-0.1864). The directs effects by all other characters were smaller and negligible.

4.1.7 Indirect effects

4.1.7.1 Days to first male flower

This character had positive indirect effect on yield through vine length (0.0730), fruit diameter (0.03) and fruit weight (0.12) and it exhibited a negative indirect influence through number of node at first male flower appeared (-0.03), fruit length (-0.0008),

Table 14 : Phenotypic path coefficients among fruit yield per plant and yield components in twenty four genotypes of bottle gourd

Character	No.of node at which first male flower appeared	Days to First Male Flower	No.of node at which first female flower appeared	Days to First Female Flower	Fruit Length	Fruit Diameter	Fruit Weight	No.of Seeds per Fruit	Thousand Seed Weight	Fruit Flesh thickness	No.of Fruits per Vine	Vine Length	Corre-lations with yield
No.of node at which first male flower appeared	-0.0542	-0.1079	-0.0092	0.0332	-0.0019	0.0310	0.1331	-0.0036	-0.0162	-0.0743	-0.1013	0.0910	-0.08
Days to first male flower	-0.0340	-0.1719	-0.0058	0.0397	-0.0008	0.0318	0.1233	-0.0024	-0.0266	-0.0665	-0.0073	0.0730	-0.04
No.of node at which first female flower appeared	-0.0455	-0.0908	-0.0109	0.0361	-0.0030	0.0244	-0.0126	0.0012	-0.0093	-0.0621	-0.1655	0.0635	-0.27
Days to first female flower	-0.0377	-0.1428	-0.0082	0.0477	-0.0020	0.0303	0.0899	-0.0009	-0.0173	-0.0689	-0.0972	0.0657	-0.14
Fruit length	0.0077	0.0102	0.0025	-0.0073	0.0131	-0.0077	0.3910	-0.0124	-0.0218	0.0297	0.3386	-0.0028	0.74**
Fruit diameter	-0.0330	-0.1074	-0.0052	0.0285	0.0020	0.0508	0.3407	-0.0085	-0.0230	-0.1092	-0.0886	0.0767	0.12
Fruit weight	-0.0106	-0.0310	0.0002	0.0063	0.0075	0.0254	0.6831	-0.0178	-0.0265	-0.0438	0.1149	0.0589	0.76**
No.of seeds per Fruit	-0.0076	-0.0162	0.0005	0.0017	0.0064	0.0170	0.4785	-0.0254	-0.0065	-0.0307	0.1318	0.0512	0.60**
Thousand seed weight	-0.0156	-0.0812	-0.0018	0.0147	0.0051	0.0208	0.3221	-0.0029	-0.0563	-0.0437	0.1270	0.0386	0.32
Fruit flesh thickness	-0.0351	-0.0997	-0.0059	0.0287	-0.0034	0.0484	0.2609	-0.0068	-0.0215	-0.1146	-0.1422	0.0749	-0.02
No.of fruits per vine	0.0093	0.0021	0.0031	-0.0079	0.0075	-0.0077	0.1333	-0.0057	-0.0121	0.0277	0.5889	-0.0229	0.71**
Yield per Vine	-0.0399	-0.1015	-0.0056	0.0254	-0.0003	0.0316	0.3257	-0.0105	-0.0176	-0.0695	-0.1093	0.1236	0.15

Phenotypic (Upper diagonal)
Genotypic (Lower diagonal)

Table 15 : Genotypic path coefficients among fruit yield per plant and yield components in twenty four genotypes of bottle gourd

Character	No.of node at which first male flower appeared	Days to First Male Flower	No.of node at which first female flower appeared	Days to First Female Flower	Fruit Length	Fruit Diameter	Fruit Weight	No.of Seeds per Fruit	Thousand Seed Weight	Fruit Flesh thickness	No.of Fruits per Vine	Vine Length	Corre-lations with yield
No.of node at which first male flower appeared	-0.0503	0.0476	0.1093	-0.1321	0.0516	-0.1452	0.0669	-0.0018	-0.0149	0.0368	-0.2153	0.0441	-0.20
Days to first male flower	-0.0279	0.0859	0.0356	-0.1348	0.0636	-0.0635	-0.1201	0.0259	-0.0226	0.0130	-0.2172	0.0398	-0.32
No.of node at which first female flower appeared	-0.0421	0.0234	0.1307	-0.1281	0.0835	-0.0404	-0.2873	0.0355	-0.0223	0.0185	-0.3437	0.0299	-0.49*
Days to first female flower	-0.0343	0.0598	0.0864	-0.1936	0.0928	-0.0392	-0.1846	0.0396	0.0158	0.0145	-0.3739	0.0355	-0.48*
Fruit length	0.0139	-0.0293	-0.0586	-0.0964	-0.1864	0.1424	0.5669	-0.0574	-0.0413	-0.0392	0.3310	-0.0038	0.73**
Fruit diameter	-0.0277	0.0207	0.0200	-0.0287	0.1005	-0.2640	0.3883	-0.0170	-0.0048	0.0582	-0.4051	0.0455	-0.11
Fruit weight	-0.0033	-0.0101	-0.0366	0.0349	-0.1030	-0.1000	0.0255	-0.0871	-0.0480	0.0122	0.0530	0.0274	0.76**
No.of seeds per Fruit	-0.0007	-0.0174	-0.0363	0.0600	-0.0837	-0.0351	0.6988	-0.1278	0.0115	0.0034	0.0761	0.0227	0.57**
Thousand seed weight	-0.0056	0.0146	-0.0219	0.0231	-0.0579	-0.0096	0.3706	0.0111	-0.1329	0.0015	0.0361	0.0165	0.24
Fruit flesh thickness	-0.0294	0.0177	0.0384	-0.0445	0.1159	-0.2436	0.1989	-0.0068	-0.0032	0.0630	-0.4209	0.0403	-0.27
No.of fruits per vine	-0.0184	-0.0316	-0.0761	0.1227	-0.1045	0.1812	0.0921	-0.0165	-0.0081	-0.0450	-0.5902	-0.0154	0.70**
Yield per Vine	-0.0381	0.0587	0.0671	-0.1182	0.0123	-0.2062	0.4823	-0.0499	-0.0376	0.0437	-0.1560	0.0582	0.11

Phenotypic (Upper diagonal)
Genotypic (Lower diagonal)

number of seeds per fruit (-0.0024), thousand seed weight (-0.0266), fruit flesh thickness (-0.0666) and number of fruits per vine (-0.0073).

4.1.7.2 Days to first female flower

This character exerted positive and indirect influence through fruit diameter (0.0303), fruit weight (0.0899) and vine length (0.0657) and it showed negative indirect effect through other characters.

4.1.7.3 Number of node at which first male flower appeared

This trait showed positive, indirect effect on yield through days to first female flower (0.0332), fruit weight (0.1331) and vine length (0.0910). Its indirect effect through other characters was negative.

4.1.7.4 Number of node at which first female appeared

The indirect influence of this trait on yield through days to first female flower (0.036), **fruit** diameter (0.0244), number of seeds per fruit (0.0012) and vine length (0.0398) were positive. Its effect through other characters was negative.

4.1.7.5 Fruit length

This character expressed indirect positive effects on yield via fruit weight (0.3910), number of fruits per vine (0.3386). Its effect through fruit diameter (-0.0077), number of seeds per fruit (-0.0124) and vine length (-0.0028) were negative.

4.1.7.6 Number of seeds per fruit

Influence of this character on yield through fruit diameter (0.0170), fruit weight (0.4785), number of fruits per vine (0.1318) and vine length (0.0512) were positive while it showed negative effect through all other characters.

4.1.7.7 Thousand seed weight

Its indirect effects on yield via fruit diameter (0.0208), fruit weight (0.3221) and number of fruits per vine (0.1270) were positive.

4.1.7.8 Fruit flesh thickness

It exhibited positive indirect effect through days to first female flower (0.0287), fruit diameter (0.0484), fruit weight (0.2609) and vine length (0.0749). While high negative effect was exhibited through number of fruits per vine (-0.1422).

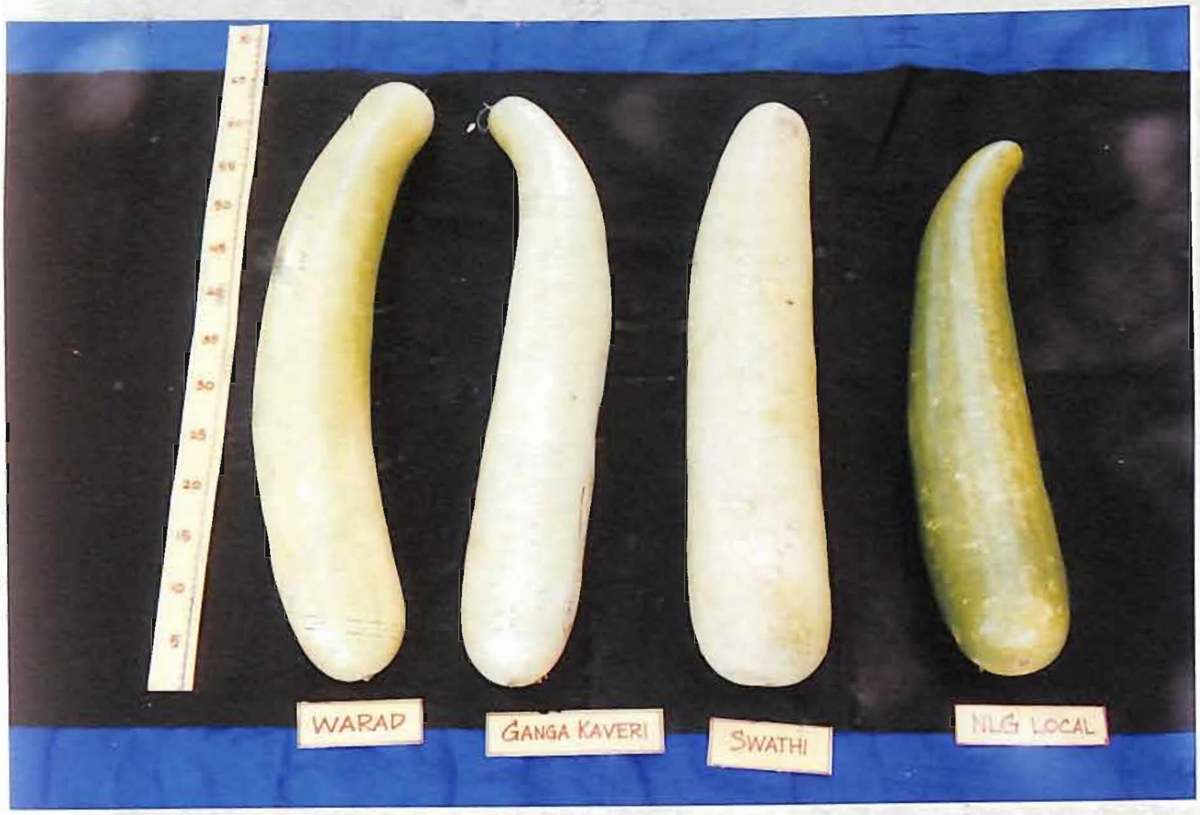
4.1.7.9 Number of fruits per vine

Its highest positive indirect effect was through fruit weight (0.1333) and fruit flesh thickness (0.0277) and its influence through other characters was negligible.

4.1.7.10 Vine length

Vine length indirectly influenced the yield through days to first female flower (0.0254), fruit diameter (0.0316), fruit diameter (0.3257) and its influence through other characters was negative.

LIST OF PLATES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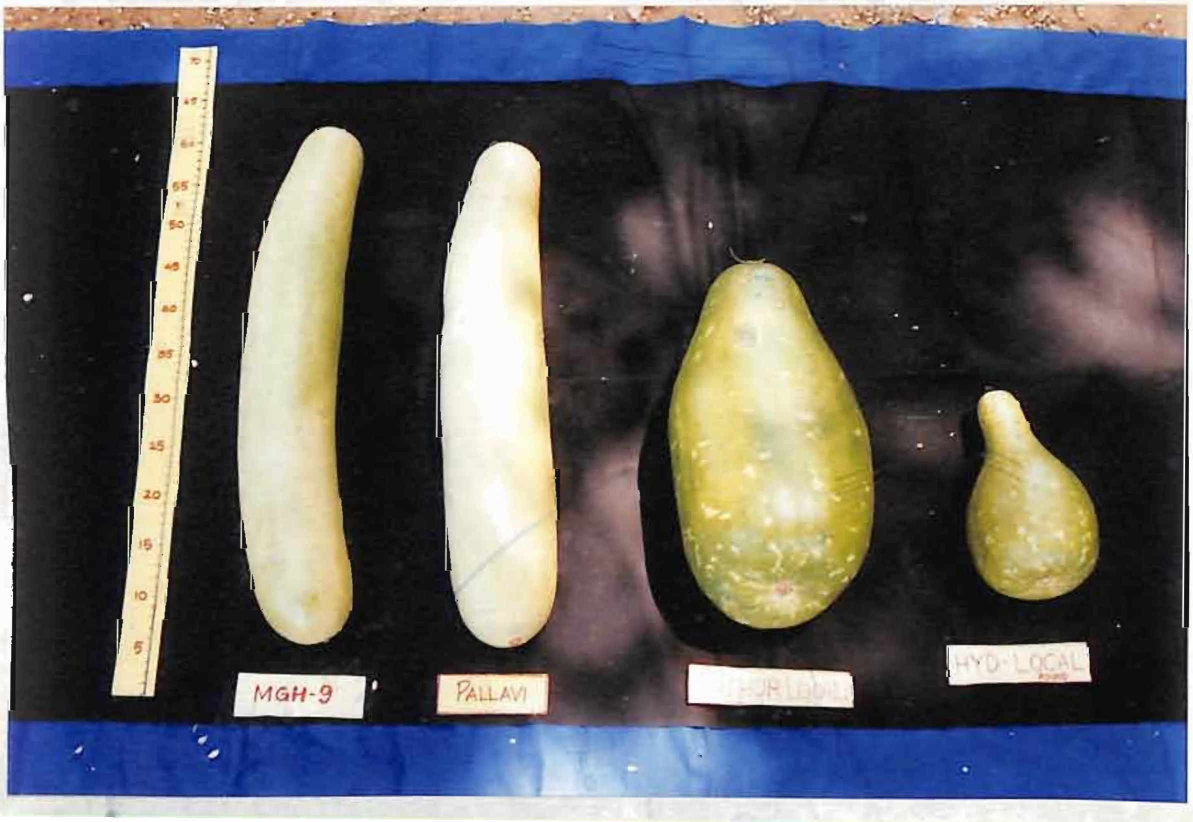
GANGA KAVERI
SWATHI
NLG LOCAL


MGH-9
PALLAVI
HYD-LOCAL


PUSA NAVEEN
ARKA BAHAR
PSPL
INDAM-1720
VIPUL-7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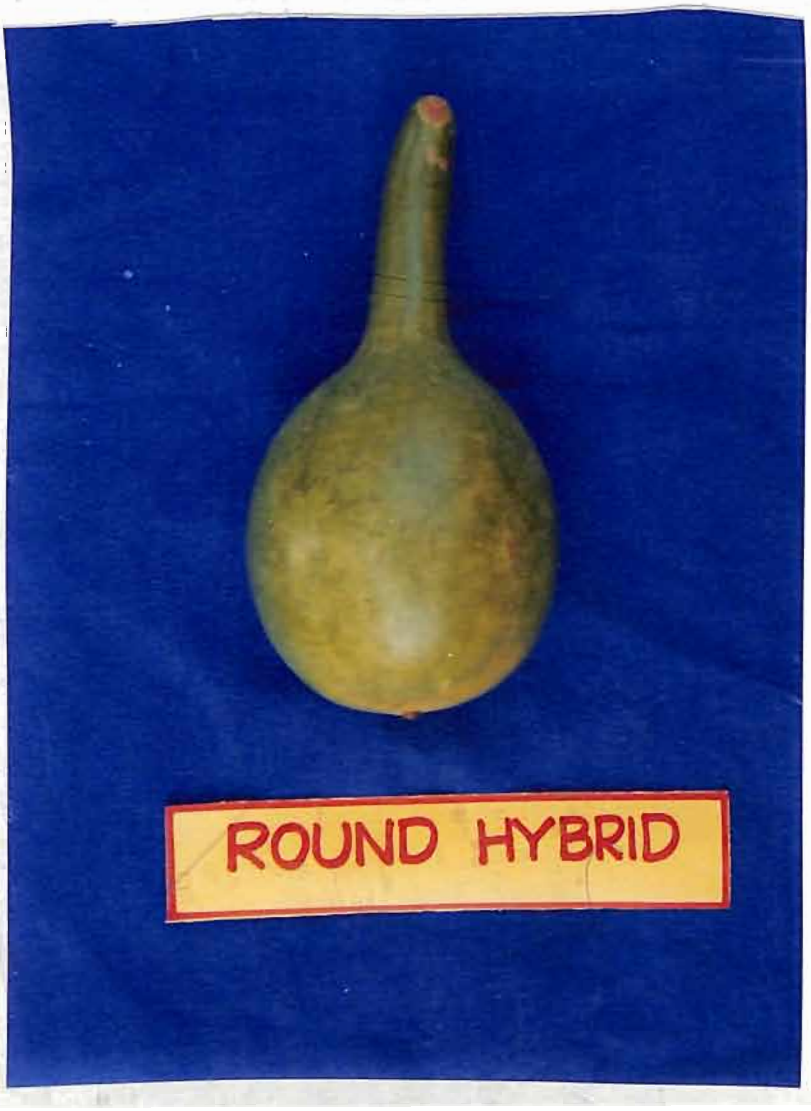
ROUND HYBRID

Discussion

CHAPTER – V

DISCUSSION

Bottle gourd is basically a cross pollinated crop with predominantly monoecious sex expression. The existence of different size of fruits ranging from long to short and cylindrical to round fruits depicts considerable amount of genetic variability in this crop. According to Tyagi (1972) there is a good scope for the increasing the yield of bottle gourd through crop improvement. Hence an attempt has been made to study the genetic divergence, variability, heritability, genetic advance, character association and path analysis and the results obtained from these studies are discussed here under.

5.1 MEAN PERFORMANCE

The genotypes PSPL, Satur Local, Warad, Avinasi Local, Pusa Meghdoot, Ganesh, MGH-8 recorded high per se performance for fruit yield among the twenty four genotypes of bottle gourd (Table 3). The increased fruit yield in genotype PSPL and Warad was due to more number of fruits per vine. Similarly Satur Local and Avinasi Local recorded fairly higher mean values for fruit weight, fruit diameter and fruit flesh thickness. Genotypes Pusa Meghdoot, Ganesh and MGH-8 registered high mean values for fruit length, fruit diameter and number of fruits per vine. Thus these genotypes *viz*., PSPL, Warad, Pusa Meghdoot, Ganesh, MGH-8, Satur Local and Avinasi Local can be used to cross with adapted local varieties to get better seggregants with better yield potential.

Fruit length, fruit diameter, fruit weight and number of fruits per vine are the important components of fruit yield as they bear the sink in bottle gourd. Improvement in the above characters will result in an increase in fruit yield. Similar findings were observed by Krishnaprasad and Singh (1992) in cucumber. The genotype Swathi and Shramika exhibited fairly high mean performance for fruit length, fruit diameter, fruit weight and number of fruits per vine. Further the yield performance of these genotypes was fairly good. Hence these genotypes can be grown for increasing the productivity of bottle gourd.

The genotypes Ganesh, MGH-8, MGH-9, Warad, SRP-1 were earliest to mature among the twenty four genotypes followed by Pusa Meghdoot and Swathi. These can be used as donors for evolving early types of bottle gourd.

The genotypes NLG Local, Avinasi Local, Satur Local recorded maximum length of the main vine and high mean performance for fruit diameter fruit weight and fruit flesh thickness. These genotypes can be used in hybridization programmes for evolving seggregants recombining these characters. Similar result was obtained by Varalakshmi (1992) in ridge gourd.

5.2 GENETIC DIVERGENCE

Genetic diversity has been considered as an important factor in discriminating the genotypes for selecting diverse parents for obtaining high yielding lines for efficient and successful hybridization programme. This will not only result in inducing genetic variability but also provide new recombinations of genes in the gene pool.

In cucurbits, multivariate analysis has been successfully utilized by several workers to estimate the genetic diversity of the populations [Kalloo *et al.*, (1982) in muskmelon; Kadam and Kale (1995) in ridge gourd and Sukhija *et al.*, (1982) and Sidhu and Brar (1985) in water melon.]

5.3 MAHALANOBIS'S D^2 ANALYSIS

Mahalanobis D^2 statistic technique provides a useful statistical method for measuring the amount of genetic diversity in a given population in respect of characters considered together and to classify the genotypes on the basis of genetic diversity. In the present study, the data collected on the yield and yield component characters of the twenty four genotypes of bottle gourd were subjected to D^2 analysis and the genetic diversity was estimated. Tocher's method of grouping is most widely used procedure of clustering using Mahalanobis's D^2 statistic.

In the present study, round fruited varieties, Indo American, SRP-1 fall in cluster IV. This might be due to their striking diverse features like growth habit, large round fruit size, greater flesh thickness. Similarly the genotypes Avinasi Local and Satur Local fall in cluster III which had greater vine length, fruit weight and fruit flesh thickness. These results are in agreement with Varalakshmi (1992).

The genotype Nadhaswaram was the lone entry in cluster II which had fairly high yield, greater fruit flesh thickness, number of fruits per vine and fruit diameter.

Similarly the genotype, NLG-local was alone in cluster V which had greater vine length, fruit flesh thickness and fairly high yield.

The low intra-cluster divergence recorded in cluster I indicated the closeness f genotypes with each other in this cluster. This may be explained on the basis that yield is a complex character of polygenic inheritance. Similar phenotypes could be produced by many different combination of genes and such combinations may have similar selective advantage. These results are in agreement with Wahab and Gopalakrishnan (1993) in bitter gourd.

The clusters viz., I and IV were most divergent with the highest inter cluster distance while the inter cluster distance of cluster II and V was the lowest. This elucidates the fact that hybridization of genotypes belonging to highly divergent clusters can be used for exploitation of hybrid vigour and for getting good segregants. Similar results were obtained by Wahab and Gopalkrishnnan (1993) in bitter gourd, Sidhu and Brar (1995) in water melon.

Cluster III recorded highest fruit weight and number of seeds per fruit. Thus the genotypes in this cluster will be useful in breeding for increased fruit weight and number of seeds per fruit.

Cluster I also serves as a good source for early female flowering parents as they had highly desirable performance in respect of lowest node number and days taken to first female flower appearance. Similar results were obtained by Varalakshmi (1992) in ridge gourd.

The genotypes belonging to cluster I, III and Clusters II, IV were found divergent based on D^2 values and had high mean values for the most important yield contributing characters such as number of fruits per vine, fruit weight, and yield per plant. Hence, these can be successfully utilized in the further breeding programme to get better seggregants for selection.

5.4 GENETIC PARAMETERS

5.4.1 Variability

The success of any breeding programme depends on the availability of genetic variability present in the genotype, which is however not directly measurable by itself, but has to be inferred by the expression of phenotypes. The extent of genetic variation observed for most of the attributes in this crop was quite high and the same can be exploited by the breeder for increasing the productivity. Generally PCV and GCV are measured to study the variability.

In the present study, the estimates of phenotypic coefficients of variation for all the characters were higher than the estimates of genotypic coefficient of variation.

The character yield per vine showed high PCV and GCV. This was in confirmity with the findings of Arora *et al.* (1983) in sponge gourd, Krishnaprasad and Singh (1989) in ridge gourd, Maharana *et al.* (1995) in spine gourd, Maurya and Singh (1994) in bottle gourd, Mohanty and Mishra (1999) in pumpkin, Rastogi and Aryadeep (1990) in cucumber, Varalakshmi *et al.* (1995) in ridge gourd. Number of node at which first female flower appeared also showed high PCV and GCV. Similar results were also recorded by Sharma and Dhankar (1990 in bottle gourd and Narsimharao (1997) in ridge gourd. High

PCV with equally high GCV indicates maximum variability existing in the genotypes for these characters and offers good scope for the improvement through selection in these characters.

Low PCV and GCV were recorded for the characters fruit diameter, seed weight, days to first female flower. This suggested that these characters were markedly influence by the environment, hence selection in these characters will be difficult as the expression will be modified by the environment. Similar findings were reported by Deol *et al.* (1981) in muskmelon, Mangal *et al.* (1981) in bitter gourd, Narsimharao (1997) in ridge gourd, Panwar *et al.* (1997) in sponge gourd, Reddy and Rao (1984) in ribbed gourd, Narsimharao (1997) in ribbed gourd. The remaining characters recorded moderate GCV, PCV and indicated lesser effect of environment fluctuations. High PCV and larger difference between PCV and GCV were recorded for node at which first female flower appeared indicating the role of environment in the expression of these characters.

High magnitudes of phenotypic and genetic variance were observed for number of seeds per fruit, thousand seed weight, days to first female flower and number of node at which first female flower appeared. Deol *et al.* (1981) also reported high PV and GV for days to first female flower in muskmelon. Molina *et al.* (1989) in muskmelon, Mariappan and Pappaih (1990) in cucumber, Sendurkumaran *et al.* (1997) in pumpkin also reported high phenotypic variance genotypic variance for number of seeds per fruit and thousand seed weight. This hinted that there might be greater scope for improvement of these characters.

5.4.2 Heritability and genetic advance

Improvement in any crop species depends on the quantum of genetic variability, which reflects the heritable portion of variability. Heritability indicates effectiveness with which selection of genotypes could be based on phenotypic performance (Johnson *et al.* 1955). Therefore, it may not lead to success, if selection is based on heritability alone. Hence, heritability estimates in conjunction with the estimates of genetic advance as per cent are more useful in selecting superior genotypes.

Higher estimates of heritability was observed for almost all the characters except for day to first male/female flower and fruit diameter. High heritability coupled with high genetic advance was observed for number of seeds per fruit and seed weight. Similar findings were observed by Doijode and Sulladmath (1986) in pumpkin, Thakur and Nandpuri (1974) in water melon, Suribabu *et al.* (1986) in bitter gourd, Gopalakrishnan *et al.* (1980) in pumpkin, Mariappan and Pappiah (1990) in cucumber. If high heritability is accompanied by high genetic advance it indicates that the heritability is due to additive gene effects and selection is effective for the characters under study. If high heritability is accompanied by low genetic advance, it indicates non additive gene effects and selection for such traits may not be rewarding. In the present study high heritability accompanied by low genetic advance was observed for the characters viz., fruit weight, number of fruits per vine and vine length. This was in consonance with the findings of Solanki and Seth (1980b) in cucumber for fruit weight, number of fruits per vine, Deol *et al.* (1981) in muskmelon, Rastogi and Aryadeep (1990) in cucumber for vine length.

The character number of node at which first female flower appeared, exhibited moderate heritability and high genetic advance indicating more scope for selection.

5.4.3 Heritability and genetic advance as per cent of mean

High estimates for genetic advance as a per cent of mean was observed for yield per vine, number of node at which first female/male flower appeared and vine length. These results lend support to the findings of Singh *et al.* (1977) in bitter gourd for yield per vine, Rastogi and Aryadeep (1990) in cucumber for vine length, Sharma and Dhankar (1990) in bottle gourd for number of node at which first female flower appeared.

High heritability coupled with high genetic advance as per cent of mean was observed for yield per vine, vine length. Hence there is a possibility of improving these characters by simple selection. High heritability coupled with moderate GA as per cent of mean for fruit weight, fruit length, number of fruits per vine indicated presence of additive gene action.

Moderate heritability coupled with low GA as per cent of mean was observed for fruit flesh thickness and thousand seed weight. Hence, there heterosis breeding is advocated for the improvement of these characters. Johnson *et al.* (1955) also indicated that high value of heritability is not always an indication of high genetic gain.

In the present study, high value of GCV and heritability estimates associated with greater GA as per cent of mean observed for yield per vine length indicated that the variation in the above characters was most likely due to additive gene effects. Hence, simple directional selection may be effective to improve these characters.

5.5 CHARACTER ASSOCIATION

A thorough understanding of the association of plant characters with yield and among themselves is essential for successful crop improvement progamme. It enables the breeder to manipulate the expression of these traits in crop improvement. Correlation analysis provides information on the nature and magnitude of the association of different component characters with yield, which is regarded as highly complex trait in which the breeder is ultimately interested. It also helps us to understand the nature of interrelationship among the component traits themselves. Ultimately this gives a broad idea of the mutual effect of one character on the other and finally on the yield and suggests the relative importance of different characters in increasing the production. The phenotypic *correlation* indicates the extent of the observed relationship between two characters while the genotypic correlation provides an estimate of inherent association between genes controlling any two characters.

In the present investigation, correlation analysis indicated that yield was positively and significantly correlated with fruit length, fruit weight, number of fruits per vine, and number of seeds per fruit both phenotypically and genotypically i.e. as the magnitudes of above characters increased, yield also significantly increases. Similar kind of association was revealed by Kadam *et al.* (1992) and Varalakshmi and Reddy (1994) in ridge gourd, Lawande and Patil (1989) and Khattra *et al.* (1994) in bitter gourd, Sidhu and Brar (1981) and Vijay (1987) in muskmelon, Abusaleha and Dutta (1988) in cucumber for the characters fruit weight, number of fruits per vine and fruit length and Sarkar *et al.*(1999) in pointed gourd, Thamburaj (1973) in ridge gourd, Tyagi (1972) in bottle gourd, Parhi *et al.* (1995) in bitter gourd for number of seeds per fruit.

The relationship between fruit length and fruit weight, fruit length and number of fruits per vine is positive and significant both at phenotypic and genotypic levels. Similarly, Singh *et al.* (1977) reported positive and significant association between fruit length and number of fruits per vine in bitter gourd, Krishnaprasad and Singh (1989), Reddy and Rao (1984) for association between fruit length and fruit weight in ridge gourd.

Fruit diameter correlated positively and significantly with fruit flesh thickness i.e. flesh thickness increases as the diameter of the fruit increases. This association is seen at both phenotypic and genotypic levels. Similar reports were made by Krishnaprasad and Singh (1992) in cucumber.

Vine length showed a positive and significant correlation with most of the characters except for fruit length and number of fruits per vine. This may be due to more number of crooked and deformed fruits. These results were supported by Sarkar *et al.* (1999) in pointed gourd.

As the number of days for male and female flower production was increasing number of fruits per vine, fruit length was decreasing showing negative correlation at both phenotypic and genotypic levels but with fruit weight it showed negative correlation at genotypic level and positive but non significant correlation at phenotypic levels. Similar findings were obtained by Krishnaprasad and Singh (1992) in cucumber, Murali *et al.* (1986) in bottle gourd, Panwar *et al.* (1977) in sponge gourd, Singh and Singh (1988) in water melon for association between days to male and female flower and number of fruits, Reddy and Rao (1984) in ridge gourd for the association between days to male and female flower and fruit weight.

The present correlation studies revealed that fruit length, fruit weight, number of fruits per vine showed positive and significant relationship with yield and also among themselves indicating simultaneous selection for these characters would result in improvement of high yielding genotypes of bottle gourd.

5.6 PATH COEFFICIENTS ANALYSIS

Although correlation coefficient indicates the nature of association among the characters, path analysis splits the correlation coefficient into measures for direct and indirect effects, thus providing an understanding on the direct and indirect contribution of each character towards yield.

If the correlation between a causal factor and the effect is almost equal to its direct effect, then correlation explains the true relationship and a direct selection through this traits will be effective. If the correlation coefficient is positive but the direct effect is negative or negligible, the indirect effects seen to be cause correlation. In such situations the in0direct causal factors are to be considered simultaneously. If correlation coefficients are negative but the direct effect is positive and high, a restricted simultaneous selection model is to be followed i.e. restrictions are to be imposed to nullify the undesirable indirect effects in order to make use of the direct effect (Singh and Kakrar, 1977).

In the present study, the characters fruit weight, number of fruits per vine and vine length exhibited positive direct effects on yield revealing that these are major yield contributing traits in bottle gourd. These findings are in agreement with the reports made by Vijay (1987) in muskmelon, Ramachandran *et al.* (1978) in bitter gourd, Thamburaj *et al.* (1978) and Kondalraj *et al.* (1984) in snake gourd and Narsimharao (1997) in ridge gourd.

The characters, fruit length, fruit diameter, fruit flesh thickness and number of fruits per vine showed highest positive indirect effects on fruit yield through fruit weight. Similarly positive indirect effects of other characters viz., fruit length and fruit weight through number of fruits per vine were also observed. Similar findings were documented by Krishnaprasad and Singh (1992) in cucumber, Ramachandran *et al.* (1978) in bitter gourd and Gopalakrishna *et al.* (1980) in pumpkin.

Though the character number of seed per fruit exerted negative direct effect on yield, their association with fruit yield was found to be positive. This is due to the fact that indirect effects of these characters through fruit weight and number of fruits per vine were high and positive.

Critical analysis of the results by path analysis revealed the importance of the characters fruit weight, number of fruits per vine, fruit length in influencing the fruit yield. Hence, selection should be practiced for these characters in order to isolate superior plant types for improvement of fruit yield.

Summary

CHAPTER – VI

SUMMARY

The present investigation was carried out with twenty four diverse genotypes of bottle gourd with a view to study genetic divergence, the nature and amount of variability, the degree of association between yield and its component characters, direct and indirect effects of the different quantitative characters on yield and to identify the genotypes which are highly efficient with respect to different trait besides their yielding ability.

The experimental material was sown in a randomized block design with three replications at horticultural garden, S.V. Agricultural College, Tirupati during *rabi* 1999-2000. Observations were recorded on randomly selected five plants for thirteen characters viz., days to first male flower, number of node at which first male flower appeared, days to first female flower, number of node at which first female flower appeared, fruit weight, fruit length, fruit diameter, fruit flesh thickness, number of fruits per vine, number of seeds per fruit, thousand seed weight, vine length and yield per vine.

Analysis of variance indicated highly significant variation among the genotypes for all the traits. The genotypes Satur Local, PSPL, Warad, Pusa Meghdoot showed high mean performance for fruit yield and its components.

The results of Mahalanobis's D^2 analysis revealed considerable variability among the twenty four genotypes and the genotypes were grouped into five clusters. It revealed that among the 13 characters studied vine length, numbers of seeds per fruit, number of node at which first female flower appeared, fruit flesh thickness and yield per vine contributed maximum towards the genetic divergence.

Based on Tocher's method of clustering, the genotypes PSPL, Indo American, Warad, IC-92330, Arka Bahar, Pratik, were suggested for inclusion in hybridization programme. High estimates of phenotypic and genotypic coefficients of variation were observed for vine length, number of node at which flower appeared, number of node at which first male flower appeared and yield per vine. This abundant variability reflects possible chances of improving these traits by exercising selection. However, days to first male and female flowers recorded low PCV and GCV.

The characters vine length, yield per vine, fruit length, number of seeds per fruit, number of fruits per vine, fruit weight, fruit length showed high heritability. But high heritability coupled with high GA as per cent of mean was observed only for yield per vine, vine length, number of seeds per fruit indicating selection will be fruitful through improvement of such traits. High heritability accompanied by low genetic advance as per cent of mean was recorded for days to first male flower, fruit diameter, thousand seed weight, hence selection for such characters may not be rewarding.

In general, it was observed that the genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients. This indicated that strong inherent associations were somewhat masked at phenotypic level due to environmental effect. Among the different quantitative characters, fruit length, fruit weight, number of fruits per vine were significantly and positively associated with fruit yield. Therefore, these characters can be used as criteria for selection of genotypes with high yield potential.

The correlation of the yield components inter se revealed strong positive association of fruit length with fruit weight, and number of fruits per vine, fruit diameter with fruit weight and fruit flesh thickness and fruit weight with vine length. Hence simultaneous selection for these characters might bring an improvement in fruit yield.

Path coefficient analysis revealed that fruit weight, number of fruits per vine, fruit length, vine length were the most important characters which could be used as selection criteria for effective improvement of fruit yield.

Based on the results obtained in the present study and also in view of their implication in the breeding of suitable bottle gourd varieties, the following suggestions are made to plan an efficient breeding programmes.

1. Diverse parents should be selected on the basis of per se performance and contribution to genetic divergence
2. The characters like fruit weight, fruit flesh thickness, number of fruits per vine were predominantly under the control of non-additive gene action, which can be improved through hybridization, while additive gene action was predominant in yield per vine, number of seeds per fruits, vine length which can be improved by conventional breeding methods.
3. Keeping in view the correlation and path coefficient analysis selection based on fruit weight, number of fruits per vine and vine length will be effective for selecting high yielding genotypes.

The better genetic divergence among high yielding genotypes identified in the present study viz., PSPL, Sathur Local, Avinasi Local. NLG Long, Nadaswaram are late flowering genotypes. Early flowering genotypes like SRP1, Ganesh can may be used as parents to develop promising of hybrids with early flowering and high yield.

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