

**GENETIC DIVERSITY AND CHARACTER
ASSOCIATION STUDIES IN BITTER GOURD
(*Momordica charantia* L.)**

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**GENETIC DIVERSITY AND CHARACTER
ASSOCIATION STUDIES IN BITTER GOURD
(*Momordica charantia* L.)**

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By

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JULY, 2018



**Affectionately
Dedicated to
My Beloved
Parents,
Brothers**

UNIVERSITY OF HORTICULTURAL SCIENCES, BAGALKOT
COLLEGE OF HORTICULTURE, KOLAR
DEPARTMENT OF VEGETABLE SCIENCE

CERTIFICATE

This is to certify that the thesis entitled “**GENETIC DIVERSITY AND CHARACTER ASSOCIATION STUDIES IN BITTER GOURD (*Momordica charantia* L.)**” submitted by **Mr. NITHINKUMAR, K.R., ID. No. UHS16PGM844**, in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (Horticulture)** in **VEGETABLE SCIENCE** to the University of Horticultural Sciences, Bagalkot, is a record of research work carried out by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar titles.

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GENETIC DIVERSITY AND CHARACTER ASSOCIATION STUDIES IN BITTER GOURD (*Momordica charantia* L.)

ABSTRACT

The investigation on “Genetic diversity and character association studies in bitter gourd” was conducted at the vegetable block in the Department of Vegetable Science, College of Horticulture, Mysuru. Forty genotypes of bitter gourd collected from different sources were evaluated in randomized block design with 2 replications during *kharif* 2017. The analysis of variance revealed significant ($p = 0.05$) differences among the genotypes for all the characters studies indicating the presence of wide range of variability in the genotypes. Based on Mahalanobis’s D^2 analysis, the 40 genotypes were grouped into 6 clusters. The cluster II showed maximum intra-cluster distance ($D^2 = 104.02$), whereas, the maximum inter cluster distance was observed between cluster II and VI ($D^2 = 1620.05$). Among the 16 characters studied, ascorbic acid contributed maximum (37.31%) to genetic diversity. The higher GCV and heritability estimates coupled with high genetic advance over mean (GAM) were observed for the characters like fruit length, average fruit weight, fruit yield per vine, fruit yield per hectare, number of seeds per fruit and flesh thickness. This indicates predominance of additive component for these traits and hence direct selection would be more effective in improving these traits. The results on correlation and path analysis revealed high positive and significant association of fruit yield per vine with characters *viz.*, fruit length, fruit diameter, duration of crop and average fruit weight and these characters also had high direct and indirect effect on fruit yield per vine. Hence, direct selection for these traits would be more useful in the improvement of fruit yield per vine.

Signature of the student

(Nithinkumar, K.R.)

Signature of the Major Advisor

(Aravinda Kumar, J. S.)

ಹಾಗಲಕಾಯಿಯಲ್ಲಿ ಅನುವಂಶಿಕ ವೈವಿಧ್ಯತೆ ಮತ್ತು ಗುಣಲಕ್ಷಣಗಳ ಸಹಯೋಗದ ಅಧ್ಯಯನ

ಸಾರಾಂಶ

ಹಾಗಲಕಾಯಿಯಲ್ಲಿ ಅನುವಂಶಿಕ ವೈವಿಧ್ಯತೆ ಮತ್ತು ಗುಣಲಕ್ಷಣಗಳ ಸಹಯೋಗದ ಅಧ್ಯಯನದ ಸಂಶೋಧನೆಯನ್ನು ತೋಟಗಾರಿಕಾ ಮಹಾವಿದ್ಯಾಲಯ ಮೈಸೂರು ಕಾಲೇಜಿನ ತರಕಾರಿ ವಿಜ್ಞಾನ ಕ್ಷೇತ್ರದಲ್ಲಿ ನಡೆಸಲಾಯಿತು. ದೇಶದ ವಿವಿಧ ಭಾಗಗಳಿಂದ ಸಂಗ್ರಹಿಸಲಾದ ಹಾಗಲಕಾಯಿಯ ನಲವತ್ತು ತಳಿ ನಮೂನೆಗಳನ್ನು ಯಾದೃಚ್ಛಿಕ ಬ್ಲಾಕ್ ವಿನ್ಯಾಸ (ಖಃಆ)ದಲ್ಲಿ 2017ರ ಮುಂಗಾರಿನಲ್ಲಿ ಮೌಲ್ಯಮಾಪನ ಮಾಡಲಾಯಿತು. ವೈವಿಧ್ಯ ವಿಶ್ಲೇಷಣೆ ಪ್ರಕಾರ ಎಲ್ಲಾ ತಳಿ ನಮೂನೆಗಳ ಗುಣಲಕ್ಷಣಗಳ ನಡುವೆ ಗಣನೀಯ ವ್ಯತ್ಯಾಸ (ಪಿ=0.05) ಕಂಡು ಬಂದಿದೆ. ಇದರಿಂದ ಈ ಎಲ್ಲಾ ಗುಣಲಕ್ಷಣಗಳು ಸಂಯೋಜನೆಯ ಘಟಕದ ಪ್ರಾಬಲ್ಯವನ್ನು ಸೂಚಿಸುತ್ತದೆ. ಮಹಾಲನೊಬಿಸ್‌ರವರ ಪ್ರಭೇಧ ದೂರ ವಿಶ್ಲೇಷಣೆ ಅನುಸರಿಸಿ ಹಾಗಲಕಾಯಿಯ ನಲವತ್ತು ತಳಿ ನಮೂನೆಗಳನ್ನು 6 ಸಮೂಹಗಳಾಗಿ ವರ್ಗೀಕರಿಸಲಾಗಿದೆ. ಸಮೂಹಗಳ ಆಂತರಿಕ ದೂರದ ಆಧಾರದ ಮೇಲೆ ಸಮೂಹ 2 ರಲ್ಲಿ ಅತೀ ಹೆಚ್ಚು ಅಂತರ (ಆ2 = 104.02) ಕಂಡು ಬಂದಿದೆ. ಸಮೂಹಗಳ ಮಧ್ಯದ ದೂರದ ಆಧಾರದ ಮೇಲೆ ಸಮೂಹ 2 ಮತ್ತು ಸಮೂಹ 6ರ ಮಧ್ಯೆ ಅತಿ ಹೆಚ್ಚು ಅಂತರ (ಆ2 = 1620.05) ಕಂಡು ಬಂದಿದೆ. ಒಟ್ಟು 16 ಗುಣಲಕ್ಷಣಗಳ ಪೈಕಿ ಆಸ್ಕಾರ್ಬಿಕ್ ಆಮ್ಲವು (37.31%) ಅನುವಂಶಿಕ ವೈವಿಧ್ಯತೆಗೆ ಗರಿಷ್ಠ ಕೊಡುಗೆಯನ್ನು ನೀಡಿರುತ್ತದೆ. ಅನುವಂಶಿಯ ಅಧ್ಯಯನದಲ್ಲಿ ಹೆಚ್ಚಿನ ಅನುವಂಶಿಯ ಸಾಮಥ್ರ್ಯ ಮತ್ತು ಸರಾಸರಿ ಅನುವಂಶಿಕ ಅಭಿವ್ಯಕ್ತಿಯು ಹಣ್ಣಿನ ಉದ್ದ, ಹಣ್ಣಿನ ಸರಾಸರಿ ತೂಕ, ಪ್ರತಿ ಬಳ್ಳಿಯ ಕಾಯಿಗಳ ಇಳುವರಿ, ಪ್ರತಿ ಹೆಕ್ಟೇರಿಗೆ ಹಣ್ಣಿನ ಇಳುವರಿ, ಪ್ರತಿ ಕಾಯಿಯಲ್ಲಿನ ಬೀಜಗಳ ಸಂಖ್ಯೆ ಮತ್ತು ತಿರುಳಿನ ದಪ್ಪದಲ್ಲಿ ಕಂಡುಬಂದಿದೆ. ಈ ಗುಣಲಕ್ಷಣಗಳಿಗೆ ಸಂಯೋಜನೀಯ ಅಂಶದ ಪ್ರಾಬಲ್ಯವನ್ನು ಇದು ಸೂಚಿಸುತ್ತದೆ ಮತ್ತು ನೇರ ಆಯ್ಕೆಯು ಈ ಗುಣಲಕ್ಷಣಗಳನ್ನು ಸುಧಾರಿಸುವಲ್ಲಿ ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿಯಾಗಿದೆ. ಗುಣಲಕ್ಷಣಗಳ ಪರಸ್ಪರ ಸಂಬಂಧ ಮತ್ತು ಪಥ ವಿಶ್ಲೇಷಣೆ ಫಲಿತಾಂಶಗಳ ಪ್ರಕಾರ ಬಳ್ಳಿಯ ಕಾಯಿಗಳ ಇಳುವರಿಯು ಇನ್ನಿತರ ಸಸ್ಯದ ಗುಣಲಕ್ಷಣಗಳಾದ ಕಾಯಿಯ ಉದ್ದ, ಕಾಯಿಯ ಸುತ್ತಳತೆ, ಬೆಳೆಯ ಕಾಲಾವಧಿ ಮತ್ತು ಕಾಯಿಯ ಸರಾಸರಿ ತೂಕದೊಂದಿಗೆ ಗಣನೀಯ ಧನಾತ್ಮಕ ಮತ್ತು ಪ್ರಮುಖವಾದ ಸಂಯೋಜನೆಯನ್ನು ಹೊಂದಿದೆ ಹಾಗೂ ಈ ಎಲ್ಲಾ ಲಕ್ಷಣಗಳು ಸಹ ಬಳ್ಳಿಯ ಕಾಯಿಗಳ ಇಳುವರಿಯ ಮೇಲೆ ಹೆಚ್ಚಿನÀ ನೇರ ಮತ್ತು ಪರೋಕ್ಷ ಪರಿಣಾಮವನ್ನು ಬೀರಿರುತ್ತವೆ. ಆದ್ದರಿಂದ ಈ ಗುಣಲಕ್ಷಣಗಳು ನೇರ ಆಯ್ಕೆಯ ಆಧಾರದ ಮೇಲೆ ಕಾಯಿಗಳ ಇಳುವರಿ ಸುಧಾರಣೆಯಲ್ಲಿ ಬಹು ಉಪಯುಕ್ತವಾಗಿದೆ.

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(ನಿತಿನಕುಮಾರ್ ಕೆ.ಆರ್.)

ಪ್ರಮುಖ ಸಲಹೆಗಾರರು

(ಅರವಿಂದ ಕುಮಾರ್ ಜಿ. ಎಸ್.)

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I. INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is one of the most important cucurbitaceous vegetables grown throughout tropical and subtropical regions of the world. The centre of origin of this crop is Indo-Burma, with a secondary centre of diversity in China and South East Asia (Gruthew, 1977). It belongs to the family-Cucurbitaceae, subfamily-Cucurbitodeae, tribe-Joliffeae and subtribe-Thalithaneae. Cucurbitaceae family has 90 genera and 750 species (Ram, 2005). Bitter gourd has diploid chromosome number of 22 and it is widely cultivated in India, Sri Lanka, Philippines, Thailand, Malaysia, China, Japan, Australia, tropical Africa and South America.

In India, bitter gourd is grown in wild and cultivated form covering an area of 95,000 ha with an annual production of 10,30,000 metric tonnes with an average productivity of 10.84 t/ha (Anon., 2017). Major bitter gourd growing states are Chhattisgarh, Telangana, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Bihar, Tamil Nadu, and West Bengal. In Karnataka it is grown in an area of 3150 ha and an average production of 27,220 metric tonnes with an average productivity of 8.64 t/ha (Anon., 2016).

Bitter gourd is usually eaten fresh (stuffed and sliced) but can also be pickled and has been canned in brine. Its young shoots and leaves are also eaten (Vinning, 1995). Ripe fruits are rich source of vitamin-A. Among all the cucurbitaceous vegetables, bitter gourd contains the maximum amount of minerals and vitamins (Islam *et al.*, 2009). It has number of uses including cancer prevention, treatment of diabetes, treatment of general fevers, malaria (Kedar and Chakarborti, 1982) and has high iron and vitamin-C content (Choudhary *et al.*, 2003). Bitter gourd seeds contain clear brown oil which is anti-helminthic, anti-malarial, anti-viral and anti-cancerous in nature. The seed protein of bitter gourd was found to inhibit the growth of immuno deficiency virus (HIV-1) in human cell cultures (Bodeker *et al.*, 2006). The principle constituents are the lectins, cheratins and momordicin which help in glucose uptake and glycogen synthesis in liver, muscle and adipose tissues of human being and improve the glucose tolerance. In USA, England and France it is grown as an ornamental annual crop (Walters and Walters, 1988).

Bitter gourd, being an important vegetable crop with medicinal properties requires a systematic breeding programme for enhancement in its yield potential and other horticultural traits. The wild species are good source for breeding of common cultivated bitter gourd varieties with good qualitative traits and tolerance to various stresses.

Generally diverse germplasm are expected to give high hybrid vigour (Harington, 1940) and hence, it necessitates studying genetic divergence among the existing varieties and genotypes for the identification of parents for hybridization programme. The information on genetic divergence of various traits particularly of those that contribute to yield and quality would be of most useful in planning the breeding programme. D^2 statistics (Mahalanobis, 1936) provides a measure of magnitude for divergence between two genotypes under comparison. Grouping of genotypes based on D^2 analysis will be useful in choosing suitable parental lines for hybridization.

Genetic diversity in population of crop species is a key to successful hybridization for obtaining individuals with desired horticultural traits. Bitter gourd is monoecious and highly cross-pollinated in nature. Such pollination mechanism can be exploited commercially for hybrid seed production. Moreover, there is a great scope for development of open pollinated varieties by utilizing the existing variability. Large amount of variation provides the better chance of selecting desired genotypes (Vavilov, 1951)

Improvement in any crop depends upon magnitude of genetic variability and extent to which desired characters are heritable. Moreover, correlation and path co-efficient analysis have been of immense help in selecting suitable plant type. Although, correlation co-efficient indicates

the nature of association among the traits and form a basis for selecting desirable plant type. Path analysis splits the correlation co-efficient into direct and indirect effects to measure the relative importance of each character. Information on character association and direct and indirect effects of component traits on yield would greatly help in formulating the selection criteria and using them effectively in crop improvement programme in bitter gourd.

Therefore, the present investigations was carried out to study the genetic diversity, variability and association of different characters among different genotypes of bitter gourd with regard to yield and yield contributing traits with the following objectives:

1. To ascertain the nature and magnitude of genetic diversity present among the bitter gourd genotypes
2. To study the genetic variability for yield and quality parameters
3. To study the association among growth, yield and quality parameters

II. REVIEW OF LITERATURE

Bitter gourd (*Momordica charantia* L.) is an important vegetable crop and grown extensively all over the India and also throughout the world. It is a cross pollinated crop and therefore, the selection breeding is most important technique for its improvement. The strategy of plant breeding programme for high yield and selection of desirable line, the information and knowledge on the nature of genetic diversity, magnitude of genetic variability present in the breeding materials, nature of character association among the traits is highly essential. Hence, this study is necessary for improvement of bitter gourd yield and yield contributing traits.

In the present investigation, an attempt has been made to study to the genetic divergence, variability, character association and path analysis in bitter gourd. The literature related to the present investigation has been presented in this chapter under different headings. Since available relevant literature on bitter gourd to the various aspects of present study is less, so some other cucurbits had also been reviewed briefly under the following headings.

2.1 Genetic divergence

Parthi *et al.* (1993) studied genetic divergence among 13 genotypes for 14 yield components using Mahalanobis D^2 analysis. The genotypes differed significantly for all the characters studied and were grouped into six clusters based on similarities of D^2 values and found that characters like 100 seed weight, number of seeds per fruit and yield per plant had maximum contribution to variation. They concluded that selection for divergent parents may be useful heterosis breeding in bitter gourd.

Kutty and Dharmatti (2005) studied genetic divergence among 40 genotypes of bitter gourd (*Momordica charantia* L.) of different eco-geographic origin was assessed using Mahalanobis D^2 statistics. The genotypes were grouped into 10 clusters. Most of the genotypes were grouped in cluster I (16), cluster II (11) and cluster IV (4). The genotypes falling in cluster II had the maximum divergence, followed by the cluster IV and cluster I. The maximum inter-cluster distance was between cluster VI and cluster IX followed by cluster VII and cluster IX. The productive length of vine contributed maximum to divergence.

Genetic divergence study was conducted by Dey *et al.* (2007) using 38 bitter gourd genotypes including two promising gynocious lines for 17 characters. Cluster IV was very large containing 17 genotypes including some of the commercially released cultivars, while cluster IV was represented by two gynocious lines. The maximum inter-cluster distance was obtained between cluster II and IV while minimum distance was between cluster II and VI. Cluster IV followed by cluster III showed superiority for yield and other desirable traits, which indicate the potentiality of these diverse genotype collection for providing basic material for future breeding programmes as most of the commercially released cultivars were represented in cluster III.

Sundaram (2008) assessed nature and magnitude of genetic divergence in twenty two bitter gourd genotypes assembled from different geographical locations showed the presence of wide genetic diversity. The genotypes were grouped into six clusters based on Mahalanobis D^2 statistics using Trocher's method. The clustering pattern of genotypes revealed that the genetic diversity was independent of the geographical diversity. Among the six clusters, maximum number of genotypes were found in cluster I and the clusters V and VI were found to be mono genotypic. Among the fourteen quantitative characters studied, individual fruit weight constituted a maximum of 26.83 per cent to the divergence, followed by yield of fruits per vine and length of fruit.

Islam *et al.* (2010) analyzed genetic divergence of 20 bitter gourd genotypes through Mahalanobis D^2 and principal component analysis. The genotypes under study were divided into four clusters which showed sufficient variability among the genotypes. Cluster II had highest mean value for weight per fruit. The inter cluster distances were much higher than the intra cluster distances. Cluster I exhibit the highest intra cluster distance while the lowest distance was observed in cluster III. The highest inter cluster distance was observed between I and II while the lowest distance was observed between the cluster II and IV.

Bharathi and Vishalnath (2010) studied genetic divergence in 22 varieties of pointed gourd. Based on D^2 values the accessions were grouped in to five clusters. Cluster I was largest comprising 12 accessions, whereas cluster V was smallest with a single accession. The intra-cluster distance ranged from 0.00 (cluster V) to 26.67 (cluster I) and inter-cluster distances varied from 17.60 (cluster III and cluster V) to 47.76 (cluster IV and cluster V).

Based on Mahalanobis D^2 statistics, the sixty genotypes of ridge gourd were grouped into four different clusters. Clustering pattern revealed that genotypes collected from the same location were grouped into different clusters. The average inter-cluster distances were always higher than the average intra-cluster distances suggesting wider genetic diversity among the genotypes within the cluster. Cluster III had the highest intra-cluster distance. (Rabbani *et al.*, 2012)

Resmi and Sreelathakumary (2012) conducted a study on genetic divergence of 33 bitter gourd genotypes for twenty characters. The results showed that the cluster I was the largest comprising of 11 genotypes, followed by clusters III and V with 10 genotypes each. Clusters II and IV comprised of one genotype each. As regards cluster means, clusters II and IV performed better in most of the biometric characters studied. Maximum inter-cluster distance was observed in clusters III and IV followed by clusters II and III and clusters-I and IV. Intra-cluster distance was highest in cluster I.

Genetic divergence among 36 genotypes of bitter gourd (*Momordica charantia* L.) studied by using multivariate analysis based on 22 characters and genotypes were grouped into six distant clusters. Days to first male flower opening, number of primary branches per vine, fruit yield per vine, days to green fruit maturity, seed weight per fruit mature seed width had the highest contribution towards the divergence. Cluster diagram exhibited that the genotypes include in the cluster III were far diverse from the genotypes of cluster IV while the genotypes belonging to the cluster II and VI were least diversified (Kundu *et al.*, 2012).

Deepa and Mariappan (2013) studied genetic diversity among 50 genotypes of snake gourd using Mahalanobis D^2 statistic. The genotypes were grouped into four different clusters, the maximum inter cluster distance was observed between the clusters III and cluster IV and that of minimum in between the clusters I and cluster II. In case of intra-cluster distance, the maximum distance was observed in the cluster III and that of minimum was observed in the cluster IV.

Nature and magnitude of genetic divergence in 30 bitter gourd genotypes were evaluated by Bhagwat *et al.* (2013). The clustering pattern of genotypes revealed that the genetic diversity was independent of the geographical diversity. Among the 6 clusters, maximum numbers of genotypes were found in cluster V, while clusters III were found to be mono-genotypic. Among the 12 quantitative characters studied, individual fruit weight constituted a maximum of 64.14% contribution to the divergence, followed by days to first female flower appearance.

Kumari *et al.* (2017) studied genetic divergence in bitter gourd for sixteen traits using Mahalanobis D^2 statistics. The total genotypes were grouped into 6 different clusters on similarities of D^2 values. Among the different clusters, cluster I consisted the maximum number of genotypes (6 genotypes) followed by cluster II, cluster III and cluster IV (3 genotypes) and cluster

V contain only one genotype. The highest intra- cluster distance was recorded for cluster I (2411.503) and lowest intra-cluster distance was observed in cluster V. Genotypes from cluster I could be used as parental line for hybrid breeding programme owing to their higher mean performance within group. The highest inter cluster distance found between cluster V and cluster I indicated wider genetic diversity among the genotypes between these groups.

Vivek *et al.* (2018) studied twenty genotypes of bitter gourd to assess the genetic diversity the genotypes were grouped into 5 clusters based on Mahalanobis D^2 statistics using Trocher's method (Rao, 1952). The grouping pattern of genotypes revealed that among the 5 clusters, maximum numbers of genotypes were found in cluster III which comprises 6 genotypes, while clusters I and II comprises two genotypes each. The maximum intra clusters distance was observed in cluster IV and lowest intra cluster distance was recorded in cluster I. The cluster IV and V were strikingly diverse from rest of the clusters, the divergence between these two clusters was high as evident from their high inter cluster D^2 value. Therefore, the genotypes falling in these clusters were genetically more divergent.

2.2 Genetic variability, heritability, genetic advance and genetic advance over per cent mean

The literature pertaining to genetic variability, heritability and genetic advance over per cent mean has been presented in Table 1.

2.3 Correlation studies

Sankaran *et al.* (2002) conducted association studies for some physicochemical changes associated with maturity of bitter gourd cv. CO-1 and found that fruit length, girth, weight, crude fibre, crude protein, acidity, reducing sugar and total sugar were positively correlated with increasing maturity.

Bhave *et al.* (2003) reported that, the fruit number was highly correlated with total fruit yield per vine in bitter gourd. At phenotypic and genotypic levels, fruit yield per vine was positively correlated with flowering duration, harvesting span, biological yield, fruit length, breadth, rind thickness, average weight and number of fruits per vine and negatively correlated with days to first flowering.

Dey *et al.* (2005) reported higher genotypic correlation co-efficient than phenotypic correlation co-efficient in 38 indigenous genotypes of bitter gourd. The fruit yield was positively correlated with fruit weight, number of fruits per plant, flesh thickness, number of days from fruit set to maturity, fruit index, fruit length and fruit diameter.

Kutty and Dharmatti (2005) found significant positive correlation for yield per plant with characters like days to first female flower opening, node number of first female flowering, number of leaves at 50% flowering stage, number of seeds per fruit and fruit length.

Table 1. Review of literature on mean, range, components of variance, heritability, genetic advance and per cent genetic advance over mean in bitter gourd

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
A.	Growth parameters									
1.	Vine length (m)	Bitter gourd	0.59-1.53	101.51	26.40	26.39	100.00	54.54	53.73	Maneesh <i>et al.</i> (2014)
		Bitter gourd	2.13-4.53	--	38.45	23.40	--	--	--	Khan <i>et al.</i> (2015)
		Bitter gourd	--	--	9.75	8.82	81.89	0.40	16.45	Rani <i>et al.</i> (2015)
		Bitter gourd	--	284.29	17.32	17.31	100.00	101.37	35.66	Vivek <i>et al.</i> (2017)
		Bitter gourd	1.29-3.21	207.32	22.76	22.30	96.00	93.32	--	Yadagiri <i>et al.</i> (2017)
		Bitter gourd	--	1.74	2.46	1.21	--	--	1.57	Tiwari <i>et al.</i> (2018)
		Bitter gourd	1.60-3.60	--	22.56	21.55	31.21	1.03	42.39	Tyagi <i>et al.</i> (2018)
		Bitter gourd	2.70-5.10	3.51	19.01	16.06	71.00	0.98	27.96	Devendra <i>et al.</i> (2018)
		Ridge gourd	2.56-6.20	383.70	32.59	32.42	98.98	--	66.45	Singh <i>et al.</i> (2002)
		Ridge gourd	2.35-9.55	548.58	33.55	29.61	77.70	--	--	Rabbani <i>et al.</i> (2012)
		Ridge gourd	0.74-1.47	113.29	17.86	16.58	86.00	35.92	31.70	Koppad <i>et al.</i> (2015)
		Ridge gourd	2.06-3.63	287.11	17.85	12.52	49.23	--	18.10	Karthik <i>et al.</i> (2017)
		Ridge gourd	2.01-4.10	3.18	20.83	18.77	81.17	1.11	34.84	Pushpendra <i>et al.</i> (2017)
		Ridge gourd	2.43-3.71	3.13	15.12	11.25	55.30	0.54	--	Bhargava <i>et al.</i> (2017)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Bottle gourd	2.86-6.28	4.43	21.35	21.79	96.00	1.91	43.09	Kumar <i>et al.</i> (2007)
		Bottle gourd	1.41-3.42	218.84	37.11	37.11	99.98	--	75.67	Sharma and Sengupta (2013)
		Bottle gourd	2.86-7.95	5.46	32.03	31.64	97.58	3.52	64.40	Suruchi (2014)
		Bottle gourd	3.60-5.83	4.93	13.57	10.77	63.00	0.86	17.63	Ipsita and Duhan (2018)
		Cucumber	1.86-2.49	205.86	7.95	7.17	81.44	27.46	13.34	Rajawat and Collis (2017)
		Cucumber	1.96-2.49	--	12.03	12.01	--	--	--	Kandasamy (2017)
		Cucumber	1.33-3.80	2.15	28.97	25.90	79.94	1.03	--	Chandan and Singh (2018)
		Cucumber	1.43-2.55	--	17.87	17.70	98.00	71.82	36.12	Shah <i>et al.</i> (2018)
		Snake gourd	4.28-5.75	5.04	13.50	6.10	20.40	--	5.67	Rana and Pandit (2011)
		Snake gourd	--	--	15.41	15.40	99.82	--	31.70	Deepa and Mariyappan (2013)
		Snake gourd	0.83-3.82	2.20	32.61	30.29	86.30	1.280	57.97	Khan <i>et al.</i> (2016)
		Muskmelon	1.12-3.07	208.10	23.25	16.75	51.89	--	40.24	Rakhi and Rajamony (2005)
		Sponge gourd	--	--	9.53	9.33	95.81	93.99	--	Kumar <i>et al.</i> (2013)
		Pointed gourd	4.00-10.00	7.05	23.23	21.20	83.30	2.07	39.87	Malek <i>et al.</i> (2007)
2.	Number of branches	Bitter gourd	5.31-15.34	8.64	30.55	30.35	98.70	5.36	62.04	Maneesh <i>et al.</i> (2014)
		Bitter gourd	30.67-45.60	--	81.33	60.55	--	--	--	Khan <i>et al.</i> (2015)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
	per vine	Bitter gourd	--	--	10.07	9.60	90.85	1.14	18.85	Rani <i>et al.</i> (2015)
		Bitter gourd	--	8.69	16.30	15.90	95.00	2.78	31.96	Vivek <i>et al.</i> (2017)
		Bitter gourd	6.53-14.26	10.35	18.45	16.16	76.70	3.02	29.17	Yadagiri <i>et al.</i> (2017)
		Bitter gourd	18.00-18.94	18.68	3.41	1.91	--	--	2.81	Tiwari <i>et al.</i> (2018)
		Bitter gourd	10.83-16.77	14.02	16.00	15.49	94.00	4.33	30.91	Devendra <i>et al.</i> (2018)
		Ridge gourd	4.40-13.04	8.09	40.30	39.96	83.87	--	69.72	Singh <i>et al.</i> (2002)
		Ridge gourd	15.67-42.67	29.94	24.90	22.24	79.78	--	--	Rabbani <i>et al.</i> (2012)
		Ridge gourd	2.33-6.17	4.68	21.42	20.34	90.00	18.40	39.80	Koppad <i>et al.</i> (2015)
		Ridge gourd	3.60-4.93	4.13	10.34	6.77	42.9	3.37	--	Bhargava <i>et al.</i> (2017)
		Ridge gourd	6.00-9.70	7.78	18.86	6.75	12.82	--	4.98	Karthik <i>et al.</i> (2017)
		Bottle gourd	2.98-5.71	4.21	--	--	--	--	--	Kumar <i>et al.</i> (2007)
		Bottle gourd	17.71-58.34	3.78	42.77	42.72	99.75	--	87.21	Sharma and Sengupta (2013)
		Bottle gourd	5.16-9.33	6.85	16.81	15.29	82.00	1.96	29.65	Ipsita and Duhan (2018)
		Cucumber	7.20-11.26	8.80	16.29	13.79	71.64	2.11	24.04	Rajawat and Collis (2017)
		Cucumber	3.00-7.66	5.33	21.13	16.79	63.11	1.47	27.47	Chandan and Singh (2018)
		Cucumber	4.84-8.00	--	15.14	13.07	75.00	1.61	23.25	Shah <i>et al.</i> (2018)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Snake gourd	4.00-6.00	4.50	26.31	6.40	6.00	--	3.21	Rana and Pandit (2011)
		Watermelon	4.80-8.33	6.28	23.53	18.25	60.10	1.83	29.14	Saroj <i>et al.</i> (2004)
		Sponge gourd	--	--	13.22	12.71	92.47	3.22	---	Kumar <i>et al.</i> (2013)
		Pumpkin	--	--	16.98	15.18	79.93	--	--	Sampath and Krishnamoorthy (2017)
		Muskmelon	3.00-4.00	3.00	16.21	8.60	28.16	9.39	--	Rakhi and Rajamony (2005)
		Muskmelon	3.50-6.83	4.91	19.19	15.40	64.37	1.25	25.44	Mishra <i>et al.</i> (2017)
		Pointed gourd	4.00-10.00	7.05	--	--	--	--	--	Malek <i>et al.</i> (2007)
		Spine gourd	6.25-12.25	10.87	16.62	11.39	46.90	1.75	--	Archana <i>et al.</i> (2016)
3.	Duration of crop	Ash gourd	131.00-147.00	137.36	2.28	1.33	34.10	--	1.60	Mukesh, (2017)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
B.	Earliness parameters									
4.	Node at which first female flower appears	Bitter gourd	--	5.81	43.45	12.87	90.00	--	6.67	Mudassar, (2015)
		Bitter gourd	--	--	11.05	9.30	70.81	2.40	16.12	Rani <i>et al.</i> (2015)
		Bitter gourd	--	13.51	11.79	11.30	92.00	3.01	22.30	Vivek <i>et al.</i> (2017)
		Bitter gourd	11.17-17.20	14.20	13.41	12.69	90.00	3.51	24.74	Devendra <i>et al.</i> (2018)
		Bitter gourd	10.63-11.63	11.45	5.69	2.61	--	--	3.15	Tiwari <i>et al.</i> (2018)
		Bitter gourd	9.66-16.33	--	16.89	13.27	61.72	2.72	21.47	Tyagi <i>et al.</i> (2018)
		Ridge gourd	12.80-35.89	18.58	40.96	39.61	93.58	--	78.96	Singh <i>et al.</i> (2002)
		Ridge gourd	3.00-21.00	11.68	32.95	31.45	91.10	7.22	--	Bhargava <i>et al.</i> (2017)
		Ridge gourd	6.33-10.87	8.02	20.23	15.65	59.84	--	24.94	Karthik <i>et al.</i> (2017)
		Ridge gourd	--	--	14.69	14.32	95.00	--	28.73	Ananthan and Krishnamoorthy (2017)
		Ridge gourd	6.67-15.67	11.80	21.26	19.61	85.14	4.40	37.28	Pushpendra <i>et al.</i> (2017)
		Bottle gourd	6.23-11.81	8.78	--	--	--	--		Kumar <i>et al.</i> (2007)
		Bottle gourd	10.35-24.15	16.63	34.41	34.22	98.90	--	69.45	Sharma and Sengupta (2013)
		Bottle gourd	7.80-14.87	10.98	21.03	17.95	72.85	--	31.55	Mandal <i>et al.</i> (2015)
		Bottle gourd	--	12.37	13.64	13.22	93.80	3.26	26.37	Damor <i>et al.</i> (2016)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Bottle gourd	10.70-16.40	13.29	13.62	11.68	73.00	2.74	20.64	Ipsita and Duhan (2018)
		Cucumber	--	--	39.12	28.63	53.60	3.73	--	Sandeep <i>et al.</i> (2013)
		Cucumber	4.46-6.80	5.36	15.14	12.78	71.22	1.19	22.21	Rajawat and Collis (2017)
		Cucumber	7.25-11.25	--	16.28	11.47	--	--	--	Kandasamy (2017)
		Cucumber	3.00-11.00	7.03	30.72	27.46	79.92	3.56	50.58	Chandan and Singh (2018)
		Cucumber	3.58-8.87	--	29.98	29.15	94.00	3.29	58.36	Shah <i>et al.</i> (2018)
		Snake gourd	21.00-30.66	25.43	17.45	9.75	31.25	--	11.23	Rana and Pandit (2011)
		Snake gourd	--	--	18.87	16.47	76.18	--	29.62	Deepa and Mariyappan (2013)
		Snake gourd	17.00-42.00	27.00	22.00	21.68	97.10	11.88	43.01	Khan <i>et al.</i> (2016)
		Muskmelon	6.00-12.00	9.00	15.15	12.96	73.22	--	22.86	Rakhi and Rajamony (2005)
		Pumpkin	--	--	8.51	7.10	69.69	--	--	Sampath and Krishnamoorthy (2017)
		Pumpkin	--	--	9.02	2.52	1.89	0.07	0.35	Ahmed <i>et al.</i> (2018)
		Sponge gourd			10.42	9.44	82.12	1.88	--	Kumar <i>et al.</i> (2013)
5.	Days to first female flower opening	Bitter gourd	31.25-48.52	39.01	12.30	12.31	99.80	9.88	25.33	Maneesh <i>et al.</i> (2014)
		Bitter gourd	--	--	5.85	5.38	84.58	5.28	10.20	Rani <i>et al.</i> (2015)
		Bitter gourd	62.90-71.43	--	37.14	33.37	--	--	--	Khan <i>et al.</i> (2015)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
		Bitter gourd	--	66.73	9.70	9.65	99.00	13.20	19.79	Vivek <i>et al.</i> (2017)
		Bitter gourd	38.97-45.07	41.71	4.48	3.36	56.00	2.16	5.18	Devendra <i>et al.</i> (2018)
		Bitter gourd	36.83-39.40	38.98	5.84	2.74	25.90	--	3.38	Tiwari <i>et al.</i> (2018)
		Bitter gourd	40.66-60.66	--	12.24	8.21	44.99	5.28	11.34	Tyagi <i>et al.</i> (2018)
		Ridge gourd	37.17-63.70	48.47	17.54	16.67	90.49	--	32.68	Singh <i>et al.</i> (2002)
		Ridge gourd	30.40-53.46	42.64	13.69	10.81	62.30	7.49	--	Bhargava <i>et al.</i> (2017)
		Ridge gourd	41.28-56.17	49.07	10.73	7.89	54.07	--	11.95	Karthik <i>et al.</i> (2017)
		Ridge gourd	--	--	14.21	13.88	95.00	--	27.92	Ananthan and Krishnamoorthy (2017)
		Ridge gourd	38.67-56.00	45.89	9.51	7.92	69.34	6.24	13.59	Pushpendra <i>et al.</i> (2017)
		Bottle gourd	51.11-61.78	54.86	--	--	--	--	--	Kumar <i>et al.</i> (2007)
		Bottle gourd	43.22-53.21	43.26	27.26	27.25	99.95	--	55.57	Sharma and Sengupta (2013)
		Bottle gourd	--	55.96	4.10	3.61	77.60	3.67	6.56	Damor <i>et al.</i> (2016)
		Bottle gourd	44.36-66.86	56.40	10.24	9.67	89.00	10.60	18.83	Ipsita and Duhan (2018)
		Cucumber	35.33-39.86	38.02	3.75	2.88	59.13	1.74	4.57	Rajawat and Collis (2017)
		Cucumber	33.25-39.25	--	5.94	4.99	--	--	--	Kandasamy (2017)
		Cucumber	30.76-55.70	46.05	13.76	13.55	96.94	12.66	27.48	Chandan and Singh (2018)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Cucumber	32.29-43.37	--	9.03	8.91	97.00	6.78	18.10	Shah <i>et al.</i> (2018)
		Snake gourd	55.66-79.33	67.23	14.26	10.66	55.88	--	16.42	Rana and Pandit (2011)
		Snake gourd	--	--	5.82	5.08	76.18	--	9.14	Deepa and Mariyappan (2013)
		Snake gourd	69.00-91.00	77.61	7.94	7.73	94.80	12.03	15.50	Khan <i>et al.</i> (2016)
		Muskmelon	32.00-42.00	35.00	6.43	5.88	83.65	--	11.05	Rakhi and Rajamony (2005)
		Muskmelon	46.32-62.67	50.06	6.55	6.39	95.16	6.43	12.84	Mishra <i>et al.</i> (2017)
		Pumpkin	--	--	9.95	8.41	96.49	11.01	14.65	Sultana <i>et al.</i> (2015)
		Pumpkin	--	--	4.25	3.20	56.73	--	--	Sampath and Krishnamoorthy (2017)
		Pumpkin	--	--	6.06	4.64	58.75	4.27	7.33	Ahmed <i>et al.</i> (2018)
		Sponge gourd	--	--	8.95	8.12	82.35	5.24	--	Kumar <i>et al.</i> (2013)
		Spine gourd	51.25-61.75	55.61	5.14	4.12	64.30	3.78	--	Archana <i>et al.</i> (2016)
6.	Days to 50% flowering	Bitter gourd	59.67-74.67	66.04	8.36	4.85	33.70	3.83	--	Yadagiri <i>et al.</i> (2017)
		Bitter gourd	60.67-78.00	71.38	7.96	5.70	51.26	--	8.40	Debendra (2015)
		Cucumber	--	--	187.96	158.81	84.49	6.79	--	Afangideh and Uyoh (2007)
		Snake gourd	65.50-87.66	75.96	11.83	8.95	57.27	--	13.96	Rana and Pandit (2011)
		Ash gourd	82.11-110.25	95.59	8.68	5.91	46.30	--	8.28	Mukesh, (2017)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
		Pumpkin		29.97	9.47	7.82	68.18	--	--	Blessing <i>et al.</i> (2012)
7.	Days to first fruit picking	Bitter gourd	41.75-58.52	52.80	8.72	8.49	94.70	8.96	16.97	Maneesh <i>et al.</i> (2014)
		Bitter gourd	69.67-85.33	76.93	8.17	5.05	38.30	4.95	6.43	Yadagiri <i>et al.</i> (2017)
		Bitter gourd	--	80.67	11.01	10.99	100.00	18.23	22.60	Vivek <i>et al.</i> (2017)
		Bitter gourd	48.34-57.58	53.57	5.37	4.77	79.00	4.68	8.74	Devendra <i>et al.</i> (2018)
		Bitter gourd	45.63-48.56	48.10	4.97	2.18	33.30	--	2.52	Tiwari <i>et al.</i> (2018)
		Bitter gourd	37.00-67.66	--	15.50	14.65	89.27	14.90	28.51	Tyagi <i>et al.</i> (2018)
		Ridge gourd	43.00-65.26	54.61	10.91	7.47	46.80	5.74	--	Bhargava <i>et al.</i> (2017)
		Ridge gourd	50.33-64.33	57.96	7.80	6.23	63.79	5.94	10.25	Pushpendra <i>et al.</i> (2017)
		Bottle gourd	63.20-75.90	68.81	--	--	--	--	--	Kumar <i>et al.</i> (2007)
		Bottle gourd	61.33-96.27	77.71	11.23	10.19	82.34	--	19.04	Mandal <i>et al.</i> (2015)
		Bottle gourd	--	63.85	4.60	3.32	52.00	3.15	4.93	Damor <i>et al.</i> (2016)
		Bottle gourd	55.16-79.60	68.68	8.35	7.89	80.00	10.50	15.36	Ipsita and Duhan (2018)
		Cucumber	--	--	27.44	21.59	61.90	6.77	--	Sandeep <i>et al.</i> (2013)
		Cucumber	51.10-64.10	--	7.32	6.89	--	--	--	Kandasamy (2017)
		Cucumber	29.46-49.80	38.03	12.73	11.32	79.11	7.89	20.74	Chandan and Singh (2018)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Cucumber	50.21-55.31	--	3.77	3.05	66.00	2.67	5.09	Shah <i>et al.</i> (2018)
		Snake gourd	80.33-109.66	94.25	12.26	8.70	--	--	12.73	Rana and Pandit (2011)
		Ash gourd	126.33-135.50	130.18	2.05	1.11	29.30	--	1.23	Mukesh, (2017)
		Muskmelon	50.00-61.00	54.00	4.37	4.12	88.96	--	7.99	Rakhi and Rajamony (2005)
		Pumpkin	--	--	3.08	1.44	22.00	--	--	Sampath and Krishnamoorthy (2017)
		Spine gourd	69.50-90.75	80.00	9.42	7.53	63.80	9.91	--	Archana <i>et al.</i> (2016)
		Sponge gourd	--	--	12.10	10.74	78.72	1.93	--	Kumar <i>et al.</i> (2013)
		Watermelon	69.80-96.80	84.92	10.00	9.58	91.7	16.05	18.90	Saroj <i>et al.</i> (2004)
8.	Fruit length (cm)	Bitter gourd	4.35-18.49	10.35	45.98	45.92	99.70	9.68	93.53	Maneesh <i>et al.</i> (2014)
		Bitter gourd	--	--	10.32	10.05	94.95	3.31	20.18	Rani <i>et al.</i> (2015)
		Bitter gourd	15.55-21.59	--	53.70	52.09	--	--	--	Khan <i>et al.</i> (2015)
		Bitter gourd	5.73-24.77	10.59	35.73	34.16	91.40	7.13	67.32	Yadagiri <i>et al.</i> (2017)
		Bitter gourd	--	17.29	25.85	25.82	100.00	9.19	53.15	Vivek <i>et al.</i> (2017)
		Bitter gourd	11.49-22.68	15.45	17.76	16.49	86.00	4.87	31.52	Devendra <i>et al.</i> (2018)
		Bitter gourd	10.80-11.34	11.20	1.83	1.37	26.70	--	2.69	Tiwari <i>et al.</i> (2018)
		Bitter gourd	8.10-20.80	--	21.80	20.95	92.41	6.48	41.50	Tyagi <i>et al.</i> (2018)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Ridge gourd	12.63-31.33	19.35	32.51	30.49	88.10	--	59.05	Singh <i>et al.</i> (2002)
		Ridge gourd	8.00-34.67	19.16	31.81	26.54	69.63	--	--	Rabbani <i>et al.</i> (2012)
		Ridge gourd	25.26-50.63	34.32	17.79	14.31	64.80	8.14	--	Bhargava <i>et al.</i> (2017)
		Ridge gourd	12.13-32.28	19.52	34.26	33.81	97.40	--	68.74	Karthik <i>et al.</i> (2017)
		Ridge gourd	--	--	27.88	27.69	98.00	--	56.66	Ananthan and Krishnamoorthy (2017)
		Ridge gourd	14.50-32.93	23.56	18.42	17.63	91.58	8.19	34.75	Pushpendra <i>et al.</i> (2017)
		Bottle gourd	30.20-59.80	47.38	--	--	--	--	--	Kumar <i>et al.</i> (2007)
		Bottle gourd	23.20-89.05	37.67	47.40	47.40	99.97	--	96.68	Sharma and Sengupta (2013)
		Bottle gourd	15.93-40.77	28.74	27.46	24.99	82.83	--	46.85	Mandal <i>et al.</i> (2015)
		Bottle gourd	--	30.61	30.45	29.85	96.10	18.46	60.29	Damor <i>et al.</i> (2016)
		Bottle gourd	16.90-47.26	35.97	21.81	20.71	90.00	14.50	40.53	Ipsita and Duhan (2018)
		Cucumber	--	--	30.73	17.13	32.89	0.99	--	Afangideh and Uyoh (2007)
		Cucumber	--	--	21.63	20.47	89.60	5.64	--	Sandeep <i>et al.</i> (2013)
		Cucumber	12.38-19.33	16.22	11.92	11.66	95.67	3.81	23.50	Rajawat and Collis (2017)
		Cucumber	25.47-45.53	--	16.53	16.43	--	--	--	Kandasamy (2017)
		Cucumber	6.43-25.28	16.22	32.52	30.04	85.33	9.27	57.16	Chandan and Singh (2018)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Cucumber	11.94-33.75	--	28.48	28.42	100.00	11.61	58.40	Shah <i>et al.</i> (2018)
		Snake gourd	24.29-73.30	40.51	35.24	23.77	45.49	--	33.02	Rana and Pandit (2011)
		Snake gourd	--	--	47.15	47.15	99.99	--	97.13	Deepa and Mariyappan (2013)
		Snake gourd	18.84-60.08	34.00	27.99	27.91	99.48	19.50	57.36	Khan <i>et al.</i> (2016)
		Spine gourd	5.22-11.30	6.54	29.25	29.09	98.90	3.90	--	Archana <i>et al.</i> (2016)
		Sponge gourd	--	--	16.44	15.96	94.21	7.66	--	Kumar <i>et al.</i> (2013)
9.	Fruit diameter (cm)	Bitter gourd	1.10-4.10	2.39	34.16	33.40	95.60	1.61	67.36	Maneesh <i>et al.</i> (2014)
		Bitter gourd	--	--	6.43	5.63	76.75	1.31	10.16	Rani <i>et al.</i> (2015)
		Bitter gourd	9.86-11.84	--	19.31	15.26	--	--	--	Khan <i>et al.</i> (2015)
		Bitter gourd	2.20-3.93	3.00	17.18	12.35	51.70	0.55	18.33	Yadagiri <i>et al.</i> (2017)
		Bitter gourd	--	4.12	23.81	23.74	99.00	2.01	48.77	Vivek <i>et al.</i> (2017)
		Bitter gourd	2.53-5.43	4.25	24.64	21.39	75.00	1.62	38.25	Devendra <i>et al.</i> (2018)
		Bitter gourd	3.17-3.47	3.36	5.63	4.11	--	--	7.90	Tiwari <i>et al.</i> (2018)
		Bitter gourd	2.36-4.06	--	14.73	13.36	82.30	0.86	24.97	Tyagi <i>et al.</i> (2018)
		Ridge gourd	3.84-5.52	4.63	12.74	8.64	45.71	--	11.99	Singh <i>et al.</i> (2002)
		Ridge gourd	2.33-4.20	3.01	21.42	14.11	43.40	0.57	--	Bhargava <i>et al.</i> (2017)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Ridge gourd	12.05-15.50	13.38	9.79	5.98	37.36	--	7.53	Karthik <i>et al.</i> (2017)
		Ridge gourd	--	--	18.78	18.28	95.00	--	36.68	Ananthan and Krishnamoorthy (2017)
		Ridge gourd	2.23-4.53	3.38	16.45	15.13	84.51	0.97	28.65	Pushpendra <i>et al.</i> (2017)
		Bottle gourd	20.71-54.87	30.83	40.53	40.52	99.97	--	82.64	Sharma and Sengupta (2013)
		Bottle gourd	--	23.66	29.50	28.40	92.70	13.33	56.34	Damor <i>et al.</i> (2016)
		Cucumber	3.17-4.19	3.62	10.60	5.57	--	0.21	6.03	Rajawat and Collis (2017)
		Cucumber	6.26-15.38	--	26.87	26.85	99.83	55.17	55.26	Kandasamy (2017)
		Snake gourd	3.33-9.07	6.79	18.48	17.99	94.79	2.45	36.08	Khan <i>et al.</i> (2016)
		Sponge gourd	--	--	10.72	9.88	84.82	1.83	--	Kumar <i>et al.</i> (2013)
10.	Average fruit weight (g)	Bitter gourd	14.59-59.69	35.33	31.36	31.61	99.90	22.99	65.07	Maneesh <i>et al.</i> (2014)
		Bitter gourd	--	--	11.27	10.43	85.53	14.23	19.86	Rani <i>et al.</i> (2015)
		Bitter gourd	102.70-130.20	--	76.67	56.49	--	--	--	Khan <i>et al.</i> (2015)
		Bitter gourd	22.08-73.23	31.22	39.35	39.17	99.10	25.08	80.33	Yadagiri <i>et al.</i> (2017)
		Bitter gourd	81.95-106.00	97.16	7.91	7.20	83.00	13.12	13.50	Devendra <i>et al.</i> (2018)
		Bitter gourd	66.40-76.53	71.93	4.31	2.70	--	--	4.46	Tiwari <i>et al.</i> (2018)
		Bitter gourd	42.43-129.46	--	28.70	24.42	72.44	37.34	42.82	Tyagi <i>et al.</i> (2018)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
		Bitter gourd	--	73.34	26.85	26.85	100.00	40.56	55.30	Vivek <i>et al.</i> (2017)
		Ridge gourd	102.31-351.68	145.80	43.59	42.29	94.18	--	84.56	Singh <i>et al.</i> (2002)
		Ridge gourd	100.33-124.00	114.78	6.38	4.70	54.20	8.18	--	Bhargava <i>et al.</i> (2017)
		Ridge gourd	90.00-183.00	130.00	22.32	19.00	72.49	--	33.33	Karthik <i>et al.</i> (2017)
		Ridge gourd	--	--	29.41	28.86	96.00	--	58.37	Ananthan and Krishnamoorthy (2017)
		Ridge gourd	101.33-159.67	131.39	10.18	8.80	74.74	20.59	15.67	Pushpendra <i>et al.</i> (2017)
		Cucumber	139.20-177.60	157.21	8.66	7.72	79.51	22.30	14.18	Rajawat and Collis (2017)
		Cucumber	480.00-1460.00	--	29.79	27.94	88.00	47.52	54.00	Kandasamy (2017)
		Cucumber	182.98-371.87	287.89	14.91	14.79	98.51	87.09	30.25	Chandan and Singh (2018)
		Cucumber	111.76-225.76	--	19.56	19.47	99.00	64.03	39.92	Shah <i>et al.</i> (2018)
		Snake gourd	291.36-516.83	370.24	19.28	11.37	34.80	--	13.82	Rana and Pandit (2011)
		Snake gourd	87.50-325.00	198.89	31.63	31.61	99.89	129.46	65.09	Khan <i>et al.</i> (2016)
		Sponge gourd	--	--	22.77	22.49	97.60	67.94	--	Kumar <i>et al.</i> (2013)
		Spine gourd	5.14-7.83	6.15	11.36.	10.90	92.10	1.33	--	Archana <i>et al.</i> (2016)
11.	Number of fruits per	Bitter gourd	8.51-21.30	15.07	25.34	25.27	99.50	7.20	47.78	Maneesh <i>et al.</i> (2014)
		Bitter gourd	19.67-30.00	--	58.79	73.92	--	--	--	Khan <i>et al.</i> (2015)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
	vine	Bitter gourd	--	--	15.32	14.80	93.35	6.16	29.47	Rani <i>et al.</i> (2015)
		Bitter gourd	9.33-19.47	12.54	23.39	19.81	71.80	4.34	34.60	Yadagiri <i>et al.</i> (2017)
		Bitter gourd	--	40.28	11.75	11.74	100.00	9.74	24.18	Vivek <i>et al.</i> (2017)
		Bitter gourd	19.71-28.01	21.13	12.29	10.75	77.00	4.68	19.38	Devendra <i>et al.</i> (2018)
		Bitter gourd	13.76-19.76	17.83	10.18	5.78	--	--	8.67	Tiwari <i>et al.</i> (2018)
		Bitter gourd	17.96-33.80	--	19.36	13.76	50.50	4.88	20.14	Tyagi <i>et al.</i> (2018)
		Ridge gourd	3.26-11.78	5.70	52.11	48.42	86.27	--	92.59	Singh <i>et al.</i> (2002)
		Ridge gourd	4.67-19.00	9.96	40.36	39.28	94.96	--	--	Rabbani <i>et al.</i> (2012)
		Ridge gourd	12.23-19.06	15.11	15.76	10.10	41.10	2.01	--	Bhargava <i>et al.</i> (2017)
		Ridge gourd	4.09-13.15	7.79	36.72	35.09	91.35	--	69.09	Karthik <i>et al.</i> (2017)
		Ridge gourd	--	--	15.33	14.96	95.00	--	30.06	Ananthan and Krishnamoorthy (2017)
		Ridge gourd	12.47-24.40	18.71	16.45	15.38	87.34	5.54	29.60	Pushpendra <i>et al.</i> (2017)
		Bottle gourd	3.25-7.25	4.72	--	--	--	--	--	Kumar <i>et al.</i> (2007)
		Bottle gourd	5.40-16.33	7.89	40.33	39.87	97.72	--	80.48	Sharma and Sengupta (2013)
		Bottle gourd	2.10-5.30	3.35	29.55	23.44	62.91	--	38.29	Mandal <i>et al.</i> (2015)
		Bottle gourd	--	5.66	19.85	17.66	79.20	1.84	32.37	Damor <i>et al.</i> (2016)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Bottle gourd	5.16-9.33	6.86	17.94	16.73	86.00	2.22	32.12	Ipsita and Duhan (2018)
		cucumber	1.13-2.31	1.57	19.88	19.86	99.75	0.64	40.86	Rajawat and Collis (2017)
		cucumber	6.20-15.80	--	29.04	25.19	75.28	33.91	45.04	Kandasamy (2017)
		cucumber	3.30-8.30	5.60	18.50	17.68	91.35	1.95	34.82	Chandan and Singh (2018)
		cucumber	11.28-20.97	--	22.15	21.83	97.00	6.47	44.33	Shah <i>et al.</i> (2018)
		Snake gourd	3.00-6.66	4.41	31.55	15.82	25.15	--	16.34	Rana and Pandit (2011)
		Snake gourd	--	--	22.77	22.77	99.97	--	46.89	Deepa and Mariyappan (2013)
		Snake gourd	9.00-44.00	19.00	45.60	45.39	99.11	17.68	93.09	Khan <i>et al.</i> (2016)
		Pumpkin	--	--	34.85	29.16	70.00	--	--	Sampath and Krishnamoorthy (2017)
		Sponge gourd	--	---	14.01	13.40	91.54	6.72	--	Kumar <i>et al.</i> (2013)
12.	Fruit yield per vine (kg)	Bitter gourd	0.48-1.99	1.12	41.55	40.52	95.20	0.91	81.25	Maneesh <i>et al.</i> (2014)
		Bitter gourd	2.2-3.142	--	25.52	20.83	--	--	--	Khan <i>et al.</i> (2015)
		Bitter gourd	--	--	22.42	21.95	95.87	0.67	44.27	Rani <i>et al.</i> (2015)
		Bitter gourd	1.44-12.94	3.91	71.79	71.68	99.70	577.63	147.45	Yadagiri <i>et al.</i> (2017)
		Bitter gourd		2.58	33.96	33.95	100.00	1.80	69.93	Vivek <i>et al.</i> (2017)
		Bitter gourd	0.85-2.61	--	23.10	19.69	72.67	0.64	34.58	Tyagi <i>et al.</i> (2018)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Bitter gourd	171-794	142	18.77	11.55	38.00	0.21	14.63	Devendra <i>et al.</i> (2018)
		Ridge gourd	0.36-1.77	0.82	62.19	57.32	88.46	--	113.34	Singh <i>et al.</i> (2002)
		Ridge gourd	307.5-2467.50	952.77	59.77	58.00	94.16	--	--	Rabbani <i>et al.</i> (2012)
		Ridge gourd	1.21-3.31	2.11	26.29	24.21	84.80	0.97	--	Bhargava <i>et al.</i> (2017)
		Ridge gourd	0.52-1.64	0.96	38.59	95.41	84.23	--	69.95	Karthik <i>et al.</i> (2017)
		Ridge gourd	--	--	32.86	31.55	92.00	--	62.39	Ananthan and Krishnamoorthy (2017)
		Ridge gourd	1.35-3.05	2.21	23.96	19.78	68.14	0.74	33.63	Pushpendra <i>et al.</i> (2017)
		Bottle gourd	5.77-9.61	5.64	24.19	29.54	83.10	2.15	45.52	Kumar <i>et al.</i> (2007)
		Bottle gourd	5.34-16.35	9.69	38.45	38.02	97.83		76.78	Sharma and Sengupta (2013)
		Bottle gourd	3.02-10.42	6.96	26.94	26.61	97.50	3.77	54.12	Suruchi (2014)
		Bottle gourd	2.00-4.00	2.74	22.64	20.41	81.29	--	37.91	Mandal <i>et al.</i> (2015)
		Bottle gourd	3.50-7.26	5.30	14.77	12.91	76.00	1.23	23.25	Ipsita and Duhan (2018)
		Cucumber	1.13-2.31	1.57	19.88	19.86	99.75	0.64	40.86	Rajawat and Collis (2017)
		cucumber	5.69-16.20	--	33.82	31.78	88.31	--	61.52	Kandasamy (2017)
		cucumber	48.80-144.48	89.81	24.62	24.11	95.91	43.69	48.65	Chandan and Singh (2018)
		cucumber	1.73-3.01	--	18.92	18.16	92.00	0.82	34.93	Shah <i>et al.</i> (2018)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)	References
		Snake gourd	1.10-2.24	1.61	32.76	13.33	16.56	--	11.17	Rana and Pandit (2011)
		Snake gourd	--	--	29.46	29.46	99.99	--	60.69	Deepa and Mariyappan (2013)
		Snake gourd	1.10-8.36	3.68	50.17	49.88	98.86	3.76	102.17	Khan <i>et al.</i> (2016)
		pumpkin	--	--	40.27	33.88	71.04	--	--	Sampath and Krishnamoorthy (2017)
		Sponge gourd	--	--	29.92	29.48	97.13	2.63	59.86	Kumar <i>et al.</i> (2013)
13.	Number of seeds per fruit	Bitter gourd	6.61-18.19	11.79	26.15	26.13	99.90	6.34	53.77	Maneesh <i>et al.</i> (2014)
		Bitter gourd	--	--	9.40	3.95	17.67	0.67	3.42	Rani <i>et al.</i> (2015)
		Bitter gourd	5.33-20.65	14.834	24.742	22.42	82.10	6.212	41.879	Subhasmita (2015)
		Bitter gourd	6.00-18.5	10.76	34.13	32.7	91.80	6.95	64.59	Yadagiri <i>et al.</i> (2017)
		Bottle gourd	356.10-497.5	414.29	8.66	10.02	74.80	63.93	15.43	Kumar <i>et al.</i> (2007)
		Bottle gourd	--	--	56.06	53.80	92.11	--	--	Deepthi <i>et al.</i> (2016)
		Cucumber	143.33-315.00	--	24.78	24.57	98.00	97.15	50.16	Shah <i>et al.</i> (2018)
		Snake gourd	34.50-75.66	50.57	25.31	19.34	58.39	--	30.45	Rana and Pandit (2011)
		Snake gourd	--	--	22.77	22.77	99.97	--	46.89	Deepa and Mariyappan (2013)
		Ash gourd	230.66-750.25	449.48	28.21	27.45	94.70	--	55.01	Mukesh, (2017)
		Muskmelon	388.00-1103.00	580.00	27.88	25.99	87.11	--	49.98	Rakhi and Rajamony (2005)

Sl. No.	Character	Crop	Range	Mean	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
		Pumpkin	--	315.4	30.925	30.575	97.75	--	--	Blessimg <i>et al.</i> (2012)
		Sponge gourd	--	--	27.15	26.90	98.17	78.68	54.19	Kumar <i>et al.</i> (2013)
C.	Quality parameters									
14.	Flesh thickness (mm)	Bitter gourd	--	--	6.68	6.06	82.20	0.42	11.32	Rani <i>et al.</i> (2015)
		Kakri	1.67-3.33	2.50	24.46	22.29	83.07	1.04	41.86	Jat <i>et al.</i> (2014)
		Pumpkin	--	--	18.21	16.31	80.28	1.09	31.05	Ahmed <i>et al.</i> (2018)
15.	Ascorbic acid (mg)	Bitter gourd	92.15-122.07	--	19.87	19.75	--	--	--	Dey <i>et al.</i> (2006)
		Bitter gourd	--	57.79	40.03	37.89	89.00	--	62.48	Mudassar, (2015)
		Bitter gourd	--	86.73	10.68	10.56	98.00	18.65	21.50	Vivek <i>et al.</i> (2017)
		Bottle gourd	--	6.94	9.75	8.71	79.80	1.11	16.03	Damor <i>et al.</i> (2016)
		Cucumber	6.44-7.10	6.78	3.33	2.86	73.43	0.34	5.04	Rajawat and Collis (2017)

Eleven exotic and six indigenous cultivars of cucumber (*Cucumis sativus*) were evaluated by Afangideh and Uyoh (2007) for yield and quality characteristics. Linear correlation analyses showed that mean fruit number per plant and length of vine at 6 weeks were significantly and positively associated with yield ($P < 0.001$ and 0.01 , respectively).

Kumar *et al.* (2008) revealed high and positive correlation between fruit yield per vine, number of fruits per vine, average fruit weight, number of nodes per vine and yield in bitter gourd.

Islam *et al.* (2009) found that fruit yield per plant had positively and significantly correlated with number of nodes per vine. They were also revealed maximum direct contribution towards yield per plant with number of fruit per plant followed by vine length in bitter gourd.

Botau *et al.* (2010) demonstrated that the fruit yield per vine had significant and positive correlation with number of fruits per vine, fruit weight, fruit length and fruit diameter in bitter gourd.

Correlation studies revealed that fruit yield had significant positive correlation with total number of fruits, total number of primary branches and total number of nodes in snake gourd (Rana and Pandit 2011).

Rabbani *et al.* (2012) studied correlation co-efficients in 60 genotypes of ridge gourd for yield versus eight important yield contributing traits and reported that fruit yield per vine had highly significant positive relationship with the number of fruits per vine, average fruit weight, vine length at harvest and length of fruit.

Resmi and Sreelathakumary (2012) observed that fruit length, fruit girth, average fruit weight, seeds per fruit and 1000-seed weight had positive and significant correlation with fruit yield in ash gourd.

Vine length in bitter gourd had significant and positive correlation with number of nodes per vine, internodal length, fruit width and number of fruits per vine. Number of primary branches per vine had significant and negative correlation with internodal length and significant positive correlation with fruit length (Yadav *et al.*, 2013).

The correlation analysis among 12 genotypes of bitter gourd showed by Mudassar (2015) that first male flower node had higher positive than genetic association with pH (0.679) than first female flower node with pH (0.787). Highest positive correlation of yield per plot was observed with TSS (0.0887 °Brix) among all the traits.

Pathak *et al.* (2014) found that the number of fruits per plant had significant positive correlation for fruit yield. Fruit yield was found to be directly correlated with fruit weight, number of fruits per plant and fruit length, hence selection based on these characters would be more rewarding in bitter gourd.

Choudhury *et al.* (2014) study was carried out to determine correlation and path analysis in hermaphrodite ridge gourd for eight quantitative characters. The results revealed that significant positive correlation was found between fruit yield per plant and fruit weight (0.877), number of fruits per cluster (0.590) and fruit length (0.356) at phenotypic level. Significantly negative and desirable correlation at phenotypic level was observed between fruit yield per plant and days to first fruit harvest (-0.403), days to first hermaphrodite flower (-0.337) and node at which first hermaphrodite flower appeared (-0.315).

Mandal *et al.* (2015) evaluate the 27 genotypes of bottle gourd for 8 quantitative characters. Fruit yield/plant was positively and significantly correlated (at genotypic and phenotypic level) with fruit length and fruits number/plant. Negative associations of fruit yield/plant were noted with node number of first female flower, sex ratio and days to first harvest.

Correlation and path analysis were carried out in 30 germplasm of bitter gourd by Hemant *et al.* (2015). The characters like number of fruits per plant and fruit length had significant and positive correlation with yield. Number of fruits per plant and average fruit weight had the highest positive direct effect on fruit yield per plant.

Janaranjani and Kanthaswamy (2015) conducted an experiment with 18 different characters in bottle gourd comprising 36 hybrids and correlation studies reveals that fruit yield was positively and significant correlated with fruit flesh thickness, number of fruits per vine and number of fruit pickings.

Gupta *et al.* (2015) studied the correlation for 26 genotypes of bitter gourd. Genotypic correlation co-efficients were high in magnitude than phenotypic correlation co-efficients. Phenotypic correlation co-efficient among different characters showed that total marketable fruit yield per hectare had positive and significant association with average fruit weight (0.726) followed by marketable fruits per vine (0.547), seeds per fruit (0.377) at 1% level of significance. Average fruit weight had positive significant correlation with seeds per fruit (0.227). Marketable fruits per vine were positively correlated with seeds per fruit (0.315).

Khan *et al.* (2016) studied correlation in 21 genotypes of snake gourd. Studies revealed that the fruit yield had a significant, positive correlation with the number of fruits per vine, length of fruit and single fruit weight.

Yadagiri *et al.* (2017) studied 20 genotypes of bitter gourd for evaluating their performance for various horticultural characters. There was a great deal of significant correlation for all the characters among the genotypes. Correlation analysis revealed that length of vine (0.640), number of branches per vine (0.577), number of male flowers per vine (0.594), number of female flowers per vine (0.529), number of fruits per vine (0.649), length of fruit (0.724), weight of fruit (0.961), number of seeds fruit (0.360), seed weight per fruit (0.380) had significant positive correlation for yield.

2.4 Path co-efficient analysis

Srivastava and Srivastava (1976) in an experiment with 10 lines of bitter gourd reported that number of female flowers per plant have maximum direct effect on yield (+2.7544) followed by number of fruits per plant (+0.9031) and further study revealed the contribution of almost all the characters through number of female flowers per plant and number of fruits per plant.

Lal and Singh (1997) observed that in muskmelon (*Cucumis melo*) that highest direct effect on total fruit yield per vine was exhibited by number of fruits per vine (2.1388) followed by weight per fruit (1.6433) at both genotypic and phenotypic levels.

Sharma and Bhutani (2001) observed that fruits per plant had the highest direct contribution towards yield followed by, fruit length and diameter while vine length had the highest indirect contribution towards yield followed by internode length. Thus, suggesting that selection for more number of fruits per plant, vine length, average fruit weight, fruit length and diameter which lead to development of high yielding cultivars of bitter gourd.

Pandey *et al.* (2003) reported that the fruit weight and fruit length followed by number of fruits per plant and node number at which first male flower appears had maximum direct effect on yield and suggested that fruit length, fruit breadth and number of fruits per plant should be considered as selection criteria for yield improvement in snap melon breeding programme.

Bhave *et al.* (2003) studied the correlation and path co-efficients in bitter gourd. Vine length, branch number per vine, fruit length, average fruit weight, seed number per fruit had the high positive direct effects on yield per vine.

Dey *et al.* (2005) revealed that fruit weight of bitter gourd had direct effect on yield followed by number of fruits per plant and fruit length. Ascorbic acid content and total carotenoid content had a strong negative indirect effect on yield through fruit weight, fruit length and fruit diameter.

Kumar *et al.* (2008) revealed higher and positive direct effect on fruit yield of cucumber exerted by number of fruits per plant followed by number of primary branches per plant and fruit diameter.

Kumar *et al.* (2011) revealed that average fruit weight had maximum positive direct effect on yield followed by harvest duration, marketable fruits per plant and total soluble solids, whereas negative direct effect of fruit length and breadth, days to marketable maturity, seed germination, fruit length and node number bearing first female flower was observed on yield of 30 diverse cucumber genotypes.

Kumar *et al.* (2011) while studying path analysis in cucumber found maximum positive direct effect on yield for total number of fruits per vine followed by number of primary branches per vine, vine length and days to first male flower, whereas, negative and maximum direct effect on yield was observed for days to first female flower followed by number of marketable fruits per vine, fruit diameter, days to first fruit harvest, number of misshaped fruits per vine and fruit length.

Rabbani *et al.* (2012) studied variability and diversity analysis in 60 genotypes of ridge gourd (*Luffa acutangula* Roxb.). Path co-efficient analysis showed that number of fruits per plant exhibited the highest positive direct effect (0.7192) on yield followed by average fruit weight (0.4656).

Yadav (2013) reported that the genotypic co-efficient analysis showed highest positive direct effect for yield per vine, followed by number of fruits per vine, fruit weight, days to first appearance of male flower, number of nodes per vine, vine length with the dependent variable yield per hectare in bitter gourd. On the other hand, negative and direct effect was observed for the character fruit width, fruit length, first effective node, days to first appearance of female flower, internodal length and number of primary branches per vine with the dependent variable yield per hectare.

Dalamu and Behera (2013) observed that the number of fruits per plant, fruit weight and ovary length had high phenotypic and genotypic direct effects on fruit yield per plant, revealing that indirect selection for these traits would be effective in improving fruit yield per plant in bitter gourd.

Nature and magnitude of genetic diversity in 25 bitter gourd genotypes were estimated on 10 quantitative traits by Maneesh *et al.* (2014). The path co-efficient analysis based on fruit diameter as a dependent variable implicated that plant height had the highest positive direct effect on fruit yield.

A study was carried out to determine path analysis in hermaphrodite ridge gourd for 8 quantitative characters. The results revealed that maximum direct and desirable effect on fruit yield per plant was exerted by fruit length (0.850), number of fruits (0.334), days to first fruit harvest (-0.019) and node at which first hermaphrodite flower appeared (-0.057) at phenotypic level (Choudhury *et al.* 2014)

Janaranjani and Kanthaswamy (2015) conducted an experiment with 18 different characters in bottle gourd comprising 36 hybrids and observed that the number of fruits per vine, days to first female flower opening, fruit cavity and fruit weight had positive direct effect on fruit yield in bottle gourd.

Joydip *et al.* (2015) evaluated the 27 genotypes of bottle gourd for 8 quantitative characters. Path analysis revealed that days to first harvest (2.783) and fruit girth (1.356) had very high positive direct effect on fruit yield/plant.

2.5 Evaluation of bitter gourd genotypes against powdery mildew disease under natural condition

Murlee *et al.* (2008) recorded lower powdery mildew infestation percentage in JMC-22, VRBT-89, VRBT-6-9, IC-85635A, MC-56, IC-85612, JMC-4, S-17 and maximum infestation was recorded in CO-1 showing that JMC-22 was least susceptible and CO-1 was most susceptible to powdery mildew infestation in bitter gourd.

In muskmelon, Patil (2014) reported that the cross 5 (IVMM-3 × Punjab Sunheri) showed the least incidence of powdery mildew (13.34 & 22.14%), in both summer and *kharif* seasons respectively in F₂ generation which can be further exploited for obtaining tolerant variety against them.

Twenty three cucumber genotypes were screened by Parameshwar (2018) against *E. cichoracearum* under natural epiphytotic conditions in the field to identify the resistance source during late *Kharif* 2016. None were found to be immune and resistant. However, fifteen genotypes *viz.*, Swathi, BSS-949, JK-special, Mahy Sylvia, Malini, Shirakawa, Yummy, Kareena, Green Long, Ajeeth-99, White Long, Encounter-962, Shalini, Ranebennur Local and Sarpan hybrid were found to be moderately resistant. Five genotypes *viz.*, Chetak, Gullakai, Khushi, Sribasava and Harini were found to be moderately susceptible. Mangalore Local, Dharwad Green and Chitra showed highly susceptible reaction.

Five bitter gourd breeding lines (THMC 113, THMC 143, THMC 153, THMC 167, and THMC 170) were selected and evaluated for resistance potential of these 5 inbred lines against local isolates of Px at 12 locations in five Asian countries. Plants were inoculated with the respective local *Podosphaera xantii* (Px) isolate 15 and 30 days after transplanting and additional Px-infected plants of the inoculated control were interplanted throughout each test. Plants were rated 60 days after transplanting for CPM reaction using a 0 (no evidence of infection) to 5 (>75% infection evident on individual leaves) disease severity scale. THMC 153 and THMC 167 were resistant to the local race of Px in all locations, whereas THMC 143 was observed resistant in all test locations except one in China. THMC 113 was resistant in each location except one in India. THMC 170 was susceptible in three locations in India (Dhillon *et al.* 2018).

III. MATERIAL AND METHODS

The study on “Genetic diversity and character association studies in bitter gourd (*Momordica charantia* L.)” was undertaken during *kharif* 2017. The details of the materials used and techniques adopted are presented in this chapter.

3.1 Experimental site

The experiment was conducted at the Department of Vegetable Science, College of Horticulture, Yelachenahalli, Mysuru district, Karnataka.

3.2 Location and climate

The experimental site is located at an altitude of 758 meters above mean sea level (MSL), at 12°22' N latitude and 76°31'E longitude. Mysuru, which comes under Southern Dry Zone of agroclimatic zones of Karnataka, has the benefits of both south-west and north-east monsoons. The average rainfall of this area is 671.4 mm. The soil of the experimental site comprised of medium red loamy soil with a pH range of 6.0-6.5. The maximum and minimum temperatures of the station during the experiment period were 28.4°C and 16.9°C respectively. The other meteorological observations of the site are furnished in Appendix-I.

3.3 Details of experiment

3.3.1 Design

The experiment was laid out in a randomized complete block design (RCBD) with two replications. Each genotype in a replication was represented by a plot of 10.8 m² with 10 plants.

3.3.2 Experimental material

Present study was carried out with 40 genotypes collected from different sources are listed below

Sl. No.	Genotypes	Source
1	Preethi	KAU, Vellanikkara
2	Yellapur Local-2	Yellapur, Karnataka
3	Bit-25-2-1	COH, Kolar, Karnataka
4	Meghnaa-2	Masood seeds, Bangladesh
5	Jhalawar Local-3	Jalawar, Rajasthan
6	CO-1	TNAU, Coimbatore
7	Bit-22-1-1-3	COH, Kolar, Karnataka
8	Bit-9-2-4-1	Maharashtra
9	GYB-3-1-2	Tamil Nadu
10	Bit-1-2-3	COH, Kolar, Karnataka
11	Yellapur Local-1	Yellapur, Karnataka
12	Bit-37-2-1	COH, Kolar, Karnataka
13	DEB-505	Debgiri Pvt Ltd. Kolkatta
14	Bit-3-1-2-1	Tamil Nadu
15	Bit-9-3-2-3	Maharashtra
16	Bit-5-1-2-1	COH, Kolar, Karnataka
17	West Bengal Local-1	West Bengal
18	Jhalawar Local-2	Jalawar, Rajasthan
19	Super Green	Super Seeds, Odissa
20	IC-68238	NBPGR, New Delhi

Sl. No.	Genotypes	Source
21	Bit-10-1-1	COH, Kolar, Karnataka
22	West Bengal Local-2	West Bengal
23	Kotla Local-1	Rajasthan
24	Bit-10-1-2	COH, Kolar, Karnataka
25	Bit-5-1-4-1	COH, Kolar, Karnataka
26	Contai Bolder	Barasat Agri Hybrid seeds, West Bengal
27	Bit-1-2-2-4	COH, Kolar, Karnataka
28	Bit-18-1-1	Varanasi, Uttar pradesh
29	Jhalawar Local-1	Jalawar, Rajasthan
30	Bit-3-1-1-1	Tamil Nadu
31	GYB-5-1-5-2	COH, Kolar, Karnataka
32	Bit-22-1-1-1	COH, Kolar, Karnataka
33	Bit-9-2-1-2	Maharashtra
34	GYL-2	COH, Kolar, Karnataka
35	GYB-2-2	COH, Kolar, Karnataka
36	Katahi	Hyderabad
37	Bit-35-1-1	Odisha
38	Bit-31-2-2	COH, Kolar, Karnataka
39	Arka Harit	IIHR, Bengaluru
40	Bit-9-1-4-1	Maharashtra

3.4 Preparation of experimental plot and planting

The experimental field was brought to fine tilth by repeated ploughing. The recommended dose (25 t/ha) of FYM was given as basal dose and chemical fertilizers such as 63 kg of nitrogen, 50 kg phosphorous and 50 kg potassium per hectare were also incorporated in the soil before final harrowing. Ridges are opened with a distance of 120 cm. Healthy and uniform seedlings were transplanted on one side of the ridges with a spacing of 90 cm between the vines. Regular irrigation and hand weeding operations were carried out. Three weeks after transplanting, plants were supported with iron poles tied with galvanised wire and tying of vines to wire was regularly carried out. Other operations including plant protection measures, which are not specified, work carried out as per recommended package of practices of University of Horticultural Sciences, Bagalkot (Anon., 2010). General view of experimental plot is depicted in plate-1.

3.5 Observations recorded

Five randomly chosen plants in each replication of each entry were labelled and used for recording the observations. The mean of five plants was taken for analysis. The characters studied and techniques adopted to record the observations are given below.

3.5.1 Growth parameters

3.5.1.1 Vine length (m)

Length of the vine was measured in metres with a measuring tape from the base to the tip of the vine at the time of final harvest and the average was taken.

3.5.1.2 Number of branches per vine

The number of branches arising from the main vine was recorded during final harvest.

3.5.1.3 Duration of crop (days)

The number of days required to last fruit harvesting from the date of transplanting was recorded for each entry.



R I



R II

Plate 1: General view of experimental plot

3.5.2 Earliness parameters

3.5.2.1 Node at which first female flower appears

The node number from cotyledons leaves to the node at which the first female flower appeared was recorded and the average was taken.

3.5.2.2 Days to first female flower opening

The number of days taken from date of transplanting to the first female flower opening was recorded and the average was taken.

3.5.2.3 Days to 50 per cent flowering

The number of days taken from date of transplanting to the first female flower opening on 5 plants out of 10 plants was recorded.

3.5.2.4 Days to first fruit picking

The number of days taken from day of transplanting to the first harvest of fruits was recorded for 5 plants and the average was taken.

3.5.3 Yield components

3.5.3.1 Fruit length (cm)

The length of each fruit from the peduncle to the distal end was measured with scale and average was taken.

3.5.3.2 Fruit diameter (cm)

The diameter of each fruit was measured at the centre with the help of digital Vernier callipers and average diameter was taken.

3.5.3.3 Average fruit weight (g)

The five fruits were randomly taken from each genotype and their mean fruit weights were measured in grams.

3.5.3.4 Number of fruits per vine

The total number of fruits per vine of all harvests was recorded for five vines and the average was taken.

3.5.3.5 Fruit yield per vine (kg)

Total weight of fruits harvested from each selected vine was taken and mean values were worked in kilograms.

3.5.3.6 Fruit yield per hectare (t)

The yield per hectare was calculated by multiplying the yield per plant (kg) with the number of plants per hectare and expressed in tonnes per hectare.

3.5.3.7 Number of seeds per fruit

Total number of seeds from five randomly selected ripe fruits were counted and then averaged to obtain number of seeds per fruit.

3.5.4 Quality parameters

3.5.4.1 Flesh thickness (mm)

The fruit were cut open horizontally and the flesh thickness was measured by using digital vernier callipers for five randomly selected fruits and the average was expressed in millimetres.

3.5.4.2 Ascorbic acid (mg/100g)

Ascorbic acid was determined by titrating a known weight of sample with 2,6-dichlorophenol-indophenol dye using metaphosphoric acid as stabilizing agent (Albrecht 1993). Known weight of the sample was ground in pestle and mortar with 3 per cent meta phosphoric acid. Volume was made up to 100 ml and filtered. Ten ml of aliquot was titrated against 2,6-dichlorophenol-indophenol dye. The dye factor was calculated by titrating standard ascorbic acid solution against dye.

3.5.5 Disease incidence

3.5.5.1 Evaluation of bitter gourd genotypes against powdery mildew disease under natural conditions

The per cent powdery mildew incidence was recorded under natural epiphytic condition as per cent plant infected in each genotype which were scored from zero to four scales as given below (Girish, 2011 and Rana *et al.*, 2013).

Sl. No.	Score	Symptoms	Disease reaction
1	0	No symptoms	Immune
2	1	1 to 25 per cent foliage infected	Resistance
3	2	26 to 50 per cent foliage infected	Moderately resistant
4	3	50 to 75 per cent foliage infected	Susceptible
5	4	> 75 per cent foliage infected	Highly susceptible

3.6 Statistical and biometrical analysis

3.6.1 Analysis of variance

Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1961) using the mean values of random plants in each replication from all treatments to find out significance of treatment effects.

Source of Variation	df	SS	MSS	Cal.F
Replication	(r-1)	RSS	RSS/(r-1)	
Treatments	(t-1)	TrSS	TrSS/(t-1)	TrMSS/EMSS
Error	(r-1) (t-1)	ESS	ESS/(t-1) (r-1)	
Total	(rt-1)	TSS		

where,

- r = number of replications
- t = number of genotypes
- RSS = Mean sum of square due to replications
- TrMSS = Mean sum of square due to genotypes
- EMSS = Mean sum of square due to error

The significance of treatments mean squares and replication mean squares were tested by comparing cal.F with table 'F' values at 5 and 1 per cent level of probability.

3.6.2 Genetic divergence

Mahalanobis (1936) D^2 statistic was used for assessing the genetic divergence between different populations. The D^2 analysis was carried out using the data recorded on germplasms. Mahalanobis generalized distance (D^2) between any two populations is given by the formula

$$D^2 = \sum \lambda^{ij} \sigma^i \sigma^j$$

Where,

- D^2 = Square of generalized distance
- λ^{ij} = Reciprocal of the common dispersal index
- $\sigma^i = \mu_{i1} - \mu_{i2}$
- $\sigma^j = \mu_{j1} - \mu_{j2}$
- μ = General mean

Since the formula for computation requires inversion of higher order determinants, transformation of the original correlated unstandardized character mean (Xs) to standardise uncorrelated variable (Ys) was done to simplify the computational procedure. The D^2 values were obtained as the corresponding uncorrelated (Ys) values of any two uncorrelated genotypes (Rao, 1952).

3.6.2.1 Clustering D^2 values

All the $\frac{n(n-1)}{2} D^2$ values were clustered using Toucher's method (Rao, 1952).

3.6.2.2 Intra and inter-cluster distance

The intra and inter-cluster distances were calculated by following the formula described by Singh and Choudhary (1977).

$$\text{Square of intra cluster distance} = \frac{\sum D_i^2}{N}$$

Where,

$\sum D_i^2$ = Sum of distances between all possible combinations of the entries included in the cluster
N = Number of all possible combinations

$$\text{Square of inter-cluster distance} = \frac{\sum D_{ij}^2}{n_i n_j}$$

Where,

$\sum D_{ij}^2$ = Sum of distances between all possible combinations ($n_i n_j$) of the entries included in the cluster
 n_i = Number of entries in the cluster i
 n_j = Number of entries in the cluster j

3.6.3 Estimation of genetic variability parameters

Genotypic and phenotypic co-efficients of variation were estimated according to Burton and Devane (1953) based on estimate of genotypic and phenotypic variance.

3.6.3.1 Genotypic co-efficient of variation (GCV)

$$\text{Genotypic co-efficient of variation (\%)} = \frac{\sqrt{V_g}}{\bar{X}} \times 100$$

3.6.3.2 Phenotypic co-efficient of variation (PCV)

$$\text{Phenotypic co-efficient of variation (\%)} = \frac{\sqrt{V_p}}{\bar{X}} \times 100$$

where,

- $\bar{X}$ = Grand mean
- r = Number of replications
- V_g = Genotypic variance
- V_p = Phenotypic variance

GCV and PCV were classified as suggested by Burton and Devane (1953)

0-10%	:	Low
10-20%	:	Moderate
20% and above	:	High

3.6.3.3 Heritability (h^2)

Heritability in broad sense for all the characters were computed as the ratio of genetic variance to phenotypic variance as suggested by Hanson *et al.* (1956) and expressed in percentage.

$$h^2 = \frac{V_g}{V_p} \times 100$$

Where,

- h^2 (%) = Heritability (Broad sense)
- V_g = Genotypic variance
- V_p = Phenotypic variance

Heritability (B.S) was classified as suggested by Searle (1965)

Below 40%	=	Low
40-60%	=	Moderate
60-80%	=	High
Above 80%	=	Very high

3.6.3.4 Genetic advance

Genetic advance for each character was predicted by the formula given by Johnson *et al.* (1955).

$$GA = h^2 \times p \times k$$

Where,

- k = selection differential (2.06) at 5 per cent selection intensity
- h^2 = Heritability in broad sense
- p = Phenotypic standard deviation

3.6.3.5 Genetic advance over per cent of mean (GAM)

Genetic advance as percentage over mean was worked out as suggested by Johnson *et al.* (1955).

$$GAM = \frac{GA}{\bar{X}} \times 100$$

Where,

GA = Genetic advance
 $\bar{X}$ = General mean

The genetic advance as per cent of mean was categorized as suggested by Johnson *et al.* (1955) and the same is given below.

0-10%	:	Low
11-20%	:	Moderate
20% and above	:	High

3.6.4 Correlation analysis

The correlation coefficients were calculated to determine the degree of association of character with yield, quality and its components. Phenotypic and genotypic correlation coefficients were estimates employing formula (Al-Jibouri *et al.*, 1958).

$$\text{Phenotypic correlation} = r_{xy} (p) = \frac{\text{Cov}_{xy} (p)}{\sqrt{V_x (p) \times V_y (p)}}$$

$$\text{Genotypic correlation} = r_{xy} (g) = \frac{\text{Cov}_{xy} (g)}{\sqrt{V_x (g) \times V_y (g)}}$$

Where,

$\text{Cov}_{xy}(G)$	=	Genotypic covariance between x and y
$\text{Cov}_{xy}(P)$	=	Phenotypic covariance between x and y
$V_x(G)$	=	Genotypic variance of character 'x'
$V_x(P)$	=	Phenotypic variance of character 'x'
$V_y(G)$	=	Genotypic variance of character 'y'
$V_y(P)$	=	Phenotypic variance of character 'y'

The test of significance for association between characters was done by comparing table 't' values at n-2 error degrees of freedom for phenotypic and genotypic correlations with estimated values, respectively.

3.6.4 Path co-efficient analysis

The path co-efficient analysis was performed as given by Wright (1921) and Dewey and Lu (1959). The following set of simultaneous equations were formed and solved for estimating direct and indirect effects.

$$r_{1y} = a + r_{12}b + r_{13}c + \dots + r_{11i}$$

$$r_{2y} = r_{21}a + b + r_{23}c + \dots + r_{21i}$$

$$r_{3y} = r_{31}a + r_{32}b + c + \dots + r_{31i}$$

$$r_{ly} = r_{l1}a + r_{l2}b + r_{l3}c + \dots + l$$

Where,

r_{1y} to l_{iy} = Correlation co-efficients between causal factors 1 to l with dependent character Y

r_{12} to r_{li} = Correlation co-efficient among the causal factor

a, b, c, ...i = Direct effects of characters a to l on dependent character Y

Residual effect (R) was computed as follows.

$$\text{Residual effect (R)} = 1 - \sqrt{a^2 + b^2 + c^2 + \dots + i^2 + 2abr_{12} + 2acr_{13} + \dots}$$

Path co-efficient were classified as suggested by Lenka and Mishra (1973)

0.00-0.09	-	Negligible
0.10-0.19	-	Low
0.20-0.29	-	Moderate
0.30-1.00	-	High
More than 1.00	-	Very high

IV. EXPERIMENTAL RESULTS

The results of the experiments conducted on “Genetic diversity and character association studies in bitter gourd (*Momordica charantia* L.)” during *kharif* season 2017 at Department of Vegetable Science, College of Horticulture, Mysuru, were statistically analysed for various parameters and the results obtained are presented in this chapter.

4.1 Analysis of variance

The results from the analysis of variance for 16 characters are presented in Table 2 indicated that there are highly significant differences among 40 genotypes of bitter gourd.

4.2 Genetic divergence

The studies on genetic divergence based on 16 growth, yield and quality contributing traits among 40 genotypes of bitter gourd were made by adopting Trocher’s method statistical analysis.

4.2.1 Relative contribution of different characters towards divergence

The relative contributions of 16 characters towards diversity are presented in Table 3. Among all the characters, ascorbic acid contributed the maximum (37.31%) to the diversity by taking first rank in 291 times out of 780 combinations, followed by fruit length (15.64% with 122 times ranked first), fruit diameter (14.36% with 112 times ranked first), flesh thickness (11.92% with 93 times ranked first), number of seeds per fruit (9.49% with 74 times ranked first), days to first female flower opening (6.92% with 54 times ranked first), average fruit weight (1.28% with 10 times ranked first). While, there was little and negligible contribution from number of branches per vine (0.90%), number of fruits per vine (0.77%), fruit yield per vine (0.77%), vine length (0.51%) and node at which first female flower appears (0.13%). However, the duration of crop, days to 50 per cent flowering, days to first fruit picking and fruit yield per hectare had no contribution towards genetic divergence.

Table 2. Analysis of variance (mean square) for different characters in bitter gourd

Sl. No.	Characters	Replication	Treatments	Error
	Degrees of freedom	1	39	39
A	Growth parameters			
1	Vine length (m)	3.732	0.497**	0.076
2	Number of branches per vine	2.329	3.290**	0.449
3	Duration of crop (days)	1.250	70.108**	25.670
B	Earliness parameters			
4	Node at which first female flower appears	6.272	15.626**	5.540
5	Days to first female flower opening	3.490	26.050**	1.550
6	Days to 50 per cent flowering	37.812	26.364*	13.241
7	Days to first fruit picking	6.610	33.567*	17.152
C	Yield parameters			
8	Fruit length (cm)	4.627	47.943**	0.772
9	Fruit diameter (cm)	0.066	0.781**	0.048
10	Average fruit weight (g)	617.820	805.676**	111.060
11	Number of fruits per vine	112.100	10.578*	5.064
12	Fruit yield per vine (kg)	0.190	0.1287**	0.029
13	Fruit yield per hectare (t)	16.45	11.009**	2.510
14	Number of seeds per fruit	0.078	39.883**	4.052
D	Quality parameters			
15	Flesh thickness (mm)	0.092	3.207**	0.253
16	Ascorbic acid (mg/100g)	0.780	124.67**	7.672

* Significant at 5%

** Significant at 1%

Table 3. Per cent contribution of sixteen characters towards total divergence in bitter gourd genotypes

Sl. No.	Characters	No. of first rank	Per cent germplasm contribution
1	Vine length (m)	4	0.51
2	Number of branches per vine	7	0.90
3	Duration of crop (days)	0	0.00
4	Node at which first female flower appears	1	0.13
5	Days to first female flower opening	54	6.92
6	Days to 50 per cent flowering	0	0.00
7	Days to first fruit picking	0	0.00
8	Fruit length (cm)	122	15.64
9	Fruit diameter (cm)	112	14.36
10	Average fruit weight (g)	10	1.28
11	Number of fruits per vine	6	0.77
12	Fruit yield per vine (kg)	6	0.77
13	Fruit yield per hectare (t)	0	0.00
14	Number of seeds per fruit	74	9.49
15	Flesh thickness (mm)	93	11.92
16	Ascorbic acid (mg/100g)	291	37.31
	Total	780	100.00

4.2.2 Cluster pattern of genotypes

All the 40 genotypes were grouped into 6 clusters by using Trocher's method. The distribution of genotypes into 6 clusters were presented in Table 4. Cluster I is the largest cluster having 32 genotypes (Preethi, Bit-25-2-1, Meghnaa-2, Jhalawar Local-3, CO1, Bit-22-1-1-3, Bit-9-2-4-1, Bit-1-2-3, Yellapur Local-1, Bit-37-2-1, DEB-505, Bit-9-3-2-3, Bit-5-1-2-1, West Bengal Local-1, Super Green, Bit-10-1-1, West Bengal Local-2, Kotla Local-1, Bit-10-1-2, Bit-5-1-4-1, Contai Bolder, Bit-1-2-2-4, Jhalawar Local-1, GYB-5-1-5-2, Bit-22-1-1-1, Bit-9-2-1-2, GYL-2, GYB-2-2, Katahi, Bit-35-1-1, Bit-31-2-2 and Bit-9-1-4-1) followed by cluster II with four genotypes (GYB-3-1-2, Bit-3-1-2-1, Bit-3-1-1-1 and Arka Harit). Cluster III (Yellapur Local-2), cluster IV (IC-68238), cluster V (Bit-18-1-1) and cluster VI (Jhalawar Local-2) had one genotype each.

4.2.3 Intra and inter-cluster average distance

The intra and inter-cluster D^2 and D values among 6 clusters are furnished in the Table 5 and illustrated in Figure 1. Intra-cluster average D^2 values ranged from 0 to 104.02. Among the clusters, cluster II had the maximum intra-cluster distance (104.02) followed by cluster I (96.08). The clusters like III, IV, V and cluster VI had no inter cluster distance (zero) as they were represented by single genotypes.

The maximum inter cluster D^2 value was found between cluster II and VI (1620.05) followed by cluster IV and VI (1262.95), cluster II and V (1098.44), cluster II and cluster III (851.00), cluster I and cluster VI (749.76) and cluster IV and V (685.87). The minimum inter-cluster D^2 values was observed between cluster III and V (103.32) followed by cluster V and VI (168.13).

4.2.4 Cluster means analysis

The cluster means for 16 characters are presented in Table 6.

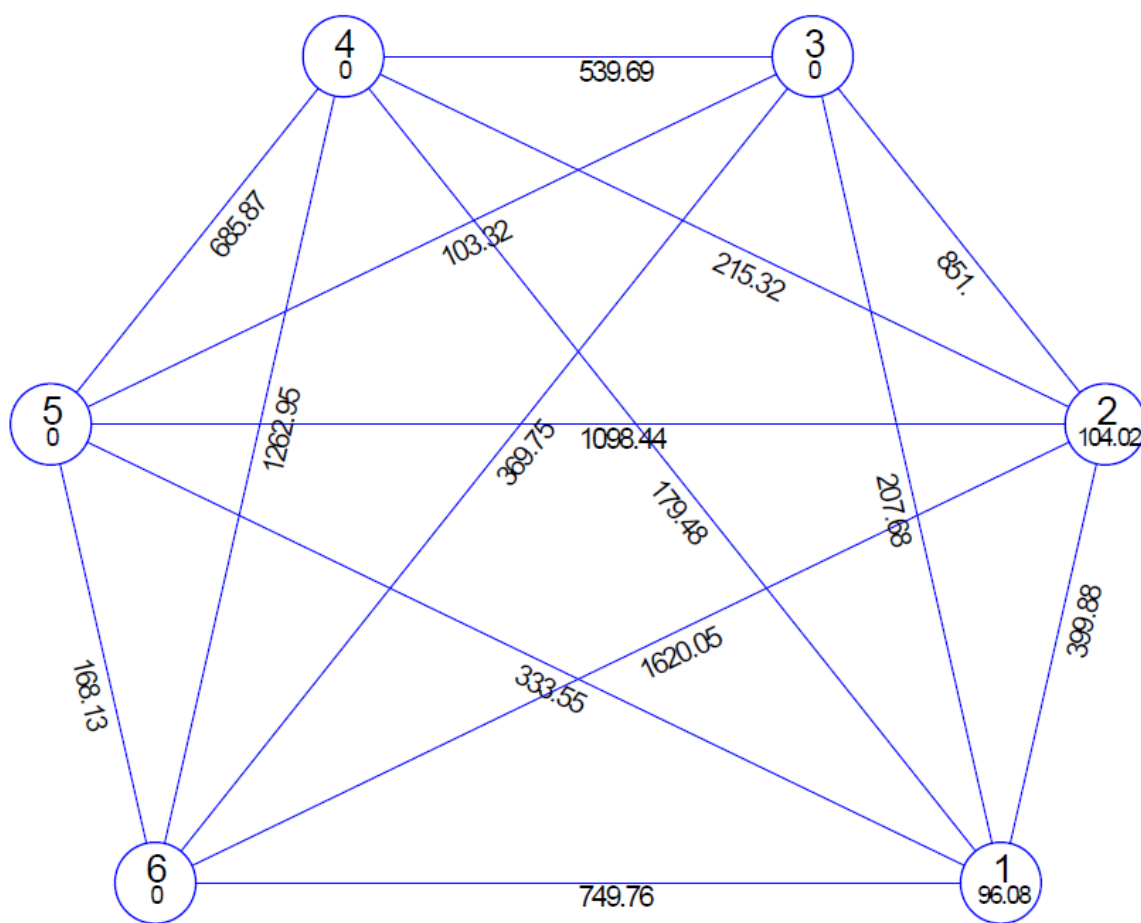
Table 4. Cluster composition based on D² statistics in bitter gourd

Cluster	Number of genotypes	Genotypes included in the cluster
I	32	Preethi, Bit-25-2-1, Meghnaa-2, Jhalawar Local-3, CO1, Bit-22-1-1-3, Bit-9-2-4-1, Bit-1-2-3, Yellapur Local-1, Bit-37-2-1, DEB-505, Bit-9-3-2-3, Bit-5-1-2-1, West Bengal Local-1, Super Green, Bit-10-1-1, West Bengal Local-2, Kotla Local-1, Bit-10-1-2, Bit-5-1-4-1, Contai Bolder, Bit-1-2-2-4, Jhalawar Local-1, GYB-5-1-5-2, Bit-22-1-1-1, Bit-9-2-1-2, GYL-2, GYB-2-2, Katahi, Bit-35-1-1, Bit-31-2-2, Bit-9-1-4-1
II	4	GYB-3-1-2, Bit-3-1-2-1, Bit-3-1-1-1, Arka Harit
III	1	Yellapur Local-2
IV	1	IC-68238
V	1	Bit-18-1-1
VI	1	Jhalawar Local-2

Table 5. Intra-cluster (diagonal) and inter-cluster D^2 and D values in bitter gourd genotypes

	I	II	III	IV	V	VI
I	96.08 (9.80)	399.88 (19.20)	207.68 (14.41)	179.48 (13.34)	333.55 (18.26)	749.76 (27.38)
II		104.02 (10.12)	851.00 (29.17)	215.32 (14.67)	1098.44 (33.14)	1620.05 (40.25)
III			0.00 (0.00)	539.69 (23.23)	103.32 (10.16)	369.75 (19.23)
IV				0.00 (0.00)	685.87 (26.19)	1262.95 (35.54)
V					0.00 (0.00)	168.13 (12.96)
VI						0.00 (0.00)

Figures in parenthesis denotes corresponding D values



Mahalanobis Euclidean Distance (Not to the scale)

Figure 1. Intra-cluster and inter-cluster distance of bitter gourd genotypes (Trocher's method)

Table 6. The cluster mean of sixteen characters for six clusters in bitter gourd genotypes

Sl. No	Characters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
1	Vine length (m)	2.71	1.91	3.67	1.84	2.58	2.33
2	Number of branches per vine	10.54	8.15	10.60	8.50	11.00	9.40
3	Duration of crop (days)	95.79	85.56	92.13	86.50	98.50	94.00
4	Node at which first female flower appears	15.39	11.33	15.50	14.10	14.30	16.50
5	Days to first female flower opening	41.46	35.69	37.60	42.55	41.35	44.50
6	Days to 50 per cent flowering	44.10	37.88	41.50	44.75	47.50	44.77
7	Days to first fruit picking	58.74	50.59	56.00	58.00	61.50	59.50
8	Fruit length (cm)	16.94	7.05	22.43	13.49	29.05	30.00
9	Fruit diameter (cm)	4.82	4.46	4.48	5.48	5.04	2.85
10	Average fruit weight (g)	84.68	36.91	85.60	79.00	88.70	91.85
11	Number of fruits per vine	12.87	14.76	13.10	12.10	14.60	8.85
12	Fruit yield per vine (kg)	1.11	0.53	1.14	0.96	1.28	0.69
13	Fruit yield per hectare (t)	10.24	4.92	10.55	8.87	11.82	6.38
14	Number of seeds per fruit	18.06	8.75	23.50	10.50	20.50	18.25
15	Flesh thickness (mm)	6.09	4.63	4.94	9.41	6.69	4.11
16	Ascorbic acid (mg/100g)	94.56	101.45	84.10	100.50	102.42	112.43

4.2.4.1 Growth parameters

For vine length highest cluster mean was observed in cluster III (3.67 m) followed by cluster I (2.71 m) and cluster V (2.58 m). The lowest cluster mean was observed in cluster IV (1.84 m).

For number of branches per vine, the highest mean was observed in the cluster V (11.00) followed by cluster III (10.60) and cluster I (10.54). The lowest mean was observed in the cluster II (8.15).

The cluster mean for duration of crop was highest in cluster V (98.50 days) followed by cluster I (95.72 days) and cluster VI (94.00 days). The lowest cluster mean was observed in cluster II (85.56 days).

4.2.4.2 Earliness parameters

The character node at which first female flower appears had lowest cluster mean in cluster II (11.33) followed by cluster IV (14.10) and cluster V (14.30). The highest cluster mean observed in cluster VI (16.50).

The cluster II (35.69 days) showed lowest cluster mean for days to first female flower opening followed by cluster III (37.60 days). The highest mean observed in cluster VI (44.50 days).

The cluster II (37.88 days) showed lowest cluster mean for days to 50 per cent flowering followed by cluster III (41.50 days). The highest mean observed in the cluster V (47.50 days).

Days to first fruit picking showed lowest cluster mean in cluster II (50.59 days) followed by cluster III (56.00 days). The highest cluster mean observed in cluster V (61.50 days).

4.2.4.3 Yield parameters

The cluster VI (30.00 cm) showed highest cluster mean for fruit length followed by cluster V (29.05 cm) and cluster III (22.43 cm). The lowest cluster mean observed in cluster II (7.05 cm).

The highest cluster mean for fruit diameter was observed in cluster IV (5.48 cm) followed by cluster V (5.04 cm) and cluster I (4.82 cm). The lowest cluster mean observed in cluster VI (2.85 cm).

The character average fruit weight had highest cluster mean in cluster VI (91.85 g) followed by cluster V (88.70 g) and cluster III (85.63 g). The lowest cluster mean observed in cluster II (36.91 g).

Number of fruits per vine showed highest cluster mean in cluster II (14.76) followed by cluster V (14.60) and cluster III (13.10). The lowest cluster mean observed in cluster VI (8.85).

The cluster V (1.28 kg) showed highest cluster mean for fruit yield per vine followed by cluster III (1.14 kg) and cluster I (1.13 kg). The lowest cluster mean observed in cluster II (0.53 kg).

The highest cluster mean for fruit yield per hectare was observed in cluster V (11.82 t) followed by cluster III (10.55 t) and cluster I (10.24 t). The lowest cluster mean observed in cluster II (4.92 t).

Number of seeds per fruit showed highest cluster means in cluster III (23.50) followed by cluster V (20.50) and cluster VI (18.25). The lowest cluster mean was observed in cluster II (8.75).

4.2.4.4 Quality parameters

The cluster IV (9.41 mm) showed highest cluster mean for flesh thickness followed by cluster V (6.69 mm) and cluster I (6.09 mm). The lowest cluster mean observed in cluster VI (4.11 mm).

The highest cluster mean for ascorbic acid was observed in cluster VI (112.43 mg) followed by cluster V (102.42 mg) and cluster II (101.45 mg). The lowest cluster mean was observed in cluster III (84.10 mg).

4.3 Genetic parameters

The estimates of genetic parameters viz., phenotypic and genotypic co-efficient of variation (PCV and GCV), heritability in broad sense, genetic advance and genetic advance as per cent of mean (GAM) were computed for 16 characters and were presented in Table 7. The phenotypic variance was higher than genotypic variance for all the characters studied. PCV ranged from 7.32 per cent (duration of crop) to 29.67 per cent (fruit length). GCV ranged from 4.94 per cent (days to first fruit picking) to 29.02 per cent (fruit length). The estimates of heritability ranged from 32.4 per cent (days to first fruit picking) to 96.80 per cent (fruit length). GAM ranged from 5.79 per cent (days to first fruit picking) to 59.19 per cent (fruit length).

4.3.1 Variability studies for different characters of bitter gourd genotypes

The data pertaining to variability, heritability and genetic advance for different characters of bitter gourd are presented in Table 7.

4.3.1.1 Vine length (m)

Vine length ranged from 1.56 m (Arka Harit) to 3.67 m (Yellapur Local-2) with a grand mean of 2.62 m. The GCV and PCV were found to be high (17.47 per cent and 20.40 per cent, respectively). The high heritability in broad sense (73.30%) was observed along with high GAM (30.83%).

4.3.1.2 Number of branches per vine

Number of branches per vine ranged from 6.80 (Arka Harit) to 13.50 (Bit-9-2-1-2) with a grand mean 10.23. Moderate GCV (11.64%) and PCV (13.36%) were recorded. High heritability (75.90%) coupled with high GAM (20.90%) was observed for this character.

Table 7. Estimates of mean, range, components of variance, heritability, genetic advance and genetic advance as per cent of mean for growth, yield and quality characters in bitter gourd

Sl. No.	Characters	Mean	Range	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
1	Vine length (m)	2.62	1.56-3.67	17.47	20.40	73.30	0.80	30.83
2	Number of branches per vine	10.23	6.80-13.50	11.64	13.36	75.90	2.13	20.90
3	Duration of crop (days)	94.46	83.25-108.75	4.98	7.32	46.40	6.61	7.00
4	Node at which first female flower appears	14.95	10.80-20.90	15.01	21.75	47.70	3.19	21.35
5	Days to first female flower opening	40.89	32.97-48.20	8.55	9.08	88.80	6.79	16.61
6	Days to 50 per cent flowering	43.52	35.25-50.50	5.88	10.22	33.10	3.03	6.97
7	Days to first fruit picking	57.92	48.25-65.75	4.94	8.69	32.40	3.35	5.79
8	Fruit length (cm)	16.63	4.82-30.00	29.02	29.67	96.80	9.85	59.19
9	Fruit diameter (cm)	4.74	2.85-5.72	12.74	13.56	88.20	1.17	24.64
10	Average fruit weight (g)	80.06	25.42-107.60	23.27	26.73	75.80	33.41	41.73
11	Number of fruits per vine	12.98	7.70-21.65	12.78	21.53	35.20	2.03	15.63
12	Fruit yield per vine (kg)	1.04	0.39-1.38	21.41	27.00	62.90	0.36	35.02
13	Fruit yield per hectare (t)	9.62	3.61-12.74	21.41	27.00	62.90	3.36	34.98
14	Number of seeds per fruit	17.14	7.50-25.00	24.68	27.33	81.60	7.87	45.93
15	Flesh thickness (mm)	5.95	3.65-9.40	20.39	22.07	85.30	2.31	38.80
16	Ascorbic acid (mg/100g)	95.78	81.29-112.43	7.98	8.49	88.40	14.81	15.47

GCV = Genotypic co-efficient of variation
 PCV = Phenotypic co-efficient of variation
 h^2 = Heritability (broad sense)

GA = Genetic advance
 GAM = Genetic advance as per cent of mean

4.3.1.3 Duration of crop

Duration of crop ranged from 83.25 days (Bit-3-1-2-1) to 108.75 days (Bit-25-2-1) with a mean of 94.46 days and this character exhibited low GCV (4.98%) and PCV (7.32%) with medium heritability (46.40%) associated with low GAM (7.00%).

4.3.1.4 Node at which first female flower appears

Node at which first female flower appears was ranged from 10.80 (Bit-3-1-2-1) to 20.90 (West Bengal Local-2) with a grand mean of 14.95. Moderate estimates of GCV (15.01%) and PCV (21.75%) were associated with moderate heritability (47.70%) and high GAM (21.35%).

4.3.1.5 Days to first female flower opening

This character was ranged from 32.97 days (GYB-3-1-2) to 48.20 days (Bit-1-2-3) with a grand mean of 40.89 days and exhibited low GCV (8.55%) and PCV (9.08%) with very high heritability (88.80%) associated with moderate GAM (16.61%).

4.3.1.6 Days to 50 per cent flowering

Days to 50 per cent flowering exhibited wide range from 36.50 days (Bit-35-1-1) to 50.50 days (Bit-1-2-2-4) with mean of 43.52 days. Low estimates of GCV (5.88%) and PCV (10.22%) were associated with low heritability (33.10%) and low GAM (6.97%).

4.3.1.7 Days to first fruit picking

The genotype GYB-3-1-2 took least number of days (48.25 days) to harvestable maturity, while, Bit-1-2-2-4 took maximum number of days (65.75 days) for attaining horticulture maturity. On an average the genotypes took 57.92 days. The estimates of GCV and PCV (4.94% and 8.69% respectively) were low. Low heritability (32.40%) coupled with low GAM (5.79%) was observed for this trait.

4.3.1.8 Fruit length (cm)

Wide variability was observed for fruit length and ranged from 4.82 cm (Bit-3-1-2-1) to 30.00 cm (Jhalawar Local-2). The average fruit length was 16.63 cm. High GCV



Plate 2a: Variation in the fruits of bitter gourd genotypes



Plate 2b: Variation in the fruits of bitter gourd genotypes



Plate 2c: Variation in the fruits of bitter gourd genotypes



Plate 2d: Variation in the fruits of bitter melon genotypes



Plate 2e: Variation in the fruits of bitter gourd genotypes

(29.02%) and PCV (29.67%) were recorded for fruit length. Very high heritability (96.80%) coupled with high GAM (59.19%) was observed for this character.

4.3.1.9 Fruit diameter (cm)

The fruit diameter ranged from 2.85 cm (Jhalawar Local-2) to 5.72 cm (Kotla Local-1) with a grand mean of 4.74 cm. Moderate estimates of GCV (12.74%) and PCV (13.56%) with very high heritability (88.20%) coupled with high GAM (24.64%) was observed for this trait.

4.3.1.10 Average fruit weight (g)

Average fruit weight ranged from 25.42 g (Bit-3-1-2-1) to 107.60 g (Bit-9-3-2-3) with a grand mean of 80.06 g. The estimates of GCV and PCV were high (23.27% and 26.73% respectively). High heritability (75.80%) was observed along with high GAM (41.73%).

4.3.1.11 Number of fruits per vine

Number of fruits per vine in bitter gourd genotypes ranged from 7.70 (Arka Harit) to 21.65 (Bit-3-1-2-1) with a mean of 12.98 and recorded moderate GCV (12.78%) and high PCV (21.53%). This character showed low heritability (35.20%) coupled with moderate GAM (15.63%) (Figure 2).

4.3.1.12 Fruit yield per vine (kg)

Fruit yield per vine ranged from 0.39 kg (Bit-3-1-1-1) to 1.38 kg (Kotla Local-1) with a grand mean of 1.04 kg. The estimates of GCV and PCV were high (21.41 % and 27.00% respectively). High heritability (62.90%) was observed along with high GAM (35.02%).

4.3.1.13 Fruit yield /ha (t)

Estimated fruit yield per hectare in bitter gourd genotypes ranged from 3.61 t (Bit-3-1-1-1) to 12.75 t (Kotla Local-1) with average mean of 9.62 t/ha. The GCV and PCV

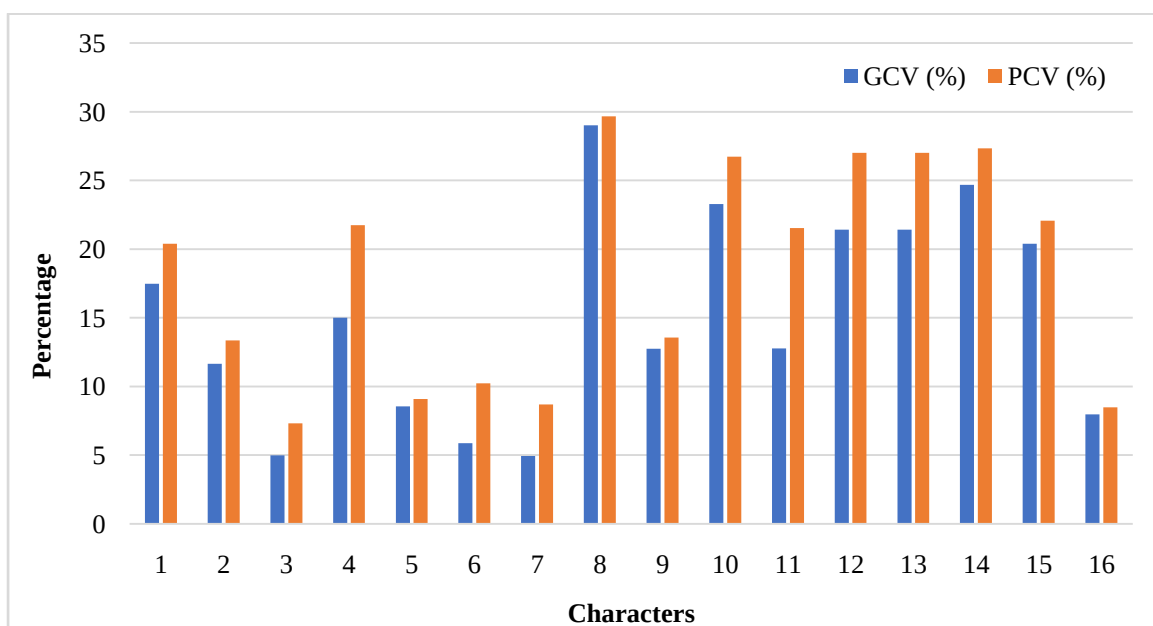


Figure 2. Genotypic and phenotypic correlation co-efficient (%) for sixteen characters in bitter gourd

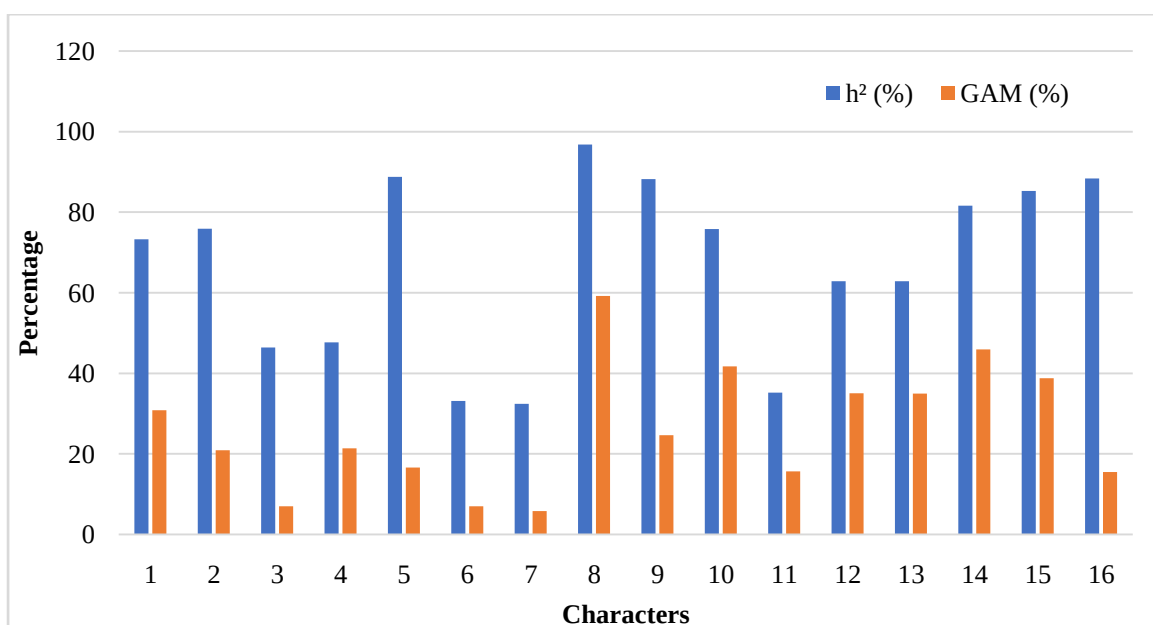


Figure 3. Heritability and genetic advance over mean (%) for sixteen characters in bitter gourd

- | | | |
|--|--------------------------------|---------------------------------|
| 1. Vine length (m) | 7. Days to first fruit picking | 13. Fruit yield per hectare (t) |
| 2. Number of branches per vine | 8. Fruit length (cm) | 14. Number of seeds per fruit |
| 3. Duration of crop (days) | 9. Fruit diameter (cm) | 15. Flesh thickness (mm) |
| 4. Node at which first female flower appears | 10. Average fruit weight (g) | 16. Ascorbic acid (mg/100g) |
| 5. Days to first female flower opening | 11. Number of fruits per vine | |
| 6. Days to 50 per cent flowering | 12. Fruit yield per vine (kg) | |

observed were high (21.41% and 27.00% respectively). High heritability (62.90%) coupled with high GAM (34.98%) were found for this trait (Figure 3).

4.3.1.14 Number of seeds per fruit

The number of seeds per fruit varied from 7.50 (Bit-3-1-1-1 and Arka Harit) to 25.00 (Bit-5-1-4-1) with a general mean of 17.14. The estimates of GCV and PCV were high (24.68% and 27.33% respectively). The estimates of heritability were very high (81.60 %) and the GAM also high (45.93%) for this trait.

4.3.1.15 Flesh thickness (mm)

Flesh thickness was ranged from 3.65 mm (Arka Harit) to 9.40 mm (IC-68238) with a grand mean of 5.95 mm. The GCV (20.39%) and PCV (22.07%) were high along with very high heritability (85.30%) and high GAM (38.8%).

4.3.1.16 Ascorbic acid (mg/100g)

Ascorbic acid content was ranged from 81.29 mg/100g (Jhalawar Local-1) to 112.43 mg/100g (Jhalawar Local-2) with a grand mean of 95.78 mg/100g. The estimates of GCV and PCV were low (7.88% and 8.79% respectively). Very high heritability (88.40%) coupled with moderate GAM (15.46%) was noticed for this trait.

4.4 Correlation studies

The Phenotypic and genotypic correlation studies were carried out to know the nature of relationship existing between growth, yield and quality and component characters and are presented in Table 8 and 9 respectively.

4.4.1 Phenotypic correlation co-efficient

The data pertaining to phenotypic correlation co-efficients for different characters of bitter gourd are presented in Table 8 and illustrated in Figure 4.

The phenotypic level, vine length was found to be highly significant (at $p = 0.01$) and positively associated with number of seeds per fruit ($r_P = 0.4992$), fruit length ($r_P =$

Table 8. Phenotypic correlation co-efficients for growth, earliness and yield characters in bitter gourd

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.0000	0.3355**	0.1589	0.1716	0.2439*	0.2502*	0.3287**	0.4064**	0.1617	0.2948**	0.0077	0.4992**	0.1388	-0.3230**	0.3389**
2		1.0000	0.3245**	0.3752**	0.2203*	0.2332*	0.3113**	0.4095**	0.3598**	0.5622**	0.0667	0.3759**	0.2793*	0.0013	0.6559**
3			1.0000	0.2480*	0.3034**	0.1987	0.4382**	0.3312**	-0.1170	0.3267**	-0.1779	0.3894**	0.2215*	-0.0678	0.2447*
4				1.0000	0.5312**	0.4586**	0.4215**	0.3197**	0.2634*	0.3505**	-0.0634	0.4290**	0.2854*	-0.0091	0.3172**
5					1.0000	0.7670**	0.6816**	0.4651**	0.0925	0.3814**	-0.2009	0.4251**	0.1951	0.0174	0.2269*
6						1.0000	0.6833**	0.4025**	0.1482	0.2818*	-0.0462	0.3908**	0.2420*	-0.0434	0.3016**
7							1.0000	0.4636**	0.1423	0.4346**	-0.2445*	0.4367**	0.2341*	-0.0155	0.3093**
8								1.0000	-0.0575	0.6454**	-0.2423*	0.6077**	0.1152	0.0817	0.5017**
9									1.0000	0.3131**	0.1061	0.1376	0.6019**	-0.0732	0.4583**
10										1.0000	-0.4459**	0.4984**	0.3286**	0.0233	0.7481**
11											1.0000	-0.0779	0.0257	0.0846	0.1057
12												1.0000	0.1718	-0.2772*	0.5121**
13													1.0000	-0.1057	0.4348**
14														1.0000	-0.0729
15															1.0000

* Significant at 5%

** Significant at 1%

1. Vine length (m)

2. Number of branches per vine

3. Duration of crop (days)

4. Node at which first female flower appears

5. Days to first female flower opening

6. Days to 50 per cent flowering

7. Days to first fruit picking

8. Fruit length (cm)

9. Fruit diameter (cm)

10. Average fruit weight (g)

11. Number of fruits per vine

12. Number of seeds per fruit

13. Flesh thickness (mm)

14. Ascorbic acid (mg/100g)

15. Fruit yield per vine (kg)

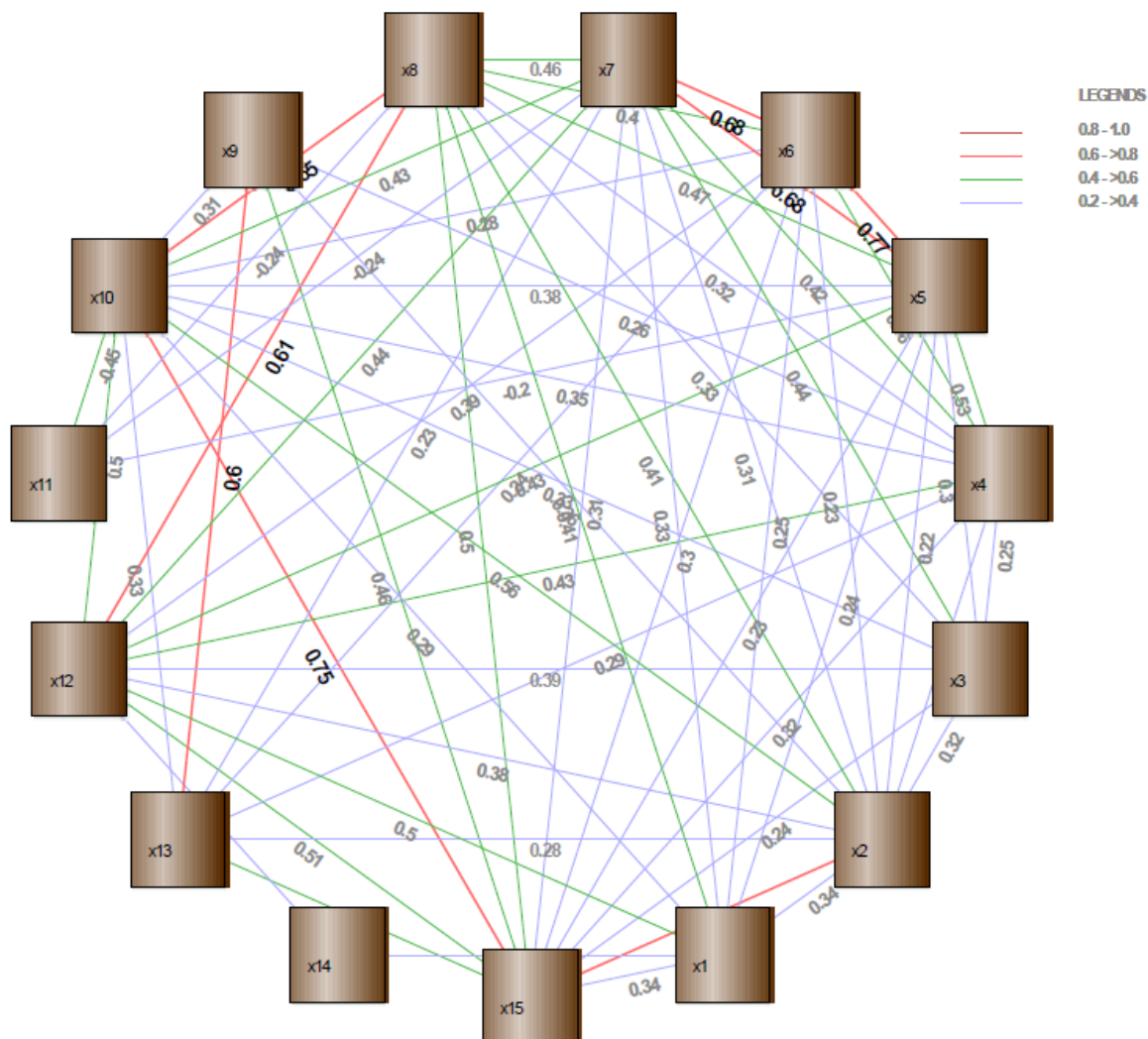


Figure 4. Phenotypic correlation co-efficient among fifteen characters of bitter gourd

- | | | |
|--|----------------------------------|-------------------------------|
| 1. Vine length (m) | 6. Days to 50 per cent flowering | 11. Number of fruits per vine |
| 2. Number of branches per vine | 7. Days to first fruit picking | 12. Number of seeds per fruit |
| 3. Duration of crop (days) | 8. Fruit length (cm) | 13. Flesh thickness (mm) |
| 4. Node at which first female flower appears | 9. Fruit diameter (cm) | 14. Ascorbic acid (mg/100g) |
| 5. Days to first female flower opening | 10. Average fruit weight (g) | 15. Fruit yield per vine (kg) |

0.4064), number of branches per vine ($rP = 0.3355$), days to first fruit picking ($rP = 0.3287$) and average fruit weight ($rP = 0.2948$) and it was also positive and significantly (at $p = 0.05$) correlated to days to 50% flowering ($rP = 0.2502$) and days to first female flower opening ($rP = 0.2439$) but negative and significantly (at $p = 0.01$) correlated with ascorbic acid ($rP = -0.3230$).

Number of branches per vine exhibited highly significant (at $p = 0.01$) and positive phenotypic association with average fruit weight ($rP = 0.5622$), fruit length ($rP = 0.4095$), number of seeds per fruit ($rP = 0.3759$), node at which first female flower appears ($rP = 0.3752$), fruit diameter ($rP = 0.3598$), duration of crop ($rP = 0.3245$) and days to first fruit picking ($rP = 0.3113$) and it was also positive and significantly correlated with flesh thickness ($rP = 0.2793$), days to 50% flowering ($rP = 0.2332$) and days to first female flower opening ($rP = 0.2203$) only at $p = 0.05$.

Duration of crop showed highly significant (at $p = 0.01$) and positive association with days to first fruit picking ($rP = 0.4382$), number of seeds per fruit ($rP = 0.3894$), fruit length ($rP = 0.3312$), average fruit weight ($rP = 0.3267$) and days to first female flower opening ($rP = 0.3034$). Whereas, significant and positive correlation with node at which first female flower appears ($rP = 0.2480$) and flesh thickness ($rP = 0.2215$) at $p = 0.05$.

Phenotypic correlation co-efficient for node at which first female flower appears showed highly significant (at $p = 0.01$) and positive association with days to first female flower opening ($rP = 0.5312$), days to 50 per cent flowering ($rP = 0.4586$), number of seeds per fruit ($rP = 0.4290$), days to first fruit picking ($rP = 0.4215$), average fruit weight ($rP = 0.3505$) and fruit length ($rP = 0.3197$) and it was also significantly (at $p = 0.05$) and positively correlated with flesh thickness ($rP = 0.2854$) and fruit diameter ($rP = 0.2634$).

Phenotypic correlation co-efficient for days to first female flower opening was found to be highly significant (at $p = 0.01$) and positive with days to 50 per cent flowering ($rP = 0.7670$), days to first fruit picking ($rP = 0.6816$), fruit length ($rP = 0.4651$), number of seeds per fruit ($rP = 0.4251$) and average fruit weight ($rP = 0.3814$).

Highly significant (at $p = 0.01$) and positive phenotypic correlations for days to 50 per cent flowering was observed with days to first fruit picking ($rP = 0.6833$), fruit length ($rP = 0.4025$), number of seeds per fruit ($rP = 0.3908$) and significant (at $p = 0.05$) and positive association with average fruit weight ($rP = 0.2818$) and flesh thickness ($rP = 0.2420$).

Days to first fruit picking showed positive and highly significant (at $p = 0.01$) association with fruit length ($rP = 0.4636$), number of seeds per fruit ($rP = 0.4367$) and average fruit weight ($rP = 0.4346$) and it was also significant ($p = 0.05$) and positive correlation with flesh thickness ($rP = 0.2341$) but negative and significantly (at $p = 0.05$) correlated with number of fruits per vine ($rP = -0.2445$).

Fruit length was positively and highly significantly (at $p = 0.01$) correlated with average fruit weight ($rP = 0.6454$), number of seeds per fruit ($rP = 0.6077$) but negative and significantly ($p = 0.05$) correlated with number of fruits per vine ($rP = -0.2429$).

Phenotypic correlation co-efficient for fruit diameter was found to be highly significant ($p = 0.01$) and positive with flesh thickness ($rP = 0.6019$) and average fruit weight ($rP = 0.3131$).

Average fruit weight showed positive and highly significant (at $p = 0.01$) association with number of seeds per fruit ($rP = 0.4984$), flesh thickness ($rP = 0.3286$) and showed negative and highly significant (at $p = 0.01$) association with number of fruits per vine ($rP = -0.4459$). Flesh thickness showed negative and significant (at $p = 0.05$) phenotypic association with ascorbic acid ($rP = -0.2772$).

Fruit yield per vine had highly significant (at $p = 0.01$) and positively associated with average fruit weight ($rP = 0.7481$), number of branches per vine ($rP = 0.6559$), number of seeds per fruit ($rP = 0.5121$), fruit length ($rP = 0.5017$), fruit diameter ($rP = 0.4583$), flesh thickness ($rP = 0.4348$), vine length ($rP = 0.3389$),

node at which first female flower appears ($r_P = 0.3172$), days to first fruit picking ($r_P = 0.3093$) and days to 50 per cent flowering ($r_P = 0.3016$). It was significantly (at $p = 0.05$) and positively correlated with duration of crop ($r_P = 0.2447$) and days to first female flower opening ($r_P = 0.2269$).

4.4.2 Genotypic correlation co-efficient

The data pertaining to genotypic correlation co-efficient for different characters of bitter gourd are presented in Table 9 and illustrated in Figure 5.

Vine length showed highly significant (at $p = 0.01$) and positive correlation with number of seeds per fruit ($r_G = 0.6358$), days to first fruit picking ($r_G = 0.5610$), days to 50 per cent flowering ($r_G = 0.5370$), fruit length ($r_G = 0.4510$), number of branches per vine ($r_G = 0.4487$), average fruit weight ($r_G = 0.4459$), node at which first female flower appears ($r_G = 0.3236$), duration of crop ($r_G = 0.3011$) and days to first female flower opening ($r_G = 0.2916$) but highly significant (at $p = 0.01$) and negatively correlated with ascorbic acid ($r_G = -0.4569$).

Number of branches per vine showed positive and highly significant (at $p = 0.01$) genotypic correlation with average fruit weight ($r_G = 0.7267$), node at which first female flower appears ($r_G = 0.6381$), days to first fruit picking ($r_G = 0.6141$), duration of crop ($r_G = 0.5863$), number of seeds per fruit ($r_G = 0.5754$), days to 50 per cent flowering ($r_G = 0.5155$), fruit length ($r_G = 0.4617$), fruit diameter ($r_G = 0.4094$), flesh thickness ($r_G = 0.3422$) and days to first female flower opening ($r_G = 0.3235$).

The genotypic correlation co-efficient was found to be highly significant (at $p = 0.01$) and positive for duration of crop with days to 50 per cent flowering ($r_G = 0.7780$), days to first fruit picking ($r_G = 0.6859$), average fruit weight ($r_G = 0.6712$), number of seeds per fruit ($r_G = 0.6712$), fruit length ($r_G = 0.4782$), node at which first female flower appears ($r_G = 0.3817$) and days to first female flower opening ($r_G = 0.3791$) but it was negatively and significantly (at $p = 0.01$) associated with number of fruits per vine ($r_G = -0.4264$).

Genotypic correlation co-efficient for node at which first female flower appearance showed significant (at $p = 0.01$) and positive association with days to first

Table 9. Genotypic correlation co-efficients for growth, earliness and yield characters in bitter gourd

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.0000	0.4487**	0.3011**	0.3236**	0.2916**	0.5370**	0.5610**	0.4510**	0.1936	0.4459**	-0.1392	0.6358**	0.1794	-0.4569**	0.3679**
2		1.0000	0.5863**	0.6381**	0.3235**	0.5155**	0.6141**	0.4617**	0.4094**	0.7267**	0.1273	0.5754**	0.3422**	-0.0001	0.9055**
3			1.0000	0.3817**	0.3791**	0.7780**	0.6859**	0.4782**	-0.1858	0.6712**	-0.4264**	0.6712**	-0.0039	-0.1423	0.6356**
4				1.0000	0.6523**	0.6932**	0.9007**	0.4178**	0.3396**	0.6914**	-0.6796**	0.6754**	0.3743**	0.0024	0.5159**
5					1.0000	1.1753**	1.1583**	0.5028**	0.1202	0.5281**	-0.4985**	0.4749**	0.2400*	0.0414	0.2821*
6						1.0000	1.6715**	0.7057**	0.2085	0.8877**	-0.8957**	0.6169**	0.4363**	0.0278	0.4457**
7							1.0000	0.7833**	0.2159	0.9786**	-0.7486**	0.7419**	0.3301**	-0.0552	0.7194**
8								1.0000	-0.0989	0.7315**	-0.4831**	-0.7048**	0.0922	0.0592	0.5865**
9									1.0000	0.3674**	0.2227*	0.1748	0.6358**	-0.0866	0.5475**
10										1.0000	-0.5972**	0.6778**	0.3433**	-0.0283	0.9484**
11											1.0000	-0.1827	0.0572	-0.1327	-0.2958**
12												1.0000	0.2284*	-0.3018**	0.6954**
13													1.0000	-0.1852	0.4799**
14														1.0000	-0.1394
15															1.0000

* Significant at 5%

** Significant at 1%

1. Vine length (m)
2. Number of branches per vine
3. Duration of crop (days)
4. Node at which first female flower appears
5. Days to first female flower opening

6. Days to 50 per cent flowering
7. Days to first fruit picking
8. Fruit length (cm)
9. Fruit diameter (cm)
10. Average fruit weight (g)

11. Number of fruits per vine
12. Number of seeds per fruit
13. Flesh thickness (mm)
14. Ascorbic acid (mg/100g)
15. Fruit yield per vine (kg)

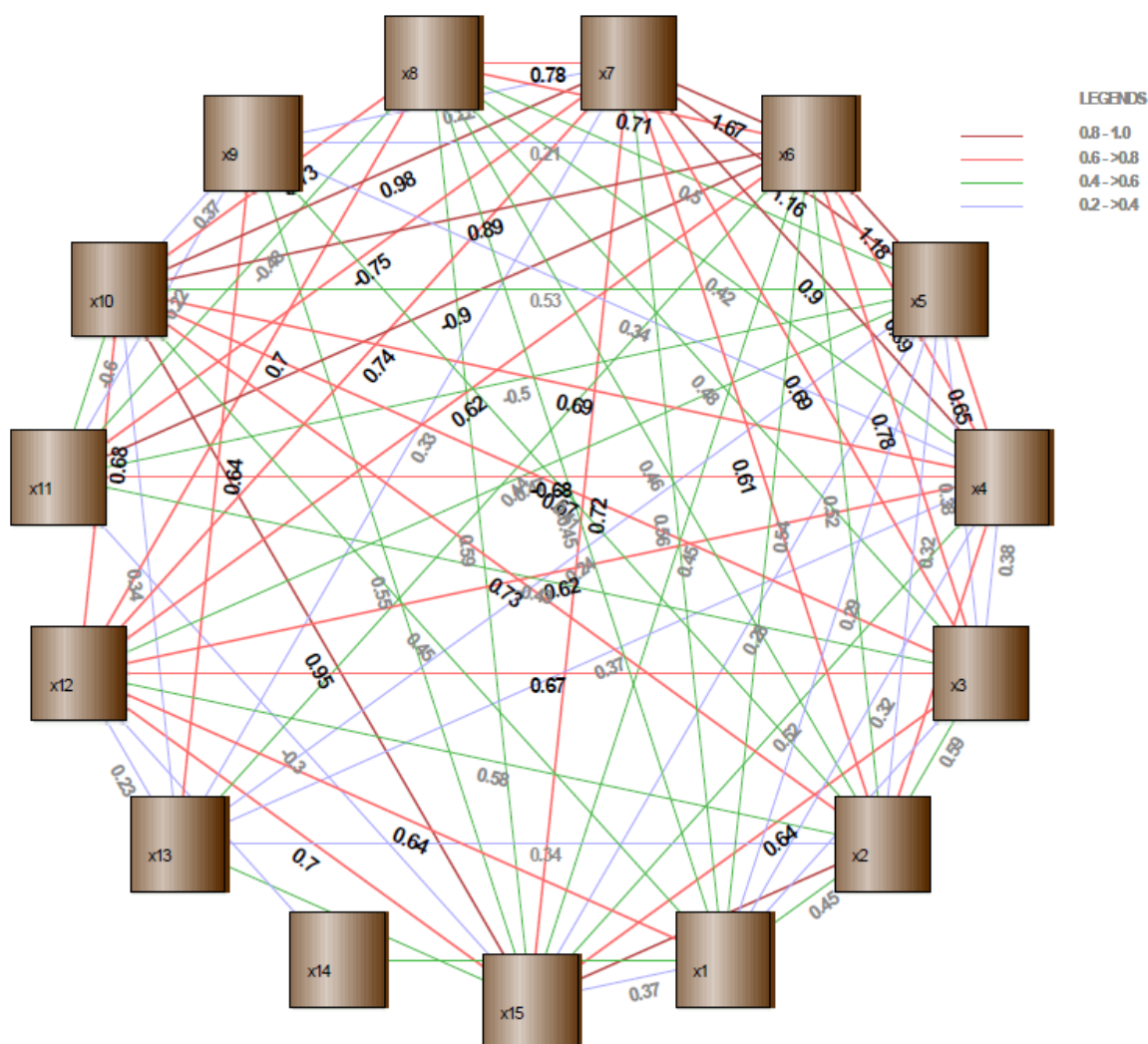


Figure 5. Genotypic correlation co-efficient among fifteen characters of bitter gourd

- | | | |
|--|----------------------------------|-------------------------------|
| 1. Vine length (m) | 6. Days to 50 per cent flowering | 11. Number of fruits per vine |
| 2. Number of branches per vine | 7. Days to first fruit picking | 12. Number of seeds per fruit |
| 3. Duration of crop (days) | 8. Fruit length (cm) | 13. Flesh thickness (mm) |
| 4. Node at which first female flower appears | 9. Fruit diameter (cm) | 14. Ascorbic acid (mg/100g) |
| 5. Days to first female flower opening | 10. Average fruit weight (g) | 15. Fruit yield per vine (kg) |

fruit picking ($rG = 0.9007$), days to 50 per cent flowering ($rG = 0.6932$), average fruit weight ($rG = 0.6914$), number of seeds per fruit ($rG = 0.6754$), days to first female flower opening ($rG = 0.6523$), fruit length ($rG = 0.4178$), flesh thickness ($rG = 0.3743$) and fruit diameter ($rG = 0.3396$) and it was negatively and significantly (at $p = 0.01$) associated with number of fruits per vine ($rG = -0.6796$).

Days to first female flower opening exhibited highly significant (at $p = 0.01$) and positive association with days to 50 per cent flowering ($rG = 1.1753$), days to first fruit picking ($rG = 1.1583$), average fruit weight ($rG = 0.5281$), fruit length ($rG = 0.5028$) and number of seeds per fruit ($rP = 0.4749$). It was significantly (at $p = 0.05$) and positive correlation with flesh thickness ($rG = 0.2400$) but negatively and significantly (at $p = 0.05$) correlated with number of fruits per vine (-0.4985).

Days to 50 per cent flowering showed highly significant (at $p = 0.01$) and positive association with days to first fruit picking ($rG = 1.6715$), fruit length ($rG = 0.7057$), average fruit weight ($rG = 0.8877$), number of seeds per fruit ($rG = 0.6169$) and flesh thickness ($rG = 0.4363$) but showed highly significant (at $p = 0.01$) and negative association with number of fruits per vine ($rG = 0.8957$).

Days to first fruit picking showed highly significant (at $p = 0.01$) and positive association with average fruit weight ($rG = 0.9786$), fruit length ($rG = 0.7833$), number of seeds per fruit ($rG = 0.7419$) and flesh thickness ($rG = 0.3301$) however, it was negatively and significantly ($p = 0.01$) associated with number of fruits per vine ($rG = -0.7486$).

Fruit length showed significant (at $p = 0.01$) and positive correlation with average fruit weight ($rG = 0.7315$) and it was highly significant (at $p = 0.01$) and negative association with number of fruits per vine ($rG = -0.4831$) and number of seeds per fruit ($rG = -0.7048$).

Fruit diameter showed highly significant (at $p = 0.01$) and positive association with flesh thickness ($rG = 0.6358$) and average fruit weight ($rG = 0.3674$) and it was positively and significantly associated with number of fruits per vine ($rG = 0.2227$) at $p = 0.05$.

Average fruit weight had highly significant (at $p = 0.01$) and positive association with number of seeds per fruit ($rG = 0.6778$) and flesh thickness ($rG = 0.3433$) but it was negatively and significantly (at $p = 0.01$) correlated with number of fruits per vine ($rG = -0.5972$).

Number of seeds per fruits had highly significant (at $p = 0.01$) and negative association with ascorbic acid ($rG = -0.3018$) and it was positively significant (at $p = 0.05$) association with flesh thickness ($rG = 0.2284$).

Fruit yield per vine had highly significant (at $p = 0.01$) and positively associated with average fruit weight ($rG = 0.9484$), , number of branches per vine ($rG = 0.9055$), days to first fruit picking ($rG = 0.7194$), number of seeds per fruit ($rG = 0.6954$), duration of crop ($rG = 0.6356$), fruit length ($rG = 0.5865$), fruit diameter ($rG = 0.5475$), node at which first female flower appears ($rG = 0.5159$), flesh thickness ($rG = 0.4799$), days to 50 per cent flowering ($rG = 0.4457$) and vine length ($rG = 0.3679$) and it was significant (at $p = 0.05$) and positively correlated with days to first female flower opening ($rG = 0.2821$) but it was negatively and significantly associated with number of fruits per vine ($rG = -0.2958$) at $p = 0.01$.

4.5 Path co-efficient analysis

Path co-efficient analysis is useful for the partitioning of correlation co-efficient 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 co-efficient analysis of different characters on fruit yield based on phenotypic and genotypic correlations in 40 genotypes of bitter melon are furnished in Table 10 and 11 respectively.

4.5.1 Phenotypic path co-efficient analysis of fruit yield per vine

The data pertaining to the phenotypic path co-efficient for following characters are presented in Table 10.

The path co-efficient analysis for fruit yield per vine was performed with a set of 15 independent characters, viz., vine length, number of branches per vine, duration of crop, node at which first female flower appears, days to first female flower opening, days to 50 per cent flowering, days to first fruit picking, fruit length, fruit diameter, average fruit weight, number of fruits per vine, number of seeds per fruit, flesh thickness and ascorbic acid.

Vine length had positive direct effect (0.0028) on fruit yield per vine and it had indirect positive effect through number of seeds per fruit (0.0014), fruit length (0.011), number of branches per vine (0.0009) and days to first fruit picking (0.0009).

Number of branches per vine had direct and positive effect (0.0859) on fruit yield per vine and it had high positive indirect effect via average fruit weight (0.0483), fruit length (0.0352), number of seeds per fruit (0.0323), node at which first female flower appears (0.0322) and fruit diameter (0.0309).

Duration of crop had positive direct effect (0.0391) on fruit yield per vine and it had positive indirect effect via days to first fruit picking (0.0171), number of seeds per fruit (0.0152), fruit length (0.0129), average fruit weight (0.0128) and days to first flower opening (0.0119).

Node at which first female appears had no positive direct effect (-0.0397) on fruit yield per vine but it had high positive indirect effect through number of fruits per vine (0.025) and ascorbic acid (0.0004). Days to first female flower opening had no positive direct effect (-0.1905) on fruit yield per vine but it had positive indirect effect via flesh thickness (0.0372) and number of fruits per vine (0.0283).

Days to 50 per cent flowering had positive direct effect (0.1823) on fruit yield per vine and it had positive indirect effect through days to first fruit picking (0.1246), fruit

Table 10. Phenotypic path co-efficient analysis for fruit yield per vine and its components in bitter gourd

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	rP
1	0.0028	0.0009	0.0004	0.0005	0.0007	0.0007	0.0009	0.0011	0.0004	0.0008	0.0000	0.0014	0.0004	-0.0009	0.3389**
2	0.0288	0.0859	0.0279	0.0322	0.0189	0.0200	0.0267	0.0352	0.0309	0.0483	0.0057	0.0323	0.0240	0.0001	0.6559**
3	0.0062	0.0127	0.0391	0.0097	0.0119	0.0078	0.0171	0.0129	-0.0046	0.0128	-0.0070	0.0152	0.0001	-0.0026	0.2447*
4	-0.0068	-0.0149	-0.0099	-0.0397	-0.0211	-0.0182	-0.0167	-0.0127	-0.0105	-0.0139	0.0025	-0.0170	-0.0113	0.0004	0.3172**
5	-0.0465	-0.0420	-0.0578	-0.1012	-0.1905	-0.1461	-0.1298	-0.0886	-0.0176	-0.0727	0.0283	-0.0810	0.0372	-0.0033	0.2269*
6	0.0456	0.0425	0.0362	0.0836	0.1398	0.1823	0.1246	0.0734	0.0270	0.0514	-0.0084	0.0712	0.0441	-0.0079	0.3016**
7	-0.0143	-0.0136	-0.0191	-0.0184	-0.0297	-0.0298	-0.0436	-0.0202	-0.2262	-0.0190	0.0107	-0.0190	-0.0102	0.0007	0.3093**
8	-0.0010	-0.0010	-0.0008	-0.0008	-0.0011	-0.0010	-0.0011	-0.2224	0.0001	-0.0015	0.0006	-0.0014	-0.0003	-0.0002	0.5017**
9	0.0110	0.0244	-0.0079	0.0179	0.0063	0.0101	0.0097	-0.0039	0.0678	0.0212	0.0072	0.0093	0.0408	-0.0050	0.4583**
10	0.2465	0.4699	0.2731	0.2930	0.3188	0.2355	0.3633	0.5395	0.2617	0.8359	-0.3727	0.4166	0.2747	0.0195	0.7481**
11	0.0034	0.0290	-0.0774	-0.0276	-0.0874	-0.0201	-0.1063	-0.1056	0.0462	-0.1940	0.4350	-0.0339	0.01120	-0.0368	0.1057
12	0.0523	0.0394	0.0408	0.0450	0.0446	0.0410	0.0458	0.0637	0.0144	0.0523	-0.0082	0.1049	0.0180	-0.0291	0.5121**
13	0.0112	0.0225	0.0001	0.0230	0.0157	0.0195	0.0189	0.0093	0.0485	0.0265	0.0021	0.0138	0.0806	-0.0085	0.4348**
14	-0.0003	0.0000	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	-0.0001	0.0000	-0.0001	-0.0002	-0.0001	-0.0008	-0.0729

Residual effect = 0.3970 * Significant at 5% ** Significant at 1% rP = Phenotypic correlation with fruit yield per vine,
 Direct effect values at diagonal and others are indirect effect on fruit yield per vine

1. Vine length (m)
 2. Number of branches per vine
 3. Duration of crop (days)
 4. Node at which first female flower appears
 5. Days to first female flower opening

6. Days to 50 per cent flowering
 7. Days to first fruit picking
 8. Fruit length (cm)
 9. Fruit diameter (cm)
 10. Average fruit weight (g)

11. Number of fruits per vine
 12. Number of seeds per fruit
 13. Flesh thickness (mm)
 14. Ascorbic acid (mg/100g)

length (0.0734), number of seeds per fruit (0.0712) and average fruit weight (0.0514). Days to first fruit picking had direct negative effect (-0.0439) on fruit yield per vine.

Fruit length had moderate negative direct effect (-0.2224) on fruit yield per vine and it had positive indirect effect via number of fruits per vine (0.0006). Fruit diameter had positive direct effect (0.0678) on fruit yield per vine and it had positive indirect effect through flesh thickness (0.0408), number of branches per vine (0.0244) and average fruit weight (0.0212).

Average fruit weight had high positive direct effect (0.8359) on fruit yield per vine and it had positive indirect effect through fruit length (0.5395), number of branches per vine (0.4699), number of seeds per fruit (0.4166), days to first fruit picking (0.3633), days to first female flower opening (0.3188) and flesh thickness (0.2747).

Number of fruits per vine had positive direct effect (0.4350) on fruit yield per vine and recorded positive indirect effects via fruit diameter (0.0462), number of branches per vine (0.0290) and flesh thickness (0.0112).

Number of seeds per fruit had positive direct effect (0.1049) on fruit yield per vine and it had positive indirect effect via fruit length (0.0637), average fruit weight (0.0523), vine length (0.0523) and days to first fruit picking (0.0458).

Flesh thickness had positive direct effect (0.0806) on fruit yield per vine and it had positive indirect effect through fruit diameter (0.0485) and average fruit weight (0.0265). Ascorbic acid had negative direct effect (-0.0008) on fruit yield per vine.

4.5.2 Genotypic path co-efficient analysis of fruit yield per vine

The data pertaining to the genotypic path co-efficients for following characters are presented in Table 11 and illustrated in Figure 6.

The vine length had no positive direct effect (-0.2409) on fruit yield per vine and it had positive indirect effect through ascorbic acid (0.1101).

Table 11. Genotypic path co-efficient analysis for fruit yield per vine and its components in bitter gourd

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	rG
1	-0.2409	-0.1081	-0.0725	-0.0779	-0.0702	-0.1294	-0.1351	-0.1086	-0.0466	-0.1074	0.0335	-0.1531	-0.0432	0.1101	0.3679**
2	0.2425	0.0946	0.0555	0.0604	0.0306	0.0488	0.0581	0.0437	0.0387	0.0688	0.0120	0.0544	0.0324	0.0000	0.9055**
3	0.1225	0.2385	0.4067	0.1553	0.1542	0.3165	0.2790	0.1945	-0.0756	0.2730	-0.1734	0.2730	-0.0016	-0.0579	0.6356**
4	0.0730	0.1439	0.0861	0.2255	0.1743	0.1563	0.2031	0.0942	0.0766	0.1559	-0.1532	0.1388	0.0844	0.0005	0.5159**
5	-0.1403	-0.1557	-0.1824	-0.3143	-0.4812	-0.5655	-0.5574	-0.2420	-0.0578	-0.2541	0.2398	-0.2285	-0.1155	-0.0199	0.2821*
6	0.1067	0.1024	0.1546	0.1378	0.2336	0.1987	0.3322	0.1402	0.0414	0.1764	-0.1780	0.1226	0.0867	0.0055	0.4457**
7	-0.0122	-0.0134	-0.0149	-0.0196	-0.0252	-0.0363	-0.0217	-0.0170	-0.0047	-0.0213	0.0163	-0.0161	-0.0072	0.0012	0.7194**
8	0.2411	0.2468	0.2557	0.2234	0.2688	0.3722	0.4187	0.5346	-0.0529	0.3910	-0.2582	0.3768	0.0493	0.0316	0.5865**
9	0.0959	0.2027	-0.0920	0.1681	0.0595	0.1032	0.1069	-0.0490	0.4951	0.1819	0.1103	0.0866	0.3148	-0.0429	0.5475**
10	0.1670	0.2721	0.2513	0.2589	0.1977	0.3324	0.3665	0.2739	0.1376	0.3745	-0.2236	0.2538	0.1285	-0.0106	0.9484**
11	-0.0297	0.0271	-0.0909	-0.1449	-0.1062	-0.1909	-0.1596	-0.1030	0.0475	-0.1273	0.2132	-0.0390	0.0122	-0.0283	-0.2958**
12	-0.1430	-0.1294	-0.1510	-0.1384	-0.1068	-0.1387	-0.1669	-0.1585	-0.0393	-0.1524	0.0411	-0.2249	-0.0514	0.0679	0.6954**
13	-0.0085	-0.0163	0.0002	-0.0178	-0.0114	-0.0208	-0.0157	-0.0044	-0.0302	-0.0163	-0.0027	-0.0109	-0.0476	0.0088	0.4799**
14	0.0939	0.0000	0.0292	-0.0005	-0.0085	-0.0057	0.0113	-0.0122	0.0178	0.0058	0.0273	0.0620	0.0381	-0.2055	-0.1394

Residual effect = 0.1876 * Significant at 5% ** Significant at 1% rG = Genotypic correlation with fruit yield per vine

Direct effect values at diagonal and others are indirect effect on fruit yield per vine

1. Vine length (m)
2. Number of branches per vine
3. Duration of crop (days)
4. Node at which first female flower appears
5. Days to first female flower opening

6. Days to 50 per cent flowering
7. Days to first fruit picking
8. Fruit length (cm)
9. Fruit diameter (cm)
10. Average fruit weight (g)

11. Number of fruits per vine
12. Number of seeds per fruit
13. Flesh thickness (m)
14. Ascorbic acid (mg/100g)

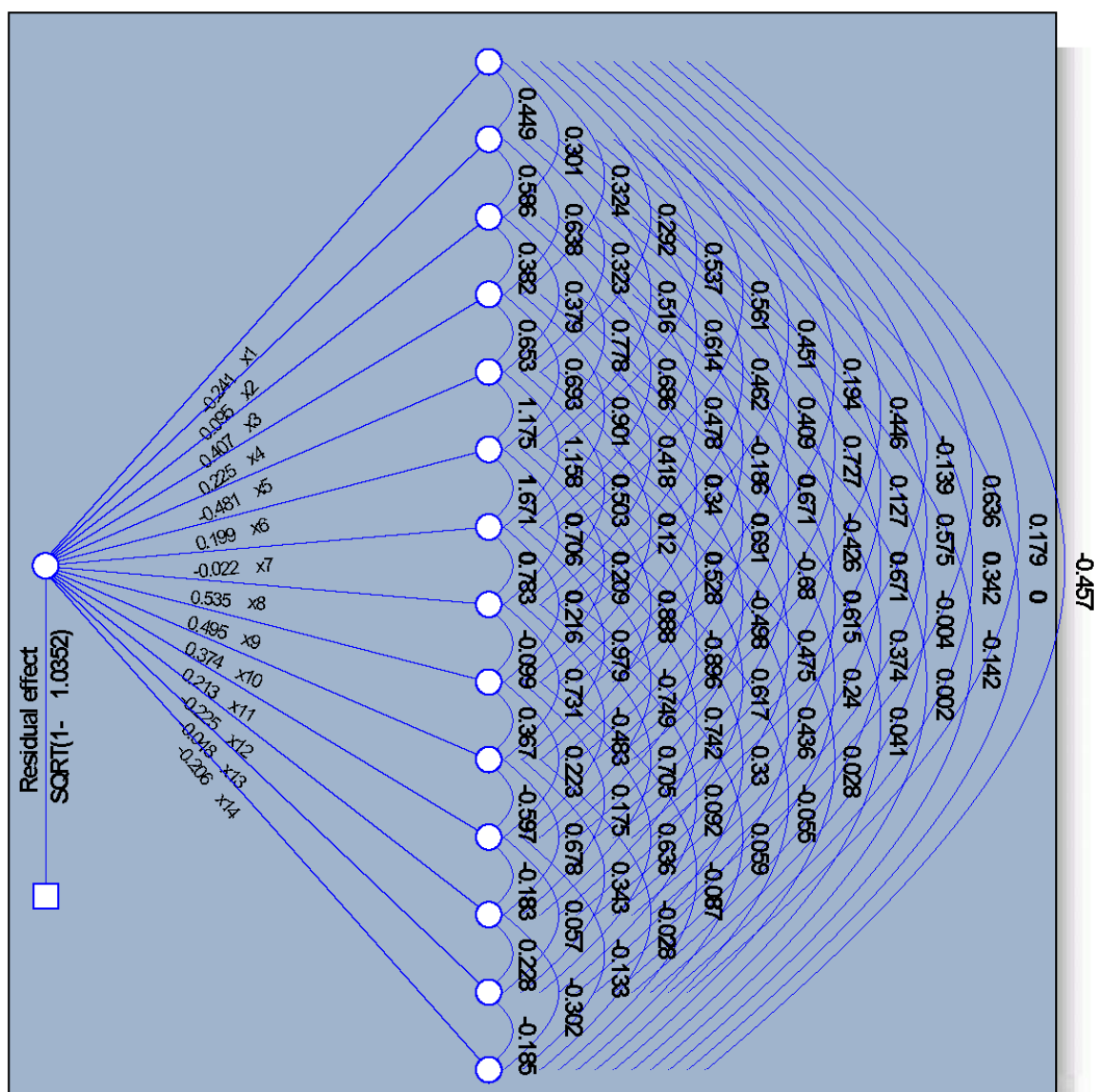


Figure 6. Genotypical path diagram for fruit yield per vine and its components in bitter gourd

- | | | |
|--|----------------------------------|-------------------------------|
| 1. Vine length (m) | 6. Days to 50 per cent flowering | 11. Number of fruits per vine |
| 2. Number of branches per vine | 7. Days to first fruit picking | 12. Number of seeds per fruit |
| 3. Duration of crop (days) | 8. Fruit length (cm) | 13. Flesh thickness (mm) |
| 4. Node at which first female flower appears | 9. Fruit diameter (cm) | 14. Ascorbic acid (mg/100g) |
| 5. Days to first female flower opening | 10. Average fruit weight (g) | |

Number of branches per vine had positive direct effect (0.0946) on fruit yield per vine and it had indirect positive effect via vine length (0.2485), average fruit weight (0.0688), node at which first female flower appears (0.0604), days to first fruit picking (0.0581), duration of crop (0.0555), number of seeds per fruit (0.0544), days to 50 per cent flowering (0.0488), fruit length (0.0437), fruit diameter (0.0387), flesh thickness (0.0324) and days to first female flower opening (0.0306).

Duration of crop had high positive direct effect (0.4067) on fruit yield per vine and it had positive indirect effect via days to 50 per cent flowering (0.3165), days to first fruit picking (0.2790), average fruit weight (0.2730), number of seeds per fruit (0.2730), fruit length (0.1945), node at which first female flower appears (0.1553) and days to first female flower opening (0.1542).

Node at which first female appears had positive direct effect (0.2255) on fruit yield per vine and it had high positive indirect effect through days to first fruit picking (0.2031), days to first female flower opening (0.1743), days to 50 per cent flowering (0.1563), average fruit weight (0.1559), number of branches per vine (0.1439) and number of seeds per fruit (0.1388).

Days to first female flower opening had high negative direct effect (-0.4812) on fruit yield per vine and it had positive indirect effect through number of fruits per vine (0.2398).

Days to 50 per cent flowering had positive direct effect (0.1987) on fruit yield per vine and it had positive indirect effect via days to first fruit picking (0.3322), days to first female flower opening (0.2336) average fruit weight (0.1764), duration of crop (0.1546) fruit length (0.1402) and number of seeds per fruit (0.1226).

Days to first fruit picking had no positive direct effect (-0.0217) on fruit yield per vine and it had positive indirect effect via number of fruits per vine (0.0163) and ascorbic acid (0.0012).

Fruit length had high positive direct effect (0.5346) on fruit yield per vine and it had positive indirect effect through days to first fruit picking (0.4187), average fruit weight (0.3910), number of seeds per fruit (0.3768), days to 50 per cent flowering (0.3722), days to first female flower opening (0.2688), duration of crop (0.2557), number of branches per vine (0.2468), vine length (0.2411) and node at which first female flower opening (0.2234).

Fruit diameter had high positive direct effect (0.4951) on fruit yield per vine and it had positive indirect effect via flesh thickness (0.3148), number of branches per vine (0.2027) average fruit weight (0.1819), node at which first female flower appears (0.1681), number of fruits per vine (0.1103) and days to 50 per cent flowering (0.1032).

Average fruit weight had positive direct effect (0.3745) on fruit yield per vine and it had positive indirect effect through days to first fruit picking (0.3665), days to 50 per cent flowering (0.3324), fruit length (0.2739), number of branches per vine (0.2721), node at which first female flower appears (0.2589) number of seeds per fruit (0.2538) and duration of crop (0.2513).

Number of fruits per vine had direct positive effect (0.2132) on fruit yield per vine and it had positive indirect effect via fruit diameter (0.0475), and number of branches per vine (0.0271) and flesh thickness (0.0122).

Number of seeds per fruit had no positive direct effect (-0.2249) on fruit yield per vine but it had positive indirect effect through ascorbic acid (0.0679) and number of fruits per vine (0.0411). Flesh thickness had negative direct effect (-0.0476) on fruit yield per vine but it had positive indirect effect via ascorbic acid (0.0088). Ascorbic acid had no positive direct effect (-0.2055) on fruit yield per vine but it had positive indirect effect through vine length (0.0939) and number of seeds per fruit (0.0620).

4.6 Evaluation of bitter gourd genotypes against powdery mildew disease under natural condition

The disease score for powdery mildew for bitter gourd germplasms are given in Table 12. Most of the genotypes showed moderately resistant reaction. The genotypes GYB-3-1-2, Yellapur Local-1 and West Bengal Local-1 were susceptible whereas the genotypes Arka Harit and Bit-3-1-1-1 were showed highly susceptible reaction to powdery mildew disease.

Table 12. Evaluation of bitter gourd genotypes against powdery mildew disease under natural condition

Sl. No.	Genotypes	Per cent disease index	Disease score	Disease reaction
1	Preethi	31.25 (33.98)	2	Moderately resistant
2	Yellapur Local-2	33.63 (35.43)	2	Moderately resistant
3	Bit-25-2-1	35.25 (36.37)	2	Moderately resistant
4	Meghnaa-2	23.75 (29.15)	2	Moderately resistant
5	Jhalawar Local-3	32.13 (34.53)	2	Moderately resistant
6	CO-1	28.63 (32.34)	2	Moderately resistant
7	Bit-22-1-1-3	25.25 (30.12)	2	Moderately resistant
8	Bit-9-2-4-1	23.25 (28.82)	2	Moderately resistant
9	GYB-3-1-2	50.25 (45.14)	3	Susceptible
10	Bit-1-2-3	25.75 (30.49)	2	Moderately resistant
11	Yellapur Local-1	30.25 (33.33)	2	Moderately resistant
12	Bit-37-2-1	26.88 (31.22)	2	Moderately resistant
13	DEB-505	25.25 (30.12)	2	Moderately resistant
14	Bit-3-1-2-1	51.25 (45.72)	3	Susceptible
15	Bit-9-3-2-3	23.75 (29.15)	2	Moderately resistant
16	Bit-5-1-2-1	34.25 (35.79)	2	Moderately resistant
17	West Bengal Local-1	40.25 (39.37)	2	Moderately resistant
18	Jhalawar Local-2	45.75 (42.55)	3	Susceptible
19	Super Green	27.25 (31.46)	2	Moderately resistant
20	IC-68238	38.25 (38.18)	2	Moderately resistant
21	Bit-10-1-1	29.75 (33.01)	2	Moderately resistant
22	West Bengal Local-2	27.63 (31.70)	2	Moderately resistant
23	Kotla Local-1	27.13 (31.38)	2	Moderately resistant
24	Bit-10-1-2	36.25 (37.01)	2	Moderately resistant
25	Bit-5-1-4-1	25.88 (30.58)	2	Moderately resistant
26	Contai Bolder	37.38 (37.69)	2	Moderately resistant
27	Bit-1-2-2-4	27.75 (31.67)	2	Moderately resistant
28	Bit-18-1-1	23.25 (28.82)	2	Moderately resistant
29	Jhalawar Local-1	28.25 (32.10)	2	Moderately resistant
30	Bit-3-1-1-1	75.75 (60.51)	4	Highly susceptible
31	GYB-5-1-5-2	22.50 (28.30)	2	Moderately resistant
32	Bit-22-1-1-1	21.75 (27.77)	2	Moderately resistant
33	Bit-9-2-1-2	20.25 (26.72)	2	Moderately resistant
34	GYL-2	38.25 (38.18)	2	Moderately resistant
35	GYB-2-2	27.25 (31.46)	2	Moderately resistant
36	Katahi	23.38 (28.91)	2	Moderately resistant
37	Bit-35-1-1	27.38 (31.52)	2	Moderately resistant
38	Bit-31-2-2	32.85 (34.84)	2	Moderately resistant
39	Arka Harit	78.25 (62.20)	4	Highly susceptible
40	Bit-9-1-4-1	28.25 (32.10)	2	Moderately resistant
SEm±		4.890		
CD @ 5%		15.095		
CV (%)		6.957		

Figures in parenthesis are arc sine transformed values

V. DISCUSSION

Success of crop improvement programme depends largely on the existence of genetic diversity and extent of variability present in the germplasm for the traits for which the improvement is aimed at. The knowledge of genetic diversity, variability and association of various characters are essential in planning the breeding programmes. With this perspective, in the present study, 40 genotypes of bitter gourd were evaluated for fruit yield per vine and its contributing characters. The genetic proportion of diversity, variability, broad sense heritability and genetic advance as per cent of mean were estimated. The association among the characters and their direct and indirect effects on fruit yield per vine were studied. The results obtained are discussed in this chapter.

5.1 Genetic divergence

Genetic divergence has been considered as an important factor in discriminating the genetically diverse parents for efficient and successful hybridization programme in order to get potential transgressive segregants and also provide new recombination of genes in the gene pool.

Multivariate analysis using Mahalanobis's D^2 statistic has been found to be a potential biometrical tool in quantifying the degree of divergence in germplasm collections of crop plants. This method is also a unique tool to discriminate the populations considering a set of parameters together rather than inferring from indices based upon morphological similarities, eco-geographical diversity and phylogenetic relationships. Therefore, the genetic divergence analysis was conducted to identify suitable parents out of 40 bitter gourd genotypes to initiate a breeding programme for development of 6 clusters.

Assessment of genetic diversity was made based on the data recorded for 16 yield and quality characters in 40 genotypes using Mahalanobis's D^2 analysis.

Trocher's method of grouping is most widely used procedure of clustering. Using this method, all the 40 genotypes were grouped into six clusters based on the relative magnitude of the D^2 values. Cluster I had 32 genotypes, Cluster II had four genotypes and single genotype was included in cluster III, cluster IV, cluster V and cluster VI (Table 4).

The 40 genotypes were grouped into 6 clusters and each have the genotypes from different geographical regions indicating that there was no association between geographical distribution and genetic diversity as reported earlier by Kutty and Dharmatti (2005), Dey *et al.* (2007), Sundaram (2008) and Bhagwat *et al.* (2013) in bitter gourd.

Studies on intra cluster distance revealed that, cluster II with four genotypes showed maximum intra-cluster distance ($D^2 = 104.02$) followed by cluster I ($D^2 = 96.08$) with 32 genotypes. The cluster III, cluster IV, cluster V and cluster VI had zero intra cluster distance ($d^2 = 0.00$) as they possessed single genotype in each. This results accordance with Rabbani *et al.* (2012) in ridge gourd.

Based on distance between clusters (inter-cluster distance), the maximum D^2 value was found between cluster II and VI (1620.05) followed by cluster IV and VI (1262.95), cluster II and V (1098.44) and cluster II and cluster III (851.00). The minimum inter-cluster D^2 value was recorded between cluster III and V (103.32). This results accordance with Deepa and Mariappan (2013) in snake gourd.

These clusters have been formed based on the contribution of different characters to the divergence which includes ascorbic acid contributing the maximum (37.31%) to the diversity followed by fruit length (15.64%), fruit diameter (14.36%), flesh thickness (11.92%), number of seeds per fruit (9.49%), days to first female flower opening (6.92%), average fruit weight (1.28%). However, number of branches per vine (0.90%), number of fruits per vine (0.77%), fruit yield per vine (0.77%), vine length (0.51%) and node at which first female flower appears (0.13%) have contributed meagrely to the divergence. On contrary, duration of crop, days to 50 per cent flowering and days to first fruit picking

had no contribution towards genetic divergence. Similar results were also observed by Parthi *et al.* (1993) for number of seeds per fruit, Sundaram (2008) and Bhagwat *et al.* (2013) for duration of crop and number of seeds per fruit. Apart from the divergence, the performance of genotypes and the character with maximum contribution towards divergence should also be given due consideration which appear as desirable for improvement of bitter gourd.

For ascorbic acid content in fruit, the highest cluster mean was shown by cluster VI followed by cluster V, cluster II and cluster IV (Table 6). The inter cluster distance between cluster IV and VI (1262.95), cluster V and II (1098.44), cluster IV and V (685.87) and cluster II and IV (215.32) were comparatively high (Table 5). Hence, crossing between the genotypes belonging to these clusters may evolve desirable variety with high ascorbic acid content.

For fruit length, the highest cluster mean was shown by cluster VI followed by cluster V, cluster III and cluster I. The inter cluster distance between cluster I and cluster VI (749.76), cluster V and cluster I (333.55), cluster III and cluster I (207.68) and cluster V and cluster III (103.32) were comparatively high. Hence, crossing between the genotypes belonging to these clusters may evolve varieties with good fruit length.

For fruit diameter, the highest cluster mean was shown by cluster IV followed by cluster V, cluster III and cluster I. The inter cluster distance between cluster IV and cluster III (539.69), cluster V and cluster I (333.55), cluster I and cluster III (207.68) and cluster V and cluster III (103.32) were comparatively high. Hence, hybridization programme may be employed between the genotypes of these clusters to evolve good varieties with good fruit diameter.

For flesh thickness, the highest cluster mean was shown by cluster IV followed by cluster V, cluster I and cluster III. The inter cluster distance between cluster IV and III (539.69), cluster V and cluster I (333.55), cluster I and cluster III (207.68) and cluster V and cluster III (103.32) were comparatively high. Hence, this character may be improved by hybridization between the genotypes of respective cultivars.

For number of seeds per fruit, the highest cluster mean was shown by cluster III followed by cluster V, cluster VI and cluster I. The inter cluster distance between cluster VI and cluster I (749.76), cluster V and cluster I (333.55), cluster III and cluster I (207.68) and cluster V and cluster VI (168.13) were comparatively high. Hence, crossing between the genotypes belonging to these clusters may evolve good varieties with more number of seeds which will be preferred in hybrid seed production.

For days to first female flower opening, the lowest cluster mean was shown by cluster II followed by cluster III, cluster V and cluster I. The inter cluster distance between cluster II and cluster I (399.88), cluster V and cluster I (333.55) and cluster III and cluster I (207.68) were comparatively low. Hence, crossing between the genotypes belonging to these clusters may evolve varieties with early female flowering.

For average fruit weight, the highest cluster mean was shown by cluster VI followed by cluster V, cluster III and cluster I. The inter cluster distance between cluster VI and cluster I (749.76), cluster V and cluster I (333.55), cluster III and cluster I (207.68) and cluster V and cluster III (103.32) were comparatively high. Thus, the crosses between the genotypes of these respective clusters would be of much help in the improvement of average fruit weight which will ultimately contribute to the total yield.

5.2 Genetic parameters

5.2.1 Genetic variability, heritability and genetic advance

The analysis of variance (Table 2) revealed significant ($p = 0.05$) variation among the genotypes for 16 growth, yield and quality parameters in bitter gourd. It is indicated that, sufficient variability existed for the characters studied and considerable improvement could be achieved. However, the analysis of variance by itself is not enough and conclusive to explain all the inherent genotypic variances in the genotypes.

One of the ways, by which variability in the characters could be assessed, was through a simple approach of examining the range of variations. Range of variation observed for all the traits in the present study (Table 7) indicated the presence of sufficient amount of variation among the genotypes for all the characters studied.

Means of genotypes varied greatly for several traits, indicating the higher magnitude of variability. The range in the values reflects the amount of phenotypic variability. In the present study, wide range of variability was observed for all the characters especially fruit length.

Range and mean values is not reliable since, it includes genotypic, phenotypic and environment variations. Hence, estimates of genotypic co-efficient of variation (GCV) and phenotypic co-efficient of variation (PCV) were carried out.

In the present investigation, high GCV and PCV were observed for fruit length, number of seeds per fruits, average fruit weight, fruit yield per vine, fruit yield per hectare and flesh thickness. The similar results were also observed for fruit length by Maneesh *et al.* (2014), Khan *et al.* (2015), Yadagiri *et al.* (2017) and Vivek *et al.* (2017) in bitter gourd; Maneesh *et al.* (2014), Subhasmita (2015), Yadagiri *et al.* (2017) for number of seeds per fruit in bitter gourd; Deepthi *et al.* (2016) in bottle gourd; Maneesh *et al.* (2014), Khan *et al.* (2015), Yadagiri *et al.* (2017) for average fruit weight in bitter gourd; Maneesh *et al.* (2014), Yadagiri *et al.* (2017), Vivek *et al.* (2017) for fruit yield per vine in bitter gourd, Singh *et al.* (2002), Rabbani *et al.* (2012) in ridge gourd and Jat *et al.* (2014) for flesh thickness in kakri. It indicates existence of broad genetic base, which would be amenable for further selection.

Moderate GCV and high PCV were observed for vine length, node at which first female flower appears and number of fruits per vine. These results are accordance with Rani *et al.* (2015) and Vivek *et al.* (2017) for node at which first female flower appears in bitter gourd; Devendra *et al.* (2018) and Tiwari *et al.* (2018) for number of fruits per vine in bitter gourd.

Moderate GCV and PCV were observed for number of branches per vine and fruit diameter. The similar results were also observed by Rani *et al.* (2015) for number of branches per vine in bitter gourd, Bhargava *et al.* (2017) in ridge gourd, Rana and Pandit (2011) in snake gourd; Yadagiri *et al.* (2017), Tyagi *et al.* (2018) for fruit diameter in bitter gourd; Singh *et al.* (2002) and Karthik *et al.* (2017) for fruit diameter in ridge gourd.

Low GCV and PCV were observed for duration of crop, days to first fruit picking and ascorbic acid. The similar results were also observed for duration of crop by Mukesh (2017) in ash gourd; Devendra *et al.* (2018), Tiwari *et al.* (2018) for days to first fruit picking in bitter gourd; Pushpendra *et al.* (2017) for days to first fruit picking in ridge gourd; Rajawat and Collis (2017) for ascorbic acid in cucumber. This indicates the narrow genetic base and hence variability has to be generated for these characters either through introduction or hybridizing divergent genotypes to recover transgressive segregants or by mutation breeding.

Co-efficient of variation indicates only the extent of variability present in germplasm for different characters, but for the prediction of responses to selection, heritability estimates are very useful. Very high (>80%) broad sense heritability was observed for days to first female flower opening, fruit length,

fruit diameter, number of seeds per fruit, flesh thickness and ascorbic acid. The similar results were also observed for days to first female flower opening by Maneesh *et al.* (2014), Rani *et al.* (2015), Vivek *et al.* (2017) in bitter gourd; Maneesh *et al.* (2014), Rani *et al.* (2015), Vivek *et al.* (2017), Tyagi *et al.* (2018) for fruit length in bitter gourd; Maneesh *et al.* (2014), Vivek *et al.* (2017) for fruit diameter in bitter gourd; Maneesh *et al.* (2014), Subhasmita (2015), Yadagiri *et al.* (2017) for number of seeds per fruit in bitter gourd; Rani *et al.* (2015) for flesh thickness in bitter gourd; Mudassar (2015) and Vivek *et al.* (2017) for ascorbic acid in bitter gourd.

High (60-80%) broad sense heritability was observed for fruit yield per vine, average fruit weight, vine length and number of branches per vine. The similar results were also observed for fruit yield per vine by Tyagi *et al.* (2018) in bitter gourd, Pushpendra *et al.* (2017) in ridge gourd; Tyagi *et al.* (2018) for average fruit weight in bitter gourd, Karthik *et al.* (2017) in ridge gourd; Devendra *et al.* (2018) for vine length in bitter gourd, Yadagiri *et al.* (2017) for number of branches per vine in bitter gourd and Rabbani *et al.* (2012) for number of fruits per vine in ridge gourd. High heritability indicates the traits were less influenced by environment and selection of such traits is economical.

Very often, heritability in broad sense is not true indicator of inheritance of characters, since only additive component of genetic variance is efficiently transferred from generation to generation. Therefore, heritability in broad sense may mislead in judging the effectiveness of selection for the character. Considering heritability in broad sense along with genetic advance may reveal the prevalence of specific components (additive or non-additive) of genetic variance for the character more accurately. In the present study most of the characters recorded high heritability estimates and selection would be effective if based on phenotypic values. However, high heritability estimates coupled with high genetic advance render the selection would be effective for such character Johnson *et al.* (1955).

The high estimates of heritability coupled with high values of genetic advance over mean (GAM) were observed for characters viz., fruit length, fruit diameter, number of seeds per fruit, flesh thickness, fruit yield per vine, fruit yield per hectare, average fruit weight, vine length and number of branches per vine. These results are in accordance with the findings for fruit length by Maneesh *et al.* (2014), Rani *et al.* (2015), Yadagiri *et al.* (2017), Vivek *et al.* (2017), Devendra *et al.* (2018) and Tyagi *et al.* (2018) in bitter gourd; Maneesh *et al.* (2014), Vivek *et al.* (2017) for fruit diameter in bitter gourd; Maneesh *et al.* (2014), Subhasmita. (2015), Yadagiri *et al.* (2017) for number of fruits per vine in bitter gourd and Jat (2014) for flesh thickness in kakri. This indicates predominance of additive component for these characters and selection would be more effective in improving their traits.

High heritability with low genetic advance (GA) shows the importance of non-additive gene action. High heritability coupled with moderate to low values of GAM were observed for days to first female flower opening and ascorbic acid. These results are in accordance with the findings for days to first female flower opening by Rani *et al.* (2015), Vivek *et al.* (2017) in bitter gourd and Shah *et al.* (2018) in cucumber; Damor *et al.* (2016) for ascorbic acid in cucumber.

Moderate to low heritability coupled with high GA indicates the importance of additive gene effects. Low to moderate heritability with high GAM was obtained for node at which first female flower appears. These results are in conformity with the findings for node at which first female flower appears by Tyagi *et al.* (2018) in bitter gourd and Karthik *et al.* (2017) in ridge gourd. This indicates the importance of additive gene effects for this trait and there can be better response to selection.

Low heritability with low GA indicates that, the character is highly influenced by environmental effects and selection would be ineffective. Moderate to low heritability with moderate to low values of GAM were observed for the characters like days to 50 per cent flowering, days to first fruit picking and number of fruits per vine. Similar results were also reported for days to 50 per cent flowering by Mukesh (2017) in ash gourd; Yadagiri *et al.* (2017) and Tiwari *et al.* (2018) for days to first fruit picking in bitter gourd. These findings elucidate prevalence of higher influence of environment on these traits and hence, selection would be ineffective.

The higher GCV and heritability estimate coupled with high GAM was observed for fruit length, average fruit weight, fruit yield per vine, fruit yield per hectare, number of seeds per fruit and flesh thickness. This indicates additive gene action hence, higher degree of genetic improvement for these traits can be achieved through selection using the existing germplasm.

5.3 Correlation studies

Correlation studies help to better understanding of yield components which helps the plant breeder during selection Johnson *et al.* (1955). It measures degree and direction of association between two or more characters. Correlation co-efficient measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield. This kind of analysis could help the breeder to design his selection strategy to improve the fruit yield, while discussing the importance of the component characters in determining the complex characters like yield. The knowledge of correlation between complex characters like yield and its component characters is of considerable use of rational approach towards improvement in the yield.

The correlation studies are used to know the suitability of various characters for indirect selection because selection for one or more traits results in correlated response for several traits and the pattern of variation will also be changed. Therefore, the knowledge of genetic correlation existing between yield and its components is essential.

In the present study, the genotypic and phenotypic correlation co-efficients obtained from 40 genotypes for 15 fruit yield and quality component characters are discussed below.

The present investigation revealed that genotypic correlation co-efficients was higher in magnitude than respective phenotypic correlation co-efficients for most of the characters (Table 8 and 9) which indicates little role of environmental expression on the genetic relationship of characters in the phenotype. This is in conformity with the work done by Pathak *et al.* (2014), Yadagiri *et al.* (2017) and Gupta *et al.* (2015) in bitter gourd.

In the present investigation, fruit yield per vine had highly significant (at $p = 0.01$) and positively associated with vine length, number of branches per vine, node at which first female flower appears, days to 50 per cent flowering, days to first fruit picking, fruit length, fruit diameter, average fruit weight, number of seeds per fruit and flesh thickness at both phenotypic and genotypic levels and it was also significant (at $p = 0.05$) and positively correlated with duration of crop and days to first female flower opening at genotypic and phenotypic level. Since, these associated traits are in the desirable direction, it indicated that simultaneous selection for these characters would be rewarding in improving the fruit yield. Similar findings were correlated by Dey *et al.* (2005) in bitter gourd for flesh thickness, days to first fruit picking, fruit length and fruit diameter; Kutty and Dharmatti (2005) for node at which first female flower appears, number of seeds per fruit, fruit length in bitter gourd; Kumar *et al.* (2008) for average fruit weight in bitter gourd; Islam *et al.* (2009) for vine length in bitter gourd and Botau *et al.* (2010) for fruit weight, fruit length and fruit diameter in bitter gourd.

Vine length exhibited significant and positive association with number of branches per vine at phenotypic and genotypic level. It was also positively and significantly associated with crop duration only at genotypic level. These results are in accordance with Islam *et al.* (2009) in bitter gourd. This indicates there is a strong association between these vegetative traits.

Node at which first female flower appears was highly significantly and positively correlated with days to first female flower opening, days to 50 per cent flowering and days to first fruit picking at both phenotypic or genotypic level. Similar observation was also made by Gupta *et al.* (2015) in bitter gourd, which indicates the presence of very strong association among the earliness parameters.

Average fruit weight showed highly significant and positive association with fruit length, fruit diameter, flesh thickness and number of seeds per fruit at both phenotypic and genotypic level. These results are inline with the observations of Rana and Pandit (2011) in snake gourd for fruit length and fruit diameter; Yadagiri *et al.* (2017) in bitter gourd and Kumar *et al.* (2013) for number of seeds per fruit in sponge gourd. This indicates, there is a strong association between average fruit weight, fruit length, fruit diameter and number of seeds per fruit.

Duration of crop was significantly and positively associated with fruit yield per vine at both phenotypic and genotypic level. Similar observation was made by Yadagiri *et al.* (2017) in bitter gourd. This indicates that more crop duration resulted in higher yield.

Ascorbic acid content showed negative and significant association with vine length and number of seeds per fruit. Similar results were obtained by Damor *et al.* (2016) in bottle gourd.

From the fore going discussion it is conceivable that a great deal of success can be achieved in improvement of fruit yield per vine by applying selection pressure on average fruit weight, number of seeds per fruit, fruit diameter, number of branches per vine, flesh thickness, days to 50 per cent flowering, days to first fruit picking and vine length as these characters had highly significant and positive association with fruit yield per vine.

5.4 Path co-efficient analysis

Yield is the result of the expression and association of several yield attributing traits, which contribute additively or help in some conditions in modifying the expression of other traits directly or indirectly. It is therefore desirable for plant breeder to know the extent of relationship between yield and its various components, which will inevitably facilitate selection of desirable characteristics. Correlation and path co-efficient become necessary tools at the disposal of the breeder. Correlation measures the mutual association between two variables, which aids in determining the most effective procedures for selection of superior genotypes. When there is positive association for major yield trait components, breeding would be very effective but on the contrary, it becomes difficult to exercise simultaneous selection for them to develop a variety. According to Cramer and Wehner (2000) path co-efficient analysis can be employed to partition the correlation between yield and its components into direct and indirect effects. Salahuddin *et al.* (2010) affirms that path co-efficient analysis provides an effective means of partitioning correlation co-efficient into unidirectional and alternative pathways thus permitting a critical examination of specific factors that produce a given correlation, which can be successfully employed in formulating an effective selection programme.

Path co-efficient analysis was used to compute direct and indirect effects of 14 characters on fruit yield per vine in the present study. Both phenotypic and genotypic paths were worked out since, the phenotypic path analysis will have greater influence of environmental factors and hence the genotypic path was considered with greater weightage.

The results of the path analysis gave higher genotypic path values compared to phenotypic paths indicating a less environmental effect on character association.

Fruit length was positively and significantly correlated with fruit yield per vine and it had also high direct and positive effect (0.5346) on fruit yield per vine and had indirect and positive effect through days to first fruit picking (0.487), average fruit weight (0.3910) number of seeds per fruit (0.3768) and days to 50 per cent flowering (0.3722) (Table 11). Similar observations made by Kundu *et al.* (2012) and Khan *et al.* (2015) in bitter gourd. Therefore, fruit length needs to be considered along with average fruit weight, days to first fruit picking, number of seeds per fruit and day to 50% flowering would be rewarding in improvement of yield.

Fruit diameter was positively and significantly associated with fruit yield per vine and it had also high direct and positive effect (0.4951) on fruit yield per vine and had indirect and positive effect via flesh thickness (0.3148). The results are in agreement with Kumar *et al.* (2013) in sponge gourd.

Even though, days to first female flower opening was significantly and positively correlated with fruit yield per vine, it had high negative direct effect (-0.4812) on fruit yield per vine but moderate levels of indirect effect through number of fruits per vine (0.2398). Under these circumstances, the indirect casual factor i.e. number of fruits per vine need to be considered along with days to first female flower opening.

Duration of crop was positively and significantly correlated with fruit yield per vine and it had high direct and positive effect (0.4067) on fruit yield per vine and it had positive indirect effect through days to 50 per cent flowering (0.3165). It also had moderate positive direct effect via days to first fruit picking (0.2790), average fruit weight (0.2730) and number of seeds per fruit (0.2730). This is in agreement with results of Yadagiri *et al.* (2017) in bitter gourd.

Average fruit weight was positively and significantly correlated with fruit yield per vine. It had positive direct effect (0.3745) on fruit yield per vine and it had positive indirect effect through days to first fruit picking (0.3665) and days to 50 per cent flowering (0.3324). It also had moderate positive indirect effect through number of branches per vine (0.2721), node at which first female flower appears (0.2589), number of seeds per fruit (0.2538) and duration of crop (0.2513). Similar observations were made by Kundu *et al.* (2012) and Rani *et al.* (2015) in bitter gourd and Ahmed *et al.* (2018) in pumpkin. Average fruit weight needs to be considered along with days to first fruit picking, days to 50 per cent flowering, number of branches per vine, node at which first female flower appears, days to first female flower opening, number of seeds per fruit and duration of crop would be rewarding in improvement of yield.

With the foregoing discussion, it can be concluded that in bitter gourd, fruit length, fruit diameter, duration of crop and average fruit weight are important characters to be accounted for gaining improvement in fruit yield per vine since, these traits had high direct and indirect effects.

5.5 Evaluation of bitter gourd genotypes against powdery mildew disease under natural condition

Significant differences were observed among bitter gourd genotypes in their reaction to powdery mildew. Among 40 genotypes, 35 genotypes were moderately resistant. The genotypes GYB-3-1-2, Yellapur Local-1 and West Bengal Local-1 were susceptible while the genotypes Arka Harit and Bit-3-1-1-1 were highly susceptible. These results were accordance with Murlee *et al.* (2008) and Dhillon *et al.* (2018) in bitter gourd and Parameshwar and Shripad (2018) in cucumber.

Future line of work

1. Higher degree of genetic improvement can be achieved through selection by using the existing germplasm for the traits *viz.*, fruit length, average fruit weight, fruit yield per vine, number of seeds per fruit, flesh thickness and vine length as there is high degree of additive components of genetic variance with high GCV, PCV, heritability and GAM for these traits.
2. For improvement of fruit yield per vine, breeder should give due consideration for fruit length, fruit diameter, duration of crop, average fruit weight, number of seeds per fruit and node at which first female flower appears, since these traits had positive direct and indirect association with fruit yield per vine as revealed by correlation and path analysis.
3. Top ranking five genotypes, Kotla Local-1, Bit-9-3-2-3, Super Green, Bit-37-2-1 and Bit-18-1-1 based on *per se* values for fruit yield per vine have been identified and these can be further

assessed for their stability before exploiting them for commercial cultivation and also could be tested for disease tolerance (Appendix IV)

4. For recovering improved progenies for yield and quality traits, crosses can be attempted between cluster II and cluster IV, cluster IV and cluster VI and cluster II and cluster V as there is high inter cluster distance and high cluster means for yield and quality parameters.

VI. SUMMARY

The present investigation on “Genetic diversity and character association studies in bitter gourd (*Momordica charantia* L.)” was carried out in the Department of Vegetable Science, College of Horticulture, Mysuru (Karnataka), during *kharif* season of 2017. The experiment was laid out in Randomized Block Design (RBD) involving 40 diverse genotypes of bitter gourd with 2 replications. The present study was under taken to elicit information on genetic divergence, the nature of variability among the 40 bitter gourd genotypes and correlation pattern among growth, earliness, yield and quality parameters and also to screen genotypes against powdery mildew disease under natural epiphytic condition. The observations were subjected to statistical analysis using WINDOSTAT software. The experimental results are summarized below.

Analysis of variance indicated highly significant difference among the genotypes for all the characters indicating the presence of wide range of variability in the genotypes studied.

Multivariate analysis (D^2 statistic) given by Mahalanobis's was used to group the 40 bitter gourd genotypes into 6 clusters. A maximum of 32 genotypes entered in cluster I, followed by 4 genotypes in cluster II. The cluster III, IV, V and VI had single genotypes each.

The highest intra cluster distance (D^2 values) was observed in cluster II (104.02) followed by cluster I (96.08). The Maximum inter cluster distance was observed between cluster II and VI (1620.05) followed by cluster IV and cluster VI (1262.95), cluster II and cluster V (1098.44) and cluster II and cluster III (851.00). This indicates, the genotypes belong to these clusters are more diverse and hence, hybridization between genotypes of respective clusters may improve the yield and quality traits in bitter gourd.

The number of genotypes per cluster varied from 1 - 32. This wider genetic variability may be due to the adaptation of these genotypes to specific environmental conditions. Among the 15 characters studied for D^2 analysis, ascorbic acid contributed the maximum (37.31%) to the genetic diversity followed by fruit length (15.64%), fruit diameter (14.36%), flesh thickness (11.92%), number of seeds per fruit (9.49%) and days to first female flower opening (6.92%).

The PCV was higher as compared to GCV for all the characters. This indicates that the environment played a major role in the expression of these traits. The high (> 20%) GCV and PCV were observed for fruit length, average fruit weight, number of seeds per fruit, fruit yield per vine and flesh thickness. It indicates existence of broad genetic base, which would be amenable for further crop improvement.

Moderate GCV and PCV (10-20%) was observed for number of branches per vine and fruit diameter which indicates more variability in these characters.

The high estimates of heritability (above 60%) coupled with high values of GAM (more than 20%) were observed for characters viz., fruit length, fruit diameter, number of seeds per fruit, flesh thickness, fruit yield per vine, fruit yield per hectare, average fruit weight, vine length and number of branches per vine. This indicates predominance of additive component for these characters and they are more reliable for effective selection to improve the yield of bitter gourd.

High heritability (> 60%) coupled with moderate to low values of GAM (< 20%) were obtained for days to first female flower opening and ascorbic acid indicated that prevalence of non-additive components and there can be little response to selection and these traits can be exploited through heterosis breeding.

Moderate to low heritability (< 60%) coupled with high GAM (> 20%) were observed for node at which first female flower appears. This indicates the importance of additive gene effects for these traits and there can be better response to selection.

Moderate to low heritability (< 60%) with moderate to low values for GAM (< 20%) were observed for duration of crop, days to 50 per cent flowering, days to first fruit picking and number of fruits per vine. These results elucidate prevalence of non-additive components and higher influence of environments on these traits and hence, selection would be ineffective.

Fruit yield per vine was highly significantly and positively associated with vine length, number of branches per vine, duration of crop, node at which first female flower appears, days to 50 per cent flowering, days to first fruit picking, fruit length, fruit diameter, average fruit weight, number of seeds per fruit and flesh thickness at phenotypic and genotypic levels. This indicated that direct selection for these characters might be effective and there is a possibility of improving yield per vine through selection based on these traits.

The characters viz., fruit length, fruit diameter, duration of crop and average fruit weight are important characters to be accounted for gaining improvement in fruit yield per vine since, these characters had high positive direct and indirect effects on fruit yield per vine.

Conclusion

Maximum inter cluster distance observed between cluster II and cluster IV followed by cluster IV and cluster V and cluster II and V. This indicates, the genotypes belonging to these clusters are more diverse and hence, hybridization between genotypes of respective cluster may improve the yield and quality of bitter gourd.

The characters viz., fruit length, average fruit weight, number of seeds per fruit, fruit yield per vine, fruit yield per hectare and flesh thickness were recorded high GCV, PCV, heritability and GAM. Hence, these characters had lot of variability with additive gene actions. Therefore, these traits can be improved by simple selection.

Fruit yield per vine was positively and significantly associated with fruit length, fruit diameter, duration of crop and average fruit weight. These characters have to be considered while selecting the genotypes for fruit yield per vine. These characters also recorded high direct effect on fruit yield per vine.

VII. REFERENCES

- Afangideh, U. and Uyoh, E. A., 2007, Genetic variability and correlation studies in some varieties of cucumber. *Jordan J. Agri. Sci.*, 3(4): 376-384.
- Ahmed, B., Masud, M. A. T., Zakaria, M., Hossain, M. M. and Mian, M. A. K., 2018, Variability, correlations and path co-efficient analysis in pumpkin (*Cucurbita moschata* Duch. Ex Poir.). *J. Appl. Life Sci. Int.*, 16(1): 1-8.
- Albrecht, J. A., 1993, Ascorbic acid retention in lettuce. *J. Food Qual.*, 16: 311-316.
- Al-Jibouri, H. A., Miller, P. A. and Robinson, H. V., 1958, Genotypic and environmental variance and co-variances in an upland cotton cross of inter specific origin. *Agron. J.*, 50: 633-636.
- Ananthan, M. and Krishnamoorthy, V., 2017, Genetic variability, correlation and path analysis in ridge gourd (*Luffa acutangula* (Roxb) L.). *Int. J. Curr. Microbiol. Appl. Sci.*, 6(6): 3022-3026.
- Anonymous, 2010, Improved production practices for Horticulture crops. *Univ. Hort. Sci. Bagalkot*, pp. 102-103
- Anonymous, 2016, Final area and production estimates for Horticulture Crops for (2015-16), National Horticulture Board, Ministry of Agriculture and Farmers Welfare, GOI, New Delhi.
- Anonymous, 2017, Final area and production estimates for Horticulture Crops for (2016-17), National Horticulture Board, Ministry of Agriculture and Farmers Welfare, GOI, New Delhi.
- Archana, K. A., Prasanna, K. P. and George, T. E., 2016, Evaluation of spine gourd genotypes for variability. *J. Trop. Agric.*, 54(1): 159-163.
- Bhagwat, S., Anoop, K. S. and Shailesh, K., 2013, Genetic divergence studies in bitter gourd (*Momordica charantia* L.). *Acad. J. Plant Sci.*, 6 (2): 89-91.
- Bharathi, L. K. and Vishalnath, 2010, Phenotypic diversity analysis in pointed gourd (*Trichosanthes dioica* Roxb.). *Rep. Cucurbit Genet. Coop.*, 33-34: 62-64.
- Bhargava, A. K., Singh, V. B., Pradeep, K. and Rakesh, K. M., 2017, Efficiency of selection based on genetic variability in ridge gourd [*Luffa acutangula* L. (Roxb.)]. *J. Pharmacogn. Phytochem.*, 6(4): 1651-1655.
- Bhave, S. G., Mehta, J. L., Bendale, V. W., Mhatre, P. P. and Pethe, U. B., 2003, Character association and path co-efficient analysis of bitter gourd (*Momordica charantia* L.). *Orissa J. Hort.*, 31 (1): 44-46.
- Blessing, C. A., Michael, I. U. and Benedict, C. O., 2012, Genetic variability and inter- relationship among some Nigerian pumpkin accessions (*Cucurbita* spp.). *Int. j. Plant Breed.*, 6(1): 34-41.
- Bodeker, G., George, C., Gemma, B. and Mark, D. L., 2006, HIV/ AIDS, Traditional system of health care and management of a global epidemics, *J. Alt. comple. med.*, 12 (6): 563-576.
- Botau, D., Ciulca, S. and Frant, A., 2010, The variability study of some quantitative traits in bitter gourd (*Momordica charantia* L.). *Bulletin UASVM Hort.*, 67(1): 230-234.

- Burton, G. W. and Devane, E. M., 1953, Estimating heritability in tall fescue (*Festuca arundianacea* L.) from replicated clonal material. *Agron. J.*, 45: 478-481.
- Chandan, S. A. and Singh, D. K., 2018, Assessment of genetic variability in cucumber (*Cucumis sativus* L.). *Int. J. Curr. Microbiol. and Appl. Sci.*, 7(3): 2319-2323.
- Choudhary, B. R., Fageria, M. S. and Dhaka, R. S., 2003, Textbook on production technology of vegetables. Kalyani Publishers. pp. 183-201.
- Choudhury, B. R., Pandey, S., Singh, P. K. and Pandey, V., 2014, Genetic diversity analysis for quantitative traits in hermaphrodite ridge gourd [*Luffa acutangula* (Roxb.) L.]. *Indian J. Hort.*, 71(2): 284-287.
- Cramer, C. S. and Wehner, T. C., 2000, Path analysis of the correlation between fruit number and plant traits of cucumber populations. *Hort. Sci.*, 35(4): 708-11.
- Dalamu and Behera, T. K., 2013, Character association and path co-efficient analysis of indigenous and exotic bitter gourd (*Momordica charantia*) germplasm. *Indian J. Agric. Sci.*, 83(5): 525-528.
- Damor, A. S., Patel, J. N., Parmar, H. K. and Vyas, N. D., 2016, Studies on genetic variability, heritability and genetic advance for yield and quality traits in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] genotypes. *Int. J. Sci, Environ. Tech.*, 5(4): 2301-2307.
- Debendra, B., 2015, Studies on genetic diversity among different genotypes of bitter gourd (*Momordica charantia* L.). M.Sc. (Hort.) Thesis, Institute of Agricultural Sciences Banaras Hindu University. Varanasi, India.
- Deepa, D. N. and Mariyappan, S., 2013, Studies on genetic diversity in Snake Gourd (*Trichosanthes anguina* L.). *African. J. Agric. Res.*, 8(42): 5221-5225.
- Deepthi, B., Syam, S. R., Satyaraj, K. and Ramanjaneya, R., 2016, Studies on PCV, GCV, heritability and genetic advance in bottle gourd genotypes for yield and yield components. *Plant Archives*. 16(2): 597-601.
- Devendra, K., Sanjay. K., Rakesh, K. M., Manoj, K. and Ram, V., 2018, Genetic variability, heritability and genetic advance for yield and quality attributes in bitter gourd (*Momordica charantia* L.). *Int. J. Pure Appl. Biosci.*, 6(2): 499-503.
- Dewey, D. H. and Lu, K. H., 1959, A correlation and path co-efficient analysis of components of crested wheat grass seed production. *Agron. J.*, 51: 515-518.
- Dey, S. S., Behera, T. K. and Charanjeet, K., 2006, Genetic variability in ascorbic acid and carotenoids content in Indian bitter gourd (*Momordica charantia* L.) germplasm. *Rep. Cucurbit Genet. Coop.*, 28-29: 91-93.
- Dey, S. S., Behera, T. K., Anand, p. and Munshi, A. D., 2005, Correlation and path co-efficient analysis in bitter gourd (*Momordica charantia* L.). *Veg. Sci.*, 32 (2): 173-176.
- Dey, S. S., Behera, T. K., Munshi A. D. and Sirohi, P. S., 2007, Studies on genetic divergence in bitter gourd (*Momordica charantia* L.). *Indian J. Hort.*, 64(1): 53-57.

- Dhillon, N. P. S., Sanguansil, S., Srimat, S., Schafleitner, R., Manjunath, B., Agarwal, P., Xiang, Q., Masud, M. A. T., Myint, T., Ngo, T. H., Tran, K. C., Balatero, C. H., Salutan, B. V., Pitrat, M., Lebeda, A. and McCreight, J. D., 2018, Preliminary evaluation of resistance to powdery mildew (*Podosphaera xanthii*) in AVRDC collections of bitter gourd (*Momordica charantia* L.). *Hort. Sci.*, 53(3): 337 - 341.
- Girish, M. H., 2011, Genetic variability and divergence studies in cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.). *M.Sc. (Hort.) Thesis*, Univ. Hort. Sci., Bagalkot.
- Gruthew, J. H., 1977, Production technology of Vegetable crops. *Indian Plant Genet. Resour.*, pp. 728-731.
- Gupta, N., Bhardwaj, M. L., Singh, S. P. and Sood, S., 2015, Correlation and path analysis of yield and yield components in some genetic stocks of bitter gourd (*Momordica charantia* L.). *SABRAO J. Breed. Genet.*, 47(4): 475-481.
- Hanson, C. H., Robinson and Comstock, R. E., 1956, Biometrical studies of yield in segregating populations of Korean Lespedeza. *Agron. J.*, 48: 268-375.
- Harrington, J. B., 1940, Yielding capacity of wheat crosses as indicated by bulk hybrid tests. *Canadian J. Res.*, 18: 550-554.
- Hemant, K. S. and Singh, D. R., 2015, Association and path co-efficient analysis among yield and its components in bitter gourd (*Momordica charantia* L.). *Asian J. Hort.*, 10(2): 212-215.
- Ipsita, P. and Duhan, D. S., 2018, Study of variability and morphological characterization of cultivated genotypes of bottle gourd [*Lagenaria siceraria* (Mol.) Stdl.]. *Int. J. Chem. Stud.*, 6(1): 1863-1866.
- Islam, M. R., Hossain, M. S., Bhuiyan, M. R., Hasan, G. N. and Syed, A., 2010, Multivariate analysis of bitter gourd (*Momordica charantia* L.). *J. Sci. Res.*, 5 (2): 86-90.
- Islam, M. R., Hossain, M. S., Bhuiyan, R., Hasan, A. and Syed, M. A., 2009, Genetic variability and path co-efficient analysis of bitter gourd (*Momordica charantia* L.). *Int. J. of sustainable Agric.*, 1(3): 53-57.
- Janaranjani, K. G. and Kanthaswamy, V., 2015, Correlation studies and path analysis in bottle gourd. *J. Hort.*, 2(1): 1-4.
- Jat, R. K., 2014, Genetic variability, heritability and genetic advance for yield and yield attributing traits in valan kakri (*Cucumis sativus* var. *Utilismus* l.). *Int. Q. J. Environ. sci.*, 6: 317-322.
- Johnson, H. W., Robinson, H. F. and Comstock, R. E., 1955, Estimates of genetic and environmental variability in soyabean. *Agron. J.*, 47: 314-318.
- Joydip, M., Mangala, T. and Vinod, K. D., 2015, Studies on genetic variability and trait inter-relationship in bottle gourd. *Hort. Flora Res. Spectr.*, 4(1): 34-38.
- Kandasamy, R., 2017, Variability studies in cucumber (*Cucumis sativus* L.). *Asian J. Hort.*, 12: 84-87.
- Karthik, D., Varalakshmi, B., Gyanesh, K. and Lakshmipathi, N., 2017, Genetic variability studies of ridge gourd advanced inbred lines (*Luffa acutangula* (L.) Roxb.). *Int. J. Pure Appl. Biosci.*, 5(6): 1223-1228.

- Kedar, P. and Chakraborti, C. H., 1982, Effects of bitter gourd and glibenclamide in streptozotocin induced diabetes milletus. *Indian J. Experimental Biol.*, 28: 232-235.
- Khan, A. S. M. M. R., Rabeya, E., Harunur, R., Sheikh, I. and Apurbo, K. C., 2016, Variability, heritability, character association, path analysis and morphological diversity in snake gourd. *Agric. Nat. Resour.*, 50 .483-489.
- Khan, M. H., Bhuiyan, S. R., Saha, K. C., Bhuyin, M. R. and Ali, A. S. M. Y., 2015, Variability, correlation and path co-efficient analysis of bitter gourd (*Momordica charantia* L.). *Bangladesh J. Agric. Res.*, 40(4): 607-618.
- Koppad, S. B., Chavan, M. L., Hallur, R. H., Rathod, V. and Shantappa, T., 2015, Variability and character association studies in ridge gourd (*Luffa acutangula* Roxb.) with reference to yield attributes., 4: 2332-2342.
- Kumar, A., Kumar, S. and Pal, A. K., 2008, Genetic variability and character association for fruit yield and yield related traits in cucumber (*Cucumis sativus* L.). *Indian J. Hort.*, 65 (4): 423-428.
- Kumar, K. H., Patil, M. G., Hanchinamani, C. N., Goud, S. I. and Hiremath, V., 2011, Genetic relationship of growth and development traits with fruit yield in F₂ population of BGD L x Hot season of cucumber (*Cucumis sativus* L.). *Karnataka J. Agric. Sci.*, 24(4): 497-500.
- Kumar, R., Ameta, K. D., Dubey, R. B. and Sunil, P., 2013, Genetic variability, correlation and path analysis in sponge gourd (*Luffa cylindrica* Roem.). *African J. Biotechnol.*, 12(6): 539-543.
- Kumar, S., Kumar, R., Gupta, R. K. and Sepahia, R., 2011, Studies on correlation and path co-efficient analysis for yield and its contributing traits in cucumber. *Crop Improvement*, 38(1): 18-23.
- Kumar, S., Singh, R. and Pal, A. K., 2007, Genetic variability, heritability, genetic advance, correlation co-efficient and path analysis in bottle gourd. *Indian J. Hort.*, 64(2): 163-168.
- Kumar, V., Maurya, S. K., Singh, M. P. and Bhatt, J. C., 2008, Evaluation of promising cultivars of bitter gourd under naturally ventilated poly house to study the correlation among the yield and yield attributes. *Ann. Hort.*, 1(1): 37-40.
- Kumari, P., Reena, K., Nisha, R., Verma, R. B. and Rahul, K. V., 2017, Genetic Divergence of Bitter Gourd (*Momordica charantia* L.) for Sixteen Important Yield Attributing Traits. *Curr. J. Appl. Sci. Technol.*, 23(2): 1-11.
- Kundu, B. C., Hossain, M. M., Khaleque, M. M. A. and Mian, I. H., 2012, Genetic divergence in bitter gourd (*Momordica charntia* L.). *J. Asiat. Soc. Bangladesh, Sci.*, 38(2): 125-134.
- Kutty, M. S. and Dharmatti, P. R., 2005, Correlation and path co-efficient studies in bitter gourd (*M. charantia* L.). *Karnataka J. Hort.*, 1(3): 7-11.
- Kutty, M. S. and Dharmatti, P. R., 2005, Genetic Divergence in Bitter gourd. *Karnataka J. Agric. Sci.*, 18 (3):740-743.
- Lal, T. and Singh, S., 1997, Genetic variability and selection indices in melon (*Cucumis melo* L.). *Veg. Sci.*, 24: 111-117.
- Lenka, D. and Mishra, B., 1973, Path co-efficient analysis of yield in rice varieties. *Indian J. Agric. Sci.*, 43: 376-379.

- Mahalanobis, P. C., 1936, On the generalised distance in statistics. *Proc. Nat. Acad. Sci.*, (India): pp. 79-85.
- Malek, M. A., Bari, M. M. A., Miah, M. O., Islam, A. M. M., Mosiul, H. and Gomes, R., 2007, Genetic variability, heritability and genetic advance in pointed gourd (*Trichosanthes dioica* Roxb.). *Bangladesh J. Pl. Breed. Genet.*, 20(1): 47-52.
- Mandal, J., Mangala, T. and Vinod, K. D., 2015, Studies on genetic variability and trait inter-relationship in bottle gourd (*Lagenaria siceraria* (Mol.) Standl). *Hort. Flora Res. Spectr.*, 4(1): 34-38.
- Maneesh, K. S., Bhardwaj, D. R. and Upadhyay, D. K., 2014, Genetic architecture and association analysis in bitter gourd (*Momordica charantia* L.) landraces. *Int. Q. J. life sci.*, 9(2): 707-711.
- Mishra, S., Sharma, A. K. and Vishwanath, S., 2017, Genetic variability studies in response to drought under different water regimes in muskmelon (*Cucumis melo* L.). *J. Appl. Nat. Sci.*, 9(3): 1744-1750.
- Mudassar, I., 2015, Study of correlation among morpho-physiological attributes in bitter gourd (*Momordica charantia* L.). *J. Agric. Res.*, 53(3): 345-349.
- Mukesh, K. B., 2017, Studies on genetic variability, heritability and genetic advance for yield and quality traits of indigenous genotypes of ash gourd [*Benincasa hispida* (Thunb.) Cogn.] of Chhattisgarh. *M.Sc. (Agri.) Thesis*, Indira Gandhi Krishi Vishwavidyalaya, Raipur.
- Murlee, Y., Singh, D. B., Rashmi, C. and Devi, S., 2008, Genetic variability in bitter gourd (*Momordica charantia* L.). *J. Hort. Sci.*, 3(1): 35-38.
- Pandey, S., Rai, M., Ram, D., Singh, B. and Chaubey, P. K., 2003, Component analysis in snap melon (*Cucumis melo* var. *momordica*). *Veg. Sci.*, 30: 64-67.
- Panse, V. G. and Sukhatme, P. V., 1961, Statistical methods for Agricultural workers. 2nd Edition ICAR, New Delhi, pp-361.
- Parameshwar, H. N. and Shripad, K., 2018, Screening of Cucumber Genotypes against Powdery Mildew. *Int. J. Curr. Microbiol. Appl. Sci.*, 7(4): 414-418.
- Parthi, G., Mishra, H. N. and Tripathy, P., 1993, Genetic divergence in bitter gourd. *South Indian Hort.*, 41(6): 344-349.
- Pathak, M., Manpreet. and Kanchan, P., 2014, Genetic variability, correlation and path co-efficient analysis in bitter gourd (*Momordica charantia* L.). *Int. J. Adv. Res.*, 2(8): 179-184.
- Patil, D. S., 2014, Generation mean analysis in muskmelon (*Cucumis melo* L.) for yield and their contributing traits. *Ph.D. (Agri.) Thesis*, Mahatma Phule Krishi Vidyapeeth, Rahuri, M.S., India.
- Pushpendra, K., Singh, V. B., Ram, C. N., Deepak, K. G. and Rajesh, K., 2017, Studies on variability analysis for yield and yield attributes in ridge gourd [*Luffa acutangula* L. (Roxb.)] germplasm. *Res. Environ. Life Sci.*, 10(6) 513-515.
- Rabbani, M. G., Naher, M. J. and Hoque, S., 2012, Variability, character association and diversity analysis of ridge gourd (*Luffa acutangula* Roxb.) genotypes of Bangladesh. *SAARC J. Agric.*, 10(2): 1-10.

- Rajawat, K. S and Collis, J. P, 2017, Genetic variability, heritability and genetic advances analysis for quantitative and qualitative traits in cucumber (*Cucumis sativus* L.). *J. Pharmacogn. Phytochem.*, 6(4): 882-885.
- Rajput, L. V., 2012, Assessment of variability studies in F₂ and F₃ generations of bitter gourd (*Momordica charantia* L.). *Ph.D. (Agri.) Thesis*, Mahatma Phule Krishi Vidyapeeth, Rahuri, M.S., India.
- Rakhi, R. and Rajamony, L., 2005, Variability, heritability and genetic advance in landraces of culinary melon (*Cucumis melo* L.). *J. Trop. Agric.*, 43(1-2): 79-82.
- Ram, H. H. 2005, Vegetable Breeding: Principles and Practices. Kalyani Publishers. pp. 420-422.
- Rana, J. C., Banyal, D. K., Sharma, K. D., Sharma, M. K., Gupta, S. K. and Yadav, S. K., 2013, Screening of pea germplasm for resistance to powdery mildew. *Euphytica*, 189: 271-282.
- Rana, N. P. and Pandit, M. K., 2011, Studies on genetic variability, character association and path analysis in snake gourd (*Trichosanthes anguina* L.) genotypes. *J. crop weed*, 7(2): 91-96.
- Rani, K. R., Raju, S. and Reddy, K. R., 2015, Variability, correlation and path analysis studies in bitter gourd (*Momordica charantia* L.). *Agric. Sci. Digest.*, 35 (2): 106-110.
- Rao, C. R., 1952, Advanced statistical methods in biometrical research. John Wiley and Sons, Inc. New York.
- Resmi, J. and Sreelathakumary, I. 2012. Character association and path co-efficient studies in ash gourd [*Benincasa hispida* (Thunb.) Congn.]. *Agric. Sci. Digest.*, 32(3): 251-255.
- Resmi, J. and Sreelathakumary, I., 2012, Studies on genetic divergence in bitter gourd (*Momordica charantia* L.). *J. Hort. Sci.*, 7(2): 152-155.
- Salahuddin, S., Abro, M., Kandhro, M., Salahuddin, L. and Laghari, S., 2010, Correlation and path co-efficient analysis of yield components of upland cotton [*Gossypium hirsutum* (L.)] sympodial. *World Appl. Sci. J.*, 8: 71-75.
- Sampath, S. and Krishnamoorthy, V., 2017, Genetic variability, correlation and path analysis in pumpkin (*Cucurbita moschata* Duch. ex. Poir). *Int. J. Curr. Microbiol. Appl. Sci.*, 6(6): 3027-3035.
- Sandeep, K., Dharminder, K., Ramesh, K., Thakur, K. S. and Balbir, S. D., 2013, Estimation of genetic variability and divergence for fruit yield and quality traits in cucumber (*Cucumis sativus* L.) in North-Western Himalays. *Universal J. Plant Sci.*, 1(2): 27-36.
- Sankaran, M., Thangaraj, T. and Veeraragavatham, D., 2002, Studies on physico chemical changes associated with maturity of bitter gourd (*Momordica charantia* L) cv. Co1. *South Indian J.*, 37(4): 71-77.
- Saroj, R., Fageria, M. S., Dhaka, R.S. and Jat, R.G., 2004, Genetic variability for growth and yield attributes in watermelon [*Citrullus.ianatus* (thunb.) Manse]. *Agric. Sci. Digest*, 24(3): 218-220.
- Searle, S. R., 1965, The value of indirect selection in mass selection. *Biometrics*, 21: 682-707.
- Shah, K. N., Rana, D. K. and Singh, V., 2018, Evaluation of genetic variability, heritability and genetic advance in cucumber (*Cucumis sativus* L.) for various quantitative, qualitative and seed characters. *Int. J. Curr. Microbiol. Appl. Sci.*, Special Issue-7: 3296-3303.

- Sharma, A. and Sengupta, S. K., 2013, Genetic diversity, heritability and morphological characterization in bottle gourd (*Lagenaria siceraria* (Mol.) Stand). *Int. Q. J. life sci.*, 8(4): 1461-1465.
- Sharma, N. K. and Bhutani, R. D., 2001, Correlation and path analysis studies in bitter gourd. *Haryana J. Hort. Sci.*, 30(1): 84-86.
- Singh, R. K. and Chaudhary, B. D., 1977, Biometrical methods in quantitative genetic analysis. New Delhi. Kalyani Publication pp. 318.
- Singh, R. P., Mohan, J. and Dharmendra, S., 2002, Studies on genetic variability and heritability in ridge gourd (*Luffa acutangula*). *Agric. Sci. Digest.*, 22(4): 279-280.
- Srivastava, V. K. and Srivastava, L. S., 1976, Genetic parameters, correlation co-efficient and path co-efficient analysis in bitter gourd (*Momordica charantia* L.). *Indian J. Hort.*, 33: 66-70.
- Subhasmita, S., 2015, Variability studies in bitter gourd (*Momordica charantia* L.). *M.Sc. (Agri.) Thesis*, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha.
- Sultana, S., Kawochar, M. A., Naznin, S., Siddika, A. and Mahmud, F., 2015, Variability, correlation and path analysis in pumpkin (*Cucurbita moschata* L.). *Bangladesh J. Agric. Res.*, 40(3): 479-489.
- Sundaram, V., 2008, Genetic diversity studies for parental selection in bitter gourd (*Momordica charantia* L.). *Asian J. Hort.*, 3(2): 333-335.
- Suruchi, P., 2014, Variability, heritability, correlation and path co-efficient analysis in diverse genotypes of bottle gourd (*Lagenaria siceraria* (Mol.) Standl.). *M.Sc. (Agri.) Thesis*, Institute of Agricultural Sciences Banaras Hindu University, Varanasi, India.
- Tiwari, N. K., Pandey, A. K., Singh, U. N. and Singh, V. B., 2018, Genetic variability, heritability in narrow sense & Genetic advance per cent of mean in bitter gourd (*Momordica charantia* L.). *J. Pharmacogn. Phytochem.*, 7(2): 2608-2610.
- Tyagi, N., Singh, V. B. and Praveen, K. M., 2018, Studies on genetic variability, heritability and genetic advance in bitter gourd (*Momordica charantia* L.) for yield and yield contributing traits. *Int. J. Curr. Microbiol. Appl. Sci.*, 7(3): 1788-1794.
- Vavilov, N. I., 1951, The origin, variation, immunity and breeding of cultivated plants. *Cronical Bot.*, 1: 363.
- Vinning, G., 1995, Market Compendium of Asian vegetables. RIRDC. Canberra, Rural Industries Research and Development Corporation., 95 (12) pp. 386.
- Vivek, S., Rana, D. K. and Shah, K. N., 2017, Genetic variability, heritability and genetic advance in some strains of bitter gourd (*Momordica charantia* L.) Under subtropical conditions of garhwal Himalaya. *Plant Archives.*, 17(1): 564-568.
- Vivek, S., Rana, D. K. and Shah, K. N., 2018, Evaluation of genetic diversity in bitter gourd (*Momordica charantia* L.) under subtropical conditions of garhwal Himalaya. *Int. J. Adv. Sci. Res. Manage., Special Issue I.*, 31-34.
- Walters, T. W. and Walters, D. D. S., 1988, Notes on economic plants: Balsam pear (*Momordica charantia* L.). *Economic Botany*, 42: 286-292.
- Wright, S., 1921, Correlation and causation. *J. Agric. Res.*, 20: 667-587.

Yadagiri, J., Gupta, N. K., Deeksha, T. and Sheela, V., 2017, Genetic variability, correlation studies and path co-efficient analysis in bitter gourd (*Momordica charantia* L.). *J. Pharmacogn. Phytochem.*, 6(2): 63-66.

Yadav, M., Pandey, T. K., Singh, D. B. and Singh, G. K., 2013, Genetic variability, correlation co-efficient and path analysis in bitter gourd. *Indian J. Hort.*, 70(1): 144-149.

APPENDIX I

Meteorological data during the period (2017-18) of experimentation collected at COH, Mysuru

Month	Temperature (°C)		Relative Humidity (%)		Rain fall (mm)
	Max.	Min.	Max.	Min.	
August 2017	28.10	20.30	94.80	61.50	131.50
September 2017	28.30	20.30	95.70	63.50	360.70
October 2017	28.40	19.80	94.90	59.90	151.4
November 2017	28.00	19.10	92.00	55.90	6.60
December 2017	27.20	16.90	94.40	50.90	21.20
January 2018	28.20	17.10	84.93	34.50	0.00

APPENDIX II

Per se performance of bitter gourd genotypes for growth characters

Sl. No.	Genotypes	Vine length (m)	Number of branches per Vine	Duration of crop (days)
1	Preethi	3.23	9.80	94.25
2	Yellapur Local-2	3.67	10.60	92.125
3	Bit-25-2-1	2.67	9.20	108.75
4	Meghnaa-2	3.10	12.00	100.00
5	Jhalawar Local-3	2.74	9.80	95.00
6	CO-1	3.13	10.00	105.50
7	Bit-22-1-1-3	3.46	10.20	91.50
8	Bit-9-2-4-1	3.02	11.70	98.25
9	GYB-3-1-2	1.84	8.60	84.00
10	Bit-1-2-3	3.11	9.80	99.50
11	Yellapur Local-1	2.36	10.20	100.50
12	Bit-37-2-1	2.24	11.10	98.00
13	DEB-505	2.89	11.60	87.50
14	Bit-3-1-2-1	2.14	8.50	83.25
15	Bit-9-3-2-3	3.46	12.10	92.50
16	Bit-5-1-2-1	3.24	10.80	98.00
17	West Bengal Local-1	2.88	10.30	90.25
18	Jhalawar Local-2	2.33	9.40	94.00
19	Super Green	2.50	11.00	95.25
20	IC-68238	1.84	8.50	86.50
21	Bit-10-1-1	2.86	10.80	89.50
22	West Bengal Local-2	2.36	11.40	91.625
23	Kotla Local-1	2.27	9.90	90.50
24	Bit-10-1-2	2.50	10.30	87.25
25	Bit-5-1-4-1	2.49	10.47	98.00

26	Contai Bolder	2.51	9.30	86.50
27	Bit-1-2-2-4	2.94	9.70	94.00
28	Bit-18-1-1	2.58	11.00	98.50
29	Jhalawar Local-1	2.99	9.80	91.00
30	Bit-3-1-1-1	2.11	8.70	89.50
31	GYB-5-1-5-2	2.03	10.30	100.50
32	Bit-22-1-1-1	2.01	12.10	100.00
33	Bit-9-2-1-2	2.29	13.50	104.50
34	GYL-2	3.39	10.90	95.00
35	GYB-2-2	2.28	11.00	93.50
36	Katahi	2.71	10.50	97.50
37	Bit-35-1-1	2.39	10.60	97.00
38	Bit-31-2-2	2.37	7.80	94.25
39	Arka Harit	1.56	6.80	85.5.
40	Bit-9-1-4-1	2.41	9.20	100.00
Mean		2.62	10.23	94.47
S.Em±		0.196	0.474	3.583
CD @ 5%		0.559	1.357	10.248

APPENDIX III

Per se performance of bitter gourd genotypes for earliness parameters

Sl. No.	Genotypes	Node at which first female flower appears	Days to first female flower opening	Days to 50 per cent flowering	Days to first fruit picking
1	Preethi	17.10	40.75	43.00	58.00
2	Yellapur Local-2	15.50	37.60	41.50	56.00
3	Bit-25-2-1	16.60	40.60	45.00	60.25
4	Meghnaa-2	17.70	44.50	44.50	60.00
5	Jhalawar Local-3	12.50	35.00	37.50	53.50
6	CO-1	11.90	41.20	46.00	60.50
7	Bit-22-1-1-3	18.30	42.90	43.00	56.50
8	Bit-9-2-4-1	19.10	45.55	48.50	64.00
9	GYB-3-1-2	11.00	32.97	37.00	48.25
10	Bit-1-2-3	12.10	48.20	49.25	61.87
11	Yellapur Local-1	12.40	41.00	42.50	56.00
12	Bit-37-2-1	11.50	39.10	40.50	56.25
13	DEB-505	17.80	42.20	46.00	59.25
14	Bit-3-1-2-1	10.80	36.15	35.25	49.50
15	Bit-9-3-2-3	12.00	38.75	46.00	62.00
16	Bit-5-1-2-1	17.975	44.83	46.50	63.37
17	West Bengal Local-1	16.70	39.61	42.50	58.75
18	Jhalawar Local-2	16.50	44.76	44.50	59.50
19	Super Green	13.60	39.95	43.50	59.12
20	IC-68238	14.10	42.55	44.75	58.00
21	Bit-10-1-1	14.00	42.70	45.25	59.50
22	West Bengal Local-2	20.90	41.45	43.50	57.00
23	Kotla Local-1	15.70	41.15	44.50	56.50
24	Bit-10-1-2	17.025	44.97	47.50	59.75
25	Bit-5-1-4-1	16.375	45.31	46.00	60.25

26	Contai Bolder	11.30	38.80	42.00	52.12
27	Bit-1-2-2-4	17.30	45.80	50.50	65.75
28	Bit-18-1-1	14.30	41.35	47.50	61.50
29	Jhalawar Local-1	12.95	38.81	42.50	57.75
30	Bit-3-1-1-1	11.50	36.05	38.75	50.62
31	GYB-5-1-5-2	14.95	34.61	38.50	53.62
32	Bit-22-1-1-1	18.10	44.70	46.00	60.00
33	Bit-9-2-1-2	19.58	44.45	47.25	63.75
34	GYL-2	14.00	39.80	40.00	54.50
35	GYB-2-2	9.90	36.90	39.00	54.25
36	Katahi	15.70	39.12	45.00	60.00
37	Bit-35-1-1	13.90	35.90	36.50	52.25
38	Bit-31-2-2	12.55	44.11	46.00	62.00
39	Arka Harit	12.55	37.60	38.50	54.00
40	Bit-9-1-4-1	19.00	44.05	47.00	61.25
Mean		14.96	40.90	43.53	57.93
S.Em±		1.664	0.881	2.573	2.929
CD @ 5%		4.761	2.519	7.361	8.377

APPENDIX IV

Per se performance of bitter gourd genotypes for yield attributes

Sl. No.	Genotypes	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of fruits per vine	Fruit yield per vine (kg)	Fruit yield (t/ha)	Number of seeds per fruit
1	Preethi	18.81	5.07	93.20	11.40	1.04	9.65	20.50
2	Yellapur Local-2	22.43	4.48	85.60	13.10	1.14	10.54	23.50
3	Bit-25-2-1	15.13	4.14	61.80	14.20	0.90	8.33	17.75
4	Meghnaa-2	15.40	5.04	89.10	13.60	1.21	11.23	18.50
5	Jhalawar Local-3	16.86	4.57	83.10	13.50	1.15	10.60	24.00
6	CO-1	16.40	3.85	79.20	8.50	0.73	6.76	16.50
7	Bit-22-1-1-3	21.60	4.55	77.30	13.80	1.08	10.03	24.25
8	Bit-9-2-4-1	17.36	5.24	81.40	13.40	1.12	10.34	23.00
9	GYB-3-1-2	9.03	5.16	40.30	15.02	0.77	7.15	11.00
10	Bit-1-2-3	20.13	4.72	93.10	12.30	1.20	11.15	20.00
11	Yellapur Local-1	18.02	3.83	70.80	14.85	1.09	10.08	14.75
12	Bit-37-2-1	17.66	4.33	84.60	15.00	1.30	12.07	23.00
13	DEB-505	16.86	5.01	70.10	16.330	1.23	11.42	16.00
14	Bit-3-1-2-1	4.82	4.60	25.42	21.65	0.53	4.90	9.00
15	Bit-9-3-2-3	18.28	5.21	107.60	12.60	1.37	12.74	16.25
16	Bit-5-1-2-1	16.96	5.52	80.65	12.87	1.03	9.75	19.50
17	West Bengal Local-1	15.35	5.70	77.52	11.57	0.95	8.85	15.50
18	Jhalawar Local-2	30.00	2.85	91.85	8.85	0.69	6.37	18.25
19	Super Green	18.96	5.13	96.50	14.20	1.34	12.37	17.50
20	IC-68238	13.48	5.47	79.00	12.10	0.96	8.87	10.50
21	Bit-10-1-1	19.35	5.03	96.20	12.10	1.17	10.85	15.50
22	West Bengal Local-2	14.61	4.91	95.00	11.50	1.20	11.09	16.00
23	Kotla Local-1	15.87	5.72	107.30	11.30	1.38	12.74	17.00
24	Bit-10-1-2	18.00	5.08	74.57	13.62	1.02	9.48	18.50
25	Bit-5-1-4-1	17.21	5.50	89.00	12.00	1.06	9.85	25.00

26	Contai Bolder	9.61	3.98	33.10	15.80	0.53	4.87	12.75
27	Bit-1-2-2-4	20.43	4.63	87.00	11.90	1.03	9.55	20.00
28	Bit-18-1-1	29.04	5.03	88.70	14.60	1.28	11.81	20.50
29	Jhalawar Local-1	14.04	5.10	90.97	12.42	1.11	10.29	13.75
30	Bit-3-1-1-1	5.72	4.26	31.22	14.67	0.39	3.61	7.50
31	GYB-5-1-5-2	14.62	3.93	81.06	12.15	1.20	11.11	15.00
32	Bit-22-1-1-1	20.86	4.65	106.30	11.90	1.23	11.44	17.00
33	Bit-9-2-1-2	16.88	5.10	104.57	12.37	1.31	12.09	18.50
34	GYL-2	18.86	4.82	94.60	12.10	1.17	10.81	17.50
35	GYB-2-2	15.81	5.16	78.20	14.80	1.10	10.19	14.50
36	Katahi	16.39	4.41	84.70	13.80	1.18	10.92	20.75
37	Bit-35-1-1	15.69	5.23	84.30	12.60	1.08	10.01	13.00
38	Bit-31-2-2	15.60	3.73	64.77	11.62	0.77	7.19	14.00
39	Arka Harit	8.62	3.81	50.70	7.70	0.43	3.98	7.50
40	Bit-9-1-4-1	14.36	5.20	92.20	11.60	1.07	9.91	22.25
Mean		16.630	4.75	80.07	12.99	1.041	9.63	17.14
S.Em±		0.621	0.156	7.452	1.591	0.121	1.120	1.424
CD @ 5%		1.777	0.446	21.316	4.552	0.346	3.204	4.072

APPENDIX V

Per se performance of bitter gourd genotypes for quality parameters

Sl. No	Genotypes	Flesh thickness (mm)	Ascorbic acid (mg/100g)
1	Preethi	5.07	97.74
2	Yellapur Local-2	4.93	84.10
3	Bit-25-2-1	6.48	89.55
4	Meghnaa-2	6.15	100.23
5	Jhalawar Local-3	5.95	86.40
6	CO-1	4.23	100.90
7	Bit-22-1-1-3	7.40	89.20
8	Bit-9-2-4-1	8.87	91.95
9	GYB-3-1-2	5.95	101.90
10	Bit-1-2-3	6.36	88.65
11	Yellapur Local-1	4.90	100.95
12	Bit-37-2-1	5.36	90.60
13	DEB-505	6.16	97.32
14	Bit-3-1-2-1	4.40	106.99
15	Bit-9-3-2-3	8.80	100.50
16	Bit-5-1-2-1	6.05	97.76
17	West Bengal Local-1	7.12	83.95
18	Jhalawar Local-2	4.11	112.43
19	Super Green	5.18	89.40
20	IC-68238	9.40	100.49
21	Bit-10-1-1	6.05	101.11
22	West Bengal Local-2	6.60	96.59
23	Kotla Local-1	7.34	104.33
24	Bit-10-1-2	5.91	101.07
25	Bit-5-1-4-1	5.70	98.89

26	Contai Bolder	5.73	84.22
27	Bit-1-2-2-4	5.01	103.04
28	Bit-18-1-1	6.69	102.41
29	Jhalawar Local-1	5.55	81.29
30	Bit-3-1-1-1	4.50	90.44
31	GYB-5-1-5-2	5.41	103.57
32	Bit-22-1-1-1	6.65	91.93
33	Bit-9-2-1-2	5.38	103.62
34	GYL-2	5.42	86.51
35	GYB-2-2	5.75	101.34
36	Katahi	5.22	87.74
37	Bit-35-1-1	6.73	103.07
38	Bit-31-2-2	4.80	88.17
39	Arka Harit	3.65	106.47
40	Bit-9-1-4-1	7.35	84.31
Mean		5.96	95.78
S.Em±		0.356	1.959
CD @ 5%		1.019	5.603