GENETIC DIVERSITY, CORRELATION AND PATH CO-EFFICIENT ANALYSIS IN BOTTLE GOURD

(*Lagenaria siceraria* L.)

BY

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CERTIFICATE

This is to certify that thesis entitled, "Genetic diversity, correlation and path co-efficient analysis of in Bottle gourd (Lagenaria siceraria L.)" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in GENETICS AND PLANT BREEDING, embodies the result of a piece of bonafide research work carried out by Asmaul Husna, Registration No. 04-01281 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June, 2009
Place: Dhaka, Bangladesh

(Dr. Firoz Mahmud)
Associate Professor
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Dedicated to my late

Grand mother

&

Grand father

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ABSTRACT

Thirty one genotypes of bottle gourd (*Lagenaria siceraria* L.) were studied in a field experiment conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, during October 2008 to March 2009. The objectives of the study were to measure the variability among the genotypes for yield and yield contributing characters, estimate genetic parameters, association among the characters and their contribution to yield. There was a great deal of significant variation for all the characters among the genotypes. High genotypic co-efficient of variation (GCV) was observed for yield per plant, days to first male flowering and female flower pedicel length whereas low genotypic co-efficient of variation (GCV) was observed for leaf petiole length and male flower pedicel length. In all cases, phenotypic variances were higher than the genotypic variance. High heritability with low genetic advance in percent of mean was observed in leaf petiole length which indicated that non-additive gene effects were involved for the expression of this character and selection for such trait might not be rewarding. High heritability with high genetic advance in percent of mean was observed for yield per plant and days of first male flowering indicated that this trait was under additive gene control and selection for genetic improvement for this trait would be effective. Correlation studies revealed that highest significant association of yield per plant with vegetative characters no. of branches per vine followed by leaf breadth and with reproductive characters no. of fruit per plant followed by fruit weight at genotypic level. Path co-efficient analysis revealed maximum direct contribution towards yield per plant with vegetative traits of no. of branches per vine followed by leaf breadth and reproductive traits of no. of fruit per plant followed by fruit weight. Highest intra-cluster distance was found in cluster II and lowest in cluster I. Among five clusters, the highest inter-cluster distance was observed between cluster I and cluster III and lowest between cluster II and cluster IV. Considering all the characters the G_4 (BD-4580), G_{31} (BD-8948), G_{26} (BD-4560) and G_{28} (BD-4569) were selected for future breeding programme.

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LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL WORD
AEZ	Agro-Ecological Zone
et al.	And others
ACC	Accessions
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
CV	Co-efficient of Variation
etc.	Etcetera
Fig.	Figure
G	Genotype
GA	Genetic Advance
GCV	Genotypic Co-efficient of Variation
δ^2_g	Genotypic Variance
g	Gram
h^2b	Heritability in broad sense
J.	Journal
Kg	Kilogram
m	Meter
MSS	Mean Sum of Square
mm	Millimeter
MP	Muriate of Potash
No.	Number
%	Percent
PCV	Phenotypic Co-efficient of Variation
δ^2_p	Phenotypic variance
RCBD	Randomized Complete Block Design
R	Replication
Res.	Research
SAU	Sher-e-Bangla Agricultural University
SE	Standard Error
m^2	Square meter
TSP	Triple Super Phosphate

Chapter I
Introduction

CHAPTER I
INTRODUCTION

Bottle gourd *(Lagenaria siceraria* L.*)* locally known as lau, is an important home garden vegetable and widely cultivated as popular winter vegetable in Bangladesh. The bottle gourd is also called birdhouse gourd, trumpet gourd, calabash gourd and white-flowered gourd. The name "bottle gourd" is especially appropriate, because this plant species is one of the few from which useful and lasting containers can be made. Bottle gourd belongs to the family Cucurbitaceae having chromosome number, 2n = 22, under the order cucurbitales, class magnoliopsida (Bose and Som, 1986). Bottle gourd is one of the cultivated annual monoecious species. The bottle gourd probably originated in Africa and from there was widely distributed in pre-Columbian times, perhaps by floating on the seas. It traveled to India, where it has evolved into numerous local varieties, and from India to China, Indonesia, and as far as New Zealand. Archaeological remains show that the bottle gourd was used in Egypt about 3500 to 3300 B.C. Molecular analysis suggested the dispersal of bottle gourd fruits from Africa to Asia and the Americas during pre-Columbian times, followed by independent domestication on all three continents (Decker-Walters *et al.* 2001).

The bottle gourd is a vigorous, annual, climbing vine with large leaves and a lush appearance.The vine is branched and climbs by means of tendrils along the stem. The foliage is covered with soft hairs and has a foul musky odor when crushed. Leaves have a velvety texture because of the fine hairs, especially on the undersurface.The bottle gourd flowers are borne singly on the axils of the leaves, the males on long and the females on short pedicels. The flowers are white and attractive. The ovary is inferior and in the shape of the fruit. The variation in bottle gourds is sometimes spectacular. The background color is either light green or dark green. The dark green can be distributed as a solid color, as regular or irregular stripes, and as an irregular blotch. The size of the fruit varies from 2 to 12 inches in diameter and from 4 to 40 inches in length. The fruit can have a sterile (seedless) neck. Wider necks usually contain seeds, and the neck may have a seed-containing bulge. Due to high keeping quality (Banerjee and Mangal, 1986), it has also export potentiality. The brownish seeds are numerous in a whitish green pulp. Each seed is somewhat rectangular in shape with grooved notches near the attached end.

From nutritional point of view, bottle gourd can be considered as nutrition rich fruit vegetable. Fruit contains considerable amount of water (96.1g), carbohydrates (2.5g), protein (0.2g), fat (0.1g), minerals (0.5g), fiber (0.6g) and energy (12kcal) per 100g of edible portion and leaves contain water (87.9g), carbohydrates (6.1g), protein (2.3g), fat (0.7g), minerals (1.7g), fiber (1.3g) and energy (39kcal) per 100g of edible portion (Gopalan *et al.*, 1982). Edible portion bottle gourd is 86%. (Gopalan *et al.*, 1982). Among all cucurbits vegetables bottle gourd contains the maximum amount of minerals due to high keeping quality (Rashid, 1993). A rich source of minerals and vitamins, bottle gourds contains many healing and medicinal properties. The cooked vegetable is not only easy to digest but also contains cooling, calming (or sedative), diuretic properties. It contains low calories also has iron, Vitamin C and B complex. Regular consumption of this vegetable provides relief to people suffering with digestive problems, diabetics and convalescents. It is good for people suffering from biliousness and indigestion (Thamburaj and Singh, 2003).

In Bangladesh, vegetables are grown in 0.2 million hectares of land which is about 1% of the cultivated. Winter vegetables are usually grown in 58.96% of the total land area (BBS, 2005). Bottle gourd is one of the most important and widely cultivated popular winter vegetable in Bangladesh. It occupies about 12,100 ha with a total production of 126,000 tons (BBS 2008). The average yield is only 8.37 tons per hectare, which is very low as compared to that in other tropical countries. On the other hand; high population growth rate is also putting increased pressure on the area of vegetable production. Bottle gourd can be grown with less cost and additional land is not required, can be grown in homestead area.

Parameters of genotypic and phenotypic coefficients of variation (GCV and PCV) are useful in detecting the amount of variability present in the available genotypes. Heritability and genetic advance help in determining the influence of environment in expression of the characters and the extent to which improvement is possible after selection (Robinson *et al.*, 1949). Crop improvement depends upon the magnitude of genetic variability and extent to which the desirable characters are heritable. The total variability can be partitioned into heritable and nonheritable components with the help of genetic parameters like phenotypic and genotypic coefficient of variation, heritability and genetic advance. Heritable variation can be effectively studied in conjunction with genetic advance. High heritability alone is not enough to make efficient selection in segregating generation, unless the information is accompanied for substantial amount of genetic advance (Johnson *et al.*, 1955).

Hybridization is one of the major tools for achieving variability aiming at the improvement of a crop. Before hybridization genetic diversity of the existing materials or entries needs to be known. Information about genetic diversity in available germplasm is important for the optimal design of any breeding program. This helps to choose desirable parents for establishing new breeding population. Besides better knowledge on genetic diversity could help to sustain long term selection gain (Chowdhury *et al.* 2002).

The knowledge of association between yield and its contributing traits is of great value in planning a breeding programme. Thus determination of correlation among the characters is a matter of considerable importance in selection of correlated response. But is does not give the exact position of the relative importance of direct and indirect effects of various yield attributes. Path analysis facilitates the partitioning of correlation coefficients into direct and indirect effects of various characters on yield or any other attribute. According to Burton (1952), for the improvement of any character through breeding, it is essential to know the extent of variability present in that species, nature of association among the characters and the contribution of different characters towards seed yield.

Considering the availability of genetic variability, its scope of yield improvement and export potential, the present investigation was undertaken with the following objectives:

- To assess the genetic diversity among the genotypes,
- To know the association of traits with yield and its contributing traits,
- To know the yield potentiality of genotypes and
- To screen out the suitable parental groups which are likely to provide superior segregates on hybridization

Chapter II
Review of literature

CHAPTER II
REVIEW OF LITERATURE

Bottle gourd (*Lagenaria siceraria* L) is an important vegetable cultivated in Bangladesh, but a few works have been done for the improvement of this crop in Bangladesh and other countries in the world. Research effort on the variability of its genetic resources, diversity on genetic and molecular level, correlation, path co-efficient analysis, heritability and genetic advance seems to be meager. However, information available in these aspects of bottle gourd and some other cucurbit crops have been reviewed and presented in this section.

2.1 Variability, Heritability and Genetic Advance:

Kumar *et al.* (2007) conducted a field experiment with twenty diverse genotypes of bottle gourd in randomized block design with three replications. Depending upon the variability, heritability and genetic advance estimates, it could be predicted that improvement by direct selection was possible in bottle gourd for traits like number of branches per vine, vine length, nodes no. of first male flower, nodes number of first female flower, length of edible fruit, number of fruit per vine, fruit weight, 100-seed weight and fruit yield per vine.

Yadav *et al.* (2009) conducted an experiment to study about genetic variability, heritability and genetic advance for different characters were studied in 20 cucumber genotypes. The study indicated existence of considerable amount of genetic variability for all the traits except cavity of fruit at edible stage. The maximum phenotypic and genotypic coefficient (PCV and GCV) was observed for number of days to first female flower anthesis. High estimates of heritability (broad sense) genotypic coefficient of variation (GCV) and genetic advance were observed for no. of fruit per plant, fruit length and fruit weight.

Pandit *et al.* (2005) evaluated fifteen genotypes of bottle gourd (*Lagenaria siceraria* Molina. Standl) during the autumn-winter season of 2003-04 at

BCKV, West Bengal, India to study the genetic variability, heritability and potential for screening suitable genotypes for future improvement programmes. The genotypes were collected from major growing areas of South-West Bengal. There was considerable variability in all traits except fruit/plant. The moderate GCV and GA in fruit length and fruit weight indicate the probable likelihood of additive gene action. Thus, improving these characters should be effective and rewarding during selection. Promising inbreds for yield/plant were BCBG-7, 17, 19 and 33.

Narayan *et al.* (1996) studied genetic variability, heritability in broad sense, genetic advance in 25 diverse populations of bottle gourd. Wide range of variation was observed in most of the characters. The high value of GCV and heritability estimates associated with greater genetic advance was observed for number of primary branches per plant and yield per plant indicated that these two characters had additive gene effect and, therefore, they are more reliable for effective selection.

Rahman *et al.* (1986) studied variability, correlation and path coefficients in four lines of bottle gourd. Genotypic and phenotypic variability were high for fruit length and number of branches per plant, but very low for number of fruits per plant and length of main vine. Heritability (broad sense) and genetic advance in percentage of mean were high for fruit length, fruit diameter and fruit weight per plant.

Masud *et al.* (2006) conducted a field experiment with seven inbred lines and their twenty-one hybrids of bottle gourd. Result showed significant variation in seven characters of the twenty eight populations. Variabilities were high in all seven characters indicating the possibilities of improvement through selection. Specific combining ability variance were significant for all characters while general combining estimates were significant for days to anthesis, fruit length, fruit diameter and yield per plant which indicated the presence of dominance for all the characters but additivity is for only few characters. Parent-two showed good GCA for earliness and fruit length, Parent-five showed good GCA for fruit length only and parent-seven showed good GCA for fruit diameter and fruit yield per plant. The cross involving parent-three and parent-five, which is the best for earliness, fruit length (53.5%) and fruit yield per plant (106.8%).

Quamruzzaman *et al.* (2009) studied heterosis in bottle gourd in a set of 13 F_1 with 26 parents. Results indicated highly significant differences for all the characters among the materials studied. Heterosis was higher for yield per plant, number of fruits per plant and individual fruit weight, medium in fruit length and fruit diameter, and lower in days to 1st harvest. Hybrids (F_1) 10 x 17 and 19 x 26 manifested highest heterosis over midparent (73.1%) and better parent (61.8%), respectively, for yield per plant.

Rahman *et al.* (1991) reported that male flower were earlier than female flower in several genotypes of bottle gourd, ribbed gourd and sweet gourd. They reported significant variations for that character among the genotypes of bitter gourd, sweet gourd, ribbed gourd and bottle gourd. Significant variation for fruit length and diameter were also observed. They also reported that bitter gourd, sweet gourd, ribbed gourd and bottle gourd genotypes differed significantly for fruit breadth and weight per fruit.

Chowdhury and Sharma (2002) studied genetic variation, heritability, genetic advance and correlation for yield and yield components (vine length, number of nodes, node on which the first flower appeared, number of fruits per plant, fruit length, fruit girth and fruit weight) in 12 *Luffa acutangula* cultivars. The genetic co-efficient of variation (GCV) was higher than the phenotypic co-efficient variation (PCV) for all the characters. High values of variability, PCV, GCV and genetic advance recorded for vine length, yield per hectare and fruit weight indicating that these characters were controlled by additive gene effects. The correlation co-efficient revealed that yield per hectare could be improved through selection for higher fruit number per plant, fruit length and girth and individual fruit weight.

Gaffar (2008) conducted an experiment with 15 sponge gourd genotypes at the experimental farm of Sher-e-Bangla Agricultural University, during April 2007 to October 2007. Among the characters the highest GCV recorded for yield per plant (63.90) followed by top fruit perimeter (46.60) and average fruit weight (39.52). Genotypes included in cluster I were suitable for yield per plant (6.55), cluster III for having the highest mean value for inter node length (17.62), cluster V for leaf length (30.43), leaf breadth (24.65), petiole length (13.28), days to first male flower (103.28), days to first female flower (107.80) and other characters.

Hossain (1996) conducted an experiment on floral biology of ridge gourd at the experimental farm of IPSA (Institute of Post Graduate Studies). Male, female and hermaphrodite flower buds appeared 29-38 days after seeding. The male flower buds developed earlier and in lower nodes than the female and hermaphrodite ones. The first male, female/hermaphrodite flowers were produced an average in the 10^{th} to 21^{st} node.

Mathew and Khader (1999) conducted an experiment on genetic studies in snake gourd (*Trichosanthen anguina*) and observed the genetic variability and heritability of 12 traits in 34 *Trichosanthen anguina* in Kerela, India and reported that the genotypic co-efficient of variation (GCV) and phenotypic co-efficient of variation (PCV) were almost equal for all characters. The highest GCV and PCV were recorded for mean fruit weight, seed per fruit, fruit yield per plant and fruit length. High heritability was observed for mean fruit weight, seeds per fruit, fruit length, days to first male flower and fruit yield per plant.

Abusaleha and Dutta (1990) carried out a study with 65 genetic stocks to assess the genetic variation and heritability in ridge gourd. Significant variability was observed for all the characters at phenotypic as well as genotypic level with a very wide range of values.

Miah *et al.* (2000) studied 30 genotypes of bitter gourd and observed the highest genotypic as well as phenotypic co-efficient of variation were found for fruit length followed by days to female flowering, fruit yield per plant, fruit weight and nodes per vine.

Sharma *et al.* (2000) evaluated ten cucumber lines and testers under different environmental conditions and reported that day to first female flower, nodal position of fruits per plant, marketable yield per plant, fruit length and fruit diameter had wide range of variation.

Saha *et al.* (1992) studied the variability, character association and path analysis of pumpkin and reported that phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV). High genotypic variance and phenotypic variance were found for fruit length (30.34 and 31.76), fruit weight (39.55 and 41.00) and low for fruit diameter (8.87 and 10.23) among the pumpkin genotypes. They also reported high heritability estimate, for both length (91.27) and diameter (75.07) of fruits indicating effectiveness of selection based on good phenotypic performances in pumpkin.

Banik (2003) conducted an experiment on variability and genetic advance of 26 genotypes of snake gourd with respect of 15 quantitative yield contributing characters and found significant difference among the characters like vine length at harvest (2.197 to 3.87 m), number of primary branches (5.23 to 11.88), days to first male flowering (41.67 to 68.67 days), days to first female flowering (48.67 to 71.33 days), node number of first male flower (6.33 to 17.67 days), fruit length (20.67 to 71.17 cm), seeds per fruit (39.03 to 69.50). Banik also found that significant differences in first female flower, node number (mean value 19.28) and fruits per plant. The highest phenotypic co-efficient of variation was observed for fruiting node on main vine, fruit yield per plant, fruit length and first male flower node. The PCV was lowest for days to maturity, 100 seed weight and days to first male flower opening. The GCV along with heritability was high for the above characters. High heritability coupled with high genetic advance was noticed for fruit yield per plant (GCV and PCV 30.75 and 30.96; h^2b 98.64%), fruit length (GCV and PCV 29.92 and 30.04; h^2b 99.19%) and first female flower node number (GCV and PCV 25.87 and 26.59; h^2b 94.63%) and number of fruits per plant (GCV and PCV 19.82 and 20.59; h^2b 92.67%).

Doijode and Sulladmath (1986) found high GCV and PCV (30.2 and 36.4), high heritability (h^2b) with high genetic advance for average fruit in pumpkin. Narrow difference between GCV and PCV observed for fruit weight in bitter gourd indicating less environmental influence on this character. Significant difference was also found among bitter gourd genotypes for seeds per fruit (Mannan, 1992).

Sharma and Dhankar (1990) reported that almost similar estimates of GCV and PCV (13.54 and 14.00) for days to first female flower opening in bottle gourd. They also observed high heritability (93.47%) with considerably high genetic advance for days to flowering in bottle gourd. In watermelon days to first female flower opening regard from 37.17 to 61.72 days and the PCV and GCV were 19.10 and 19.91 respectively (Rajendran, 1985).

Mangal *et al.* (1981) noticed that in bitter gourd significant variation for fruit length and diameter present and high heritability in bitter gourd for vine length.

Mondal *et al.* (1989) studied the genetic variability of 31 watermelon genotypes and observed a wide range of variability for days to first fruit harvest, fruit length, fruit diameter, number of fruits per plant and fruit yield per plant.

Rumaran *et al.* (1997) conducted 30 pumpkin genotypes in a field trial and reported that genotypic co-efficient of variation was smaller than phenotypic co-efficient of variation for most of the traits studied. However, GCV was high for mean fruit weight, number of fruits per plant, number of seeds per fruit, yield per plant and fruit, total soluble solids content. High heritability coupled with high genetic advance were observed for vine length, mean fruit weight, number of fruits per plant, number of seeds per fruit, fruit yield per plant and total soluble solids content of fruits. Islam (1993) reported that male flowering was earlier than female flowering in several genotypes of bottle gourd.

Varghese (1991) reported an experiment on the variability among 48 snake gourd genotypes in respect of different yield contributing characters and found significant differences among the characters. Main vine length varied from 3.035 to 7.85 m with high heritability (97.0%). In case of number of branches per vine, heritability was 91.0%. Moderate GCV and PCV in fruit length and breadth (32.15 and 32.51; 20.26 and 21.23) was also observed in snake gourd germplasms. Narrow differences between GCV and PCV in fruit weight with high heritability (h^2b) were also observed. GCV and PCV for yield per plant were 30.0 and 31.33 respectively. 100 seed weight varied from 20.0 to 41.0 g with high heritability 97.8% in snake gourd.

Kabir (2007) conducted an experiment on variability and estimation of genetic parameter, correlation, path analysis and genetic diversity of 24 accessions of pointed gourd with respect of different parameter such as days to flower, fruit length, fruit breadth, single fruit weight, pulp seed ratio, and number of fruits per plant, weight of fruit per plant and yield of fruit. The accession PG020 showed the highest performance in weight of fruits per plant, single fruit weight and yield. The highest genotypic and phenotypic co-efficients were recorded in the parameter number of fruits per plant (5415.55% and 5623.67%) and second highest was recorded from yield of fruits ton per hectare (410.30% and 410.98%). However, days require to first flowering (49.86% and 52.41%), fruit length (7.4% and 7.42%), fruit breadth (23.56% and 26.79%), single fruit weight (172.27% and 173.28%), and weight of fruit per plant (161.87% and 162.85%) recorded moderate GCV and PCV. Correlation coefficient indicated that fruit yield per plant was highly significant and there was a positive association with weight of fruit per plant, number of fruits per plant and single fruit weight. Path analysis indicates fruit breadth, number of fruits per plant and weight of fruits per plant directly contributed to the yield of pointed gourd accessions.

Singh *et al.* (2002) conducted an experiment on 80 ridge gourd genotypes to determine variability and heritability of nineteen yield contributing characters. High PCV and GCV were observed for node number for appearance of 1st male flower, male flowers per plant, sex ratio main axis and branches, fruit per plant, fruit weight, seeds per fruit, and yield per plant. The GCV and PCV values were almost equal for most of the characters studied. The broad sense heritability estimates were high for all the characters.

Swamy *et al.* (1984) also conducted an experiment on muskmelon and reported a wide range of variability among the genotypes for number of seeds per fruit.

2.1.1 Leaf Length (cm)

Gaffar (2008) conducted an experiment with fifteen genotypes of sponge gourd in Sher-e Bangla Agricultural University. He found that the genotypic and phenotypic variances of leaf length were 24.13 and 25.55, respectively. The GCV (20%) was slightly lower than PCV (20.58%). Heritability for this trait was 97% with moderate genetic advance (9.83) and genetic advance in percent of mean (40.03) was considerable for this trait indicating apparent variation was due to genotypes.

2.1.2 Leaf breadth

Gaffar (2008) observed GCV (20.94%0 was slightly lower than the PCV (23.31%), heritability in broad sense was high (94%) with moderate genetic advance (7.81) for this character in sponge gourd.

2.1.3 Petiole length

Grubben (2004) stated that leaf petiole length is 2.5 to 12.5 cm in bottle gourd. Gaffar (2008) reported the PCV (36.68%) was very high to GCV (17.12%).

The heritability for petiole length was high (47%) with low genetic advance (1.77) in sponge gourd.

2.1.4 Days to first flowering

Rahman *et al.* (1991) reported that male flower were earlier than female flower in several genotypes of bottle gourd. Islam (1993) also reported that the male flowering was earlier than female flowering in several genotypes of bottle gourd. Bose and Som (1986) stated that the first male and female flowers in bottle gourd after 40-45 days and 60-65 days of planting seedling, respectively. Days to flower was observed to be markedly influenced by the environment as was indicated by much higher environmental variance compared to the low genetic variance (Srivastava and Srivastava 1976, Singh *et al.* 1977). Both low and high values for h_b^2 have been reported for this character. Sharma and Dhankhar (1990) reported almost similar estimates of GCV and PCV (13.54 and 14.00) for days to first female flower opening in bottle gourd. They also observed high heritability (93.47%) along with considerably high genetic advance (26.99) for days to flowering in bottle gourd. In Bitter gourd, Mannan (1992) recorded considerable variability among eight lines for days to first male flower (66.7-81.6 days) and female flower (72.80-85.67 days) opening. Ramchandran and Gopalkrishnan (1979) also reported significant variability among 25 diverse genotypes of bitter gourd. Abdel *et al.* (1982) studied heritability of yield components in watermelon and reported that heritability for number of days to flowering was 94%. Quamruzzaman *et al.* (2008) conducted experiment the genetic divergence among thirty genotypes of ridge gourd (*Luffa acutangula*) at the farm of Olericulture Division, HRC and in different RARS, BARI during the summer season of 2005. The genotype RGN05, RGN06, RGN07, RGN08, RGN13, RGN17, RGN18, RGN27, RGN29 recorded highest cluster mean values for days to 1st male flower open (56.0 days) and single fruit weight (141.0 g) and RGN03, RGN12 lowest mean values for days to 1st female flower open (27.0 days) and single fruit weight (85.0 g). The role of days to 1st male flower open, days to 1st female flower open, fruit diameter, single fruit weight and fruit number in PCA indicates their importance in genetic divergence. Sureshbabu (1989) studied 50 genotypes of pumpkin and observed considerable variability for days to first male flower anthesis (41.0-73.0 days) and days to first female flower opening (41.0-84.5 days). Lowest PCV was observed for days to first male flower anthesis (13 .08).

2.1. 5 Pedicel length of flower (cm)

Rashid (1993) reported that in bottle gourd, male flower pedicel length is longer than female flower pedicel length. Grubben (2004) stated that male flowers have 7-31 cm long pedicel and female flowers have 2-10 cm long pedicel in bottle gourd.

2.1.6 Sex ratio (male flower: female flower)

Bose and Som (1986) stated that the sex ratio in cucurbits varied from 5:1 to 25-30:1, the ratio of male: female flower was changed by the climate and environmental factors. Grubben (2004) stated that male flower open earlier and close later than female flowers, the ratio being approximately 9:1 in bottle gourd, although it is lower at low temperature. Rashid (1993) said that the male female flower ratio in cucurbits varied from 4:1 to 60:1 according to the variety and environment. Gaffar (2008) reported the genotypic variance (10.67) was lower than phenotypic variance (11.67) as well as the PCV (12.13%) was, slightly higher than GCV (11.67%) and genetic advance (6.48) in sponge gourd.

2.1.7 Internodes distance (cm)

Gaffar (2008) reported almost similar estimates of GCV and PCV (10.45% and 11.16%) and heritability in broad sense was high (94%) with moderate genetic advance (3.19) for internodes length in sponge gourd. Similar result was found by Singh *et al.* (2002).

2.1.8 Number of branches per vine

Tyagi (1972) used twenty-five inbreds of bottle gourd comprising genetically diverse germplasm for divergence study. The range for the character varied from 6.2 to 10.1. Rahman *et al.* (1991) reported significant differences for number of branches per vine in bitter gourd and ribbed genotypes while bottle gourd the differences were insignificant. Thakur and Nandpuri (1974) observed low variability in water melon for branches per plant ranging from 5.34 to 7.65. Evaluating 25 diverse lines of bitter gourd, Ramachandran (1978) observed considerable variability for several vegetative and reproductive characters. The primary branches per plant in different bitter gourd genotypes ranged from 18.00 to 35.89 with a general mean of 27.12. The estimated phenotypic, genotypic and environmental variances (VP = 2.64, VG = 20.81, VE = 0.83) showed a predominant influence of genetic component in relation to the environmental effects on this character.

2.1.9 Number of fruits per plant

Rahman *et al.* (1986) noted the value of genotypic and phenotypic variances for number of fruits per vine per plant in bottle gourd (1.43 and 3.10), whereas Prasad and Singh (1989), Abusaleha and Dutta (1990), Mangal *et al.* (1981) reported the value in ribbed gourd (202.26 and 475.98), muskmelon (1.71 and 1.90), cucumber (1.15 and 1.24) and bitter gourd (9.02 and 10.45).

2.1.10 Fruit length and breadth (inch)

Significant variation for fruit length and diameter were noticed in bitter gourd (Srivastava and Srivastava, 1976; Mangal *et al.*, 1981) sponge gourds (Arora *et al.*, 1983; Prosad and Singh, 1990), ribbed gourd and bottle gourd (Rahman *et al.*, 1991). Rahman *et al.* (1986) indicated high GCV and PCV for both length (31.73 and 33.75) and diameter (39.23 and 41.96) of fruits in bottle gourd. They also observed minimum difference between GCV and PCV. Characters having high GCV indicate high potentiality for effective selection (Burton and de Vane, 1953). Saha *et al.* (1992) observed high GCV and PCV for fruit length (30.34 and 31.76) and low for fruit diameter (8.87 and 10.23) in pumpkin. They estimated high h^2 for both length (11.27 %) and diameter (75.07 %). They also found high genetic advance for fruit length (59.72) but low for fruit diameter (15.82).

2.1.11 Peduncle length (inch)

Gaffar (2008) reported almost similar estimates of GCV and PCV (28.47% and 28.52%) and heritability was high (1.00%) with moderate genetic advance (6.59) for peduncle length in sponge gourd.

2.1.12 Fruit weight (Kg)

High GCV and PCV were reported (39.55 and 41.00) by Saha *et al.* (1992); (30.2 and 36.4) by Doijode and Sulladmath (1986) for fruit weight in pumpkin. Rana *et al.* (1986) also obtained high value for this trait in pumpkin. Mannan (1992) reported narrow difference between GCV and PCV for this trait in bitter gourd indicating less environmental influence on this character. High heritability coupled with genetic advance for average fruit weight was noticed in pumpkin (82.9% and 49.6) by Doijode and Sulladmath (1986); (93.03% and 78.58) by Saha *et al.* (1992). Prasad and Singh (1992) also obtained similar results for this trait in snake gourd and cucumber. On the other hand, low heritability (45.1%) and very high genetic advance (133.05) was recorded for this trait in ribbed gourd by thakur and Choudhury (1965). Vashistha *et al.* (1983) and Vijay (1987) noted low GCV and PCV for fruit weight in water melon (0.28 and 0.41) and musk melon (0.01 and 0.02), respectively, whereas Mangal *et al.* (1981) found high value (291.89 and 318.47) in bitter gourd.

2.1.13 Yield per plant (kg)

The variation for yield per plant was recorded in bottle gourd (Rahman *et al.*, 1991), water melon (chezhiyan, 1984), musk melon (Swamy *et al.*, 1984) and pumpkin (Rana *et al.*, 1986; Shaha *et al.*, 1992). Mangal *et al.* (1981) found high value (47759.63 and 55149.80) in bitter gourd while, low GCV and PCV were recorded for this character in water melon (0.44 and 1.15) and musk melon (0.04 and 0.07) by Vashistha *et al.* (1983) and Vijay (1987). Singh and

Prasad (1989) and Saha *et al.* (1992) recorded high GCV and PCV for yield per plant in pointed gourd (46.50 and 64.10) and pumpkin (28.82 and 31.21). High h^2 associated with high genetic advance for yield per plant was reported by Saha *et al.* (1992).

2.2 Correlation Co-efficient:

Kumar *et al.* (2007) conducted an experiment to study the correlation coefficient of 20 bottle gourd (*Lagenaria vulgaris*) genotypes. Fruit yield per vine in bottle gourd is the result of interaction of number of inter-related characters. Therefore, selection should be based on these components character after assessing their correlation with fruit yield per vine. The fruit yield per vine showed positive and significant correlation with number of branches per vine, vine length, nodes number of first male flower, nodes number of first female flower, length of edible fruits, number of fruits per vine, number of seeds per fruits and 100-seed weight at genotypic and phenotypic levels. This indicated that fruit yield can be improved by making selection on the basis of no. of branches per vive, vine length, nodes no. of first female flower, length of edible fruit and no. of fruit per vine.

Badade *et al.* (2001) conducted an experiment to study the correlation of 20 bottle gourd (*Lagenaria vulgaris*) genotypes. Yield was found significantly and positively correlated with number of branch per vine, number of fruits per vine and significantly and negatively correlated with days to first male and female flower appearance and weight of deformed fruits per vine at both phenotypic and genotypic levels. Fruit length showed positive but non significant correlation with fruit yield.

Narayan *et al.* (1996) studied correlation analysis in 25 diverse populations of bottle gourd. Correlation coefficient revealed that fruit yield per plant can be successfully improved by making selection or greater fruit number, higher fruit weight, greater number of primary branches and genotypes with lesser number of days to anthesis of first male flower.

Rahman *et al.* (1986) studied Variability, correlation and path coefficients in four lines of bottle gourd. Fruit weight per plant had strong positive genotypic correlation with days to first picking, length of main vine and fruit diameter and a negative correlation with fruit length.

Parhi *et al.* (1995) studied correlation and path co-efficient of thirteen genotypes of bitter gourd. Positively significant correlations of yield per plant with fruit weight, fruit length, number of seeds per fruit, vine length and days to first harvest indicated that simultaneous improvement can be made if selection is made for any one of the correlated characters.

Singh and Ram (2003) conducted an experiment on 28 musk melon genotypes to determine the correlation among fruit characters. The simple correlation among fruit traits showed that polar diameter, latitudinal diameter, flesh thickness and seed cavity size were positively correlated with fruit weight.

Shah and Kale (2002) conducted an experiment on correlation co-efficient analysis of yield components of 55 genotypes of ridge gourd. The fruit weight per vine was positively and significantly correlated with number of fruits per vine, average fruit weight, number of female flower per vine and vine length, indicating the close association and dependency of yield these characters. The fruit length was negatively correlated with fruit diameter and fruit number per vine, while it was positively correlated with average fruit weight.

Singh *et al.* (2002) carried out 98 hybrids of cucumber derived from crosses involving fourteen male and seven female parents and found that fruit weight, fruit girth and fruit length had high correlations with fruit yield. Genotypic correlation co-efficient were higher than phenotypic co-efficient which indicated strong association among these traits.

Miah *et al.* (2000) noted that fruit yield in bitter gourd showed significant positive association with average fruit weight, fruit breadth and number of nodes per vine in genotypic and phenotypic correlation with days to male flowering.

Sarker *et al.* (1999) studied correlation and path co-efficient of 16 divergence types of pointed gourd indicated that fruit weight, fruit diameter and number of primary branches per plant were positively and significantly correlated with yield per plant at genotypic and phenotypic levels.

Li *et al.* (1997) noted that number of fruits per plant, average fruit per plant, average fruit weight, fruiting rate and leaf area of cucumber genotypes were positively correlated to yield. Days to flowering and vine length were negatively correlated.

Ananthan and Pappoah (1997) reported that fruit number per vine and seed number per fruit were positively correlated with total yield while days to first female flowering, days to first male flowering, sex ratio, fruit girth, pulp thickness and total soluble solids content were negatively correlated with total yield in cucumber.

Kumaran *et al.* (1998) carried out an experiment on correlation and path analysis studies in pumpkin. They found that positive and significant correlation of vine length, mean fruit weight, number of fruit per plant and number of seeds per fruit with fruit yield per plant.

Abusaleha and Dutta (1989) found that the yield of cucumber is positively correlated with vine length ($r = 0.35$), branches per vine ($r = 0.29$), fruits per vine ($r = 0.48$), fruit length ($r = 0.60$) and fruit girth ($r = 0.43$). Days to first male and female flowering, nodal position female flower, percentage of misshapen fruits and non-marketable yield were negatively correlated with yield.

Prasad *et al.* (1988) in a study found that phenotypic and genotypic co-efficient of variation of water melon were high for fruit per plant, average fruit weight, seed per fruit, 100 seed weight and fruit yield per plant. They also reported that fruit yield was correlated with vine length (r = 0.47), branches per plant (r = 0.75), fruit weight (r = 0.88), length (r = 0.63) and girth (r = 0.61).

Vijay (1987) worked with nine agronomic characters of 95 diverse musk melon stocks and found that fruits per vine and fruit weight were positively correlated with yield.

Chadhury and Mandal (1987) conducted a study on 30 diverse cucumber genotypes and found high positive correlations at the genotypic and phenotypic levels between yield per plant with number of fruits and female flowers per plant, fruit length and weight.

According to Singh *et al.* (1986) yield was positively and significantly correlated with fruits per plant (r = 0.60) and days to flowering, days to fruit set and days to ripeness were negatively correlated with all the other characters with the exception of a positive correlation between days to flowering and fruit weight in pointed gourd

Reddy and Rao (1984) observed negative and non-significant correlation between male flower pedicel length, female flower pedicel length traits (r =0 0.222) in ribbed gourd.

2.3 Path Co-efficient:

Kumar *et al.* (2007) conducted an experiment to study the path coefficient of 20 bottle gourd (*Lagenaria vulgaris*) genotypes. Path analysis revealed that number of branches per vine, vine length, nodes number of first female flower and number of fruit per vine had positive direct effect on fruit yield per vine.

Narayan *et al.* (1996) studied path-coefficient analysis in 25 diverse populations of bottle gourd. Path coefficient analysis revealed that maximum weightage should be given primarily to days to first harvest followed by average weight of edible fruit, number of fruits per plant and days to anthesis of first female flower while formulating selection indices for improvement of yield in bottle gourd.

Rahman *et al.* (1986) studied Variability, correlation and path coefficients in four lines of bottle gourd. Path coefficient analysis revealed that fruit diameter and fruit length had high positive direct effect on fruit weight per plant. Number of fruits per plant also had considerable positive direct effect on fruit weight per plant.

Singh *et al.* (2002) carried out 98 hybrids of cucumber derived from crosses involving fourteen male and seven female parents. Path coefficient analysis indicated that fruit weight had the highest direct effect on fruit yield.

Rao *et al.* (2000) conducted an experiment on the segregating population of ridge gourd for correlation and path coefficient analysis. Path analysis revealed that yield improvement could be achieved by direct selection for days to 50% flowering, girth of fruit, fruits per plant or vine, fruit per branch and length of the vine of ridge gourd.

Miah *et al.* (2000) conducted an experiment on bitter gourd for correlation and path coefficient analysis. Path analysis revealed that average fruit weight, number of fruits per plant, days to male flowering and fruit length had positive direct effect on fruit yield.

Sarker *et al.* (1999) studied path co-efficient of 16 divergence types of pointed gourd. The path analysis revealed that fruit volume followed by fruit weight and fruit diameter had maximum positive direct effects on yield.

Li *et al.* (1997) conducted an experiment on cucumber genotypes. From path analysis, they concluded that fruits per plant and average fruit weight affected the yield directly.

Sych (1990) conducted path co-efficient analysis in 150 genotypes of watermelon and found that fruit weight and number of fruits per plant had considerable direct effects on yield.

Mondal *et al.* (1989) studied path co-efficient in 31 genotypes of watermelon and observed that the number of fruits per plant and fruit diameter affected fruit yield directly. Path co-efficient analysis revealed that for increasing fruit yield selection should be based on plant having more number of fruits with larger diameter.

Kumaran *et al.* (1998) carried out an experiment on correlation and path analysis studies in pumpkin. They found that number of fruit per plant exhibited the highest direct effect on yield. High positive indirect effects were exerted by number of fruit per plant and mean fruit weight.

Abusaleha and Dutta (1989) carried out an experiment on correlation and path analysis studies in cucumber. Path coefficient analysis revealed that fruits per vine and fruit length had the greatest direct effects on yield.

Chadhury and Mandal (1987) conducted a study on 30 diverse cucumber genotypes and Path co-efficient analysis revealed that the number of fruits, female flowers per plant, fruit length, fruit weight and fruit diameter were the most important characters determining yield.

Parhi *et al.* (1995) studied correlation and path co-efficient of thirteen genotypes of bitter gourd. Path analysis revealed that fruit breadth, days to opening of first male and female flower, vine length and number of seeds per fruit had the maximum positive direct effect on yield in bitter gourd. The characters like fruit weight and fruit length though have significant positive correlation with yield, exhibited low direct effect. Besides direct selection for yield, indirect selection through number of seeds per fruit and fruit weight would prove worth for further improvement in yield of bitter gourd.

2.4 Genetic Diversity:

Genetic diversity is one of the important tools to quantify variability in both self and cross-pollinated crops (Griffing and Lidstorm, 1954; Murty and Arunachalam, 1966; Guar *et al.* 1978).

The quantification of genetic diversity through biometrical procedure made it possible to choose genetically diverse plants for a successful hybridization programme (Rao, 1952). D^2 analysis (originally outlined by Mahalanobis, 1936 and extended by Rao, 1952) is one of potential methods of estimating the degree of genetic diversity.

The wide diversity of genotypes can be shown by cluster analysis from the same geographical regions. To understand the usable variability, grouping or classification of genotypes based on suitable scale. Multivariate analysis formulated by Mahalanobis (1936) is a powerful tool in quantifying the degree of divergence among biological population based on multiple characters. Studies on genetic diversity in bottle gourd carried out so far are presented as follows:

Genetic divergence using Mahalanobis D^2 statistics was studied for seven quantitative characters including yield per vine in a collection of twenty diverse cultivars of bottle gourd by Badade *et al.* (2001). The cultivars differed significantly for almost all of the characters and were grouped into 10 clusters based on the similarities of D^2 value. Considerable diversity within and between clusters was noted and it was observed for the characters viz. vine length, number of branches, fruit per vine, length and diameter of fruit and yield per vine.

Quamruzzaman *et al.* (2008) studied multivariate analysis on the quantitative characters among seventeen genotypes of bottle gourd (*Lagenaria siceraria*). The genotypes were constellated into four distinct groups with the range of three genotypes in cluster II and cluster III to seven in cluster I. The maximum inter-cluster distance was observed between genotypes of cluster II and III. The highest intra-cluster value (1.0) was observed in cluster II. Mean performance of different clusters revealed that cluster III recorded the highest mean for no. of fruit per plant, individual fruit weight and fruit yield. Therefore, more emphasis should be given on cluster III for selecting genotypes as parents for crossing with the genotypes of cluster I which may produce new recombinants with desired traits.

Quamruzzaman *et al.* (2008) studied the genetic divergence among thirty genotypes of ridge gourd (*Luffa acutangula*) using D^2 and principal component analysis. The genotypes were grouped into six clusters. The highest intra cluster distance was noticed for the cluster II (0.882) and the lowest for the cluster III (0.220). The highest inter-cluster distance was observed between cluster I and II (15.045) where as the lowest was observed between cluster IV and V (3.402).

Gaffar (2008) conducted an experiment with 15 sponge gourd genotypes at the experimental farm of Sher-e-Bangla Agricultural University, during April 2007 to October 2007. The genotypes were grouped into five clusters. The highest intra cluster distance was noticed for the cluster III (0.999) and the lowest for the cluster IV (0.439). The highest inter-cluster distance was observed between cluster IV and V (7.163) where as the lowest was observed between cluster I and IV (2.258).

Banik (2003) studied 26 genotypes of snake gourd were tested using multivariate analysis and the genotypes were grouped into seven distinct cluster. No relationship was found between genetic divergence and geographical distribution of genotypes. The highest inter genotypes distance was observed between genotypes SG 026 and SG 010 (1.897). The inter cluster distance was maximum between cluster II and IV (17.74). Main vine length, first female flower node number, nodes on main vine, fruit length and number of seeds per fruit had the highest contribution towards the divergence.

Masud *et al.* (2001) studied genetic divergence in 19 genotypes of sponge gourd (*Luffa cylindrica*) collected from local and exotic resources. The genotypes were grouped into five clusters. The genetic divergence of the genotypes did not follow their geographical distribution and was fairly at random. There was no evidence of close relationship between geographical distribution and genetic divergence as estimated by D^2 statistics. Maximum inter-cluster distance (45.9) was observed between cluster II and V and minimum (10.3) between cluster II and IV. Fruit length and diameter were significant contributors to genetic divergence.

Karuppaiah *et al.* (2005) evaluated genetic divergence in 12 genotypes of bitter gourd (*Momordica charantia*) grown in Annamalai, Tamil Nadu, India, during June-July 2001. Using Mahalanobis D^2 technique, the genotypes were grouped into clusters I (four genotypes), II (one genotype), III (three genotypes) and IV (four genotypes). Among the four clusters, cluster IV (LA-7, LA-9, LA-10 and LA-12) registered the highest mean values for vine length (6.2 m), number of male flowers per plant (79.3), number of female flowers per plant (23.2), yield per plant (5.2 kg), single fruit weight (242.2 g), fruit length (29.4 cm), number of fruits per plant (24.1), number of seeds per fruit (52.3), fruit size index (173.2), and 100-seed weight (18.6 g). Hence, it is desirable to involve LA-7, LA-9, La-10 and LA-12 of cluster IV in breeding programmes.

Khan *et al.* (2008) assessed the genetic diversity among 64 pointed gourd genotypes through multivariate analysis from an experiment conducted in Regional Agricultural Research Station, Ishurdi, Pabna during the growing season 2002-2003. The genotypes were grouped into twelve clusters. The cluster V consisted of highest number of genotypes and it was nine, the cluster VI and cluster VIII contained the lowest number of genotypes and it was two in each. The clustering pattern of the genotypes under this study revealed that the genotypes collected from the same location were grouped into different clusters. The genotypes of Jessore were distributed in different clusters. The highest inter genotype distance as 366.3 observed between the genotypes

P0022 and P0007 and the lowest 2.6 as observed between the genotypes P0043 and P0044. Cluster V had the highest cluster mean value for internodes length, fruit weight per plant and yield the highest inter-cluster distance was noticed between cluster III and II (45.71) and the lowest between cluster VII and VI (3.33). The highest intra cluster distance was computed for cluster III and that was lowest for the cluster II. The first five axes accounted for 77.65% of the total variation among the 13 characters describing 64 pointed gourd genotypes. Fruit weight, seeds per fruit and fruit weight per plant contributed maximum to the total divergence.

Kabir (2007) reported that genetic divergence studied 24 accessions of pointed gourd. The accessions were grouped into five clusters. The cluster I and III had the highest number of accessions (six) followed by cluster V (five), cluster II (four) & Cluster IV (three). The highest intra cluster distance was computed for cluster IV (35.80) followed by cluster I (28.12) and Cluster V (26.63). The minimum intra cluster distance was found in III (18.87).

Harshawardhan and Ram (2003) conducted an experiment on severity germplasms of musk melon lines to elucidate genetic divergence using a non-hierarchical Euciden cluster analysis for yield and its components. The genotypes were grouped into 11 clusters irrespective of geographic and genetic diversity. Group VIII contained the largest number of 11 genotypes. The maximum genetic distance occurred between cluster II and X.

Hazra *et al.* (2003) reported that genetic divergence studied on 167 accessions of pointed gourd and grouped in eight non-overlapping clusters, with cluster IV comprising of the highest number of accessions (37 accessions) and cluster VI comprising of the lowest number of genotypes (six accessions). Inter cluster distance ranged from 1.25 in cluster I to 1.65 in cluster VII. Cluster VIII and V were the most diverse as indicated by the maximum inter cluster distance between them (6.04).

Raseed *et al.* (2002) studied the genetic divergence of 47 pumpkin genotypes collected from different parts of Bangladesh using Mahalanobis's D^2 and principal component analyses. The genotypes were grouped into seven clusters. Cluster III had the maximum (11) and cluster IV and VII had the minimum number (four) of genotypes. The characters like fruit weight yield per plant contributed maximum towards total divergence.

Prasad *et al.* (1993) evaluated 32 genotypes landraces of cucumber for 14 characters. Mahalanobis's D^2 analysis indicated considerable diversity among the genotypes that were grouped into eight clusters independently of their geographical distribution.

Sidhu and Gautam (1985) obtained higher inter cluster distance than cluster distance in watermelon and reported the low intra cluster and high inter cluster distance indicated that the population grouped were homozygous within and heterozygous between clusters.

Rashid (2000) found that no relationship between geographic distribution and genetic diversity in pumpkin. The result suggested that geographic isolation is not the only factor causing genetic diversity and this point should be considered in selecting parents for hybridization.

Mathew *et al.* (1986) studied genetic distance among five botanical varieties of *Cucumis melo*. The genetic distance was calculated for nodes to first female flower, fruit weight, seeds per fruit and fruits per plant. Total D^2 was estimated according to Mahalanobis (1936). The magnitude of D^2 indicated closeness among the varieties. The character fruits per plant contributed maximum to total divergence (80%). Seeds per fruit did not contribute to the total divergence and concluded that selection of botanical varieties based on fruits per plant would be a logical step in the selection of divergence parents in crop improvement programme.

Varalaksmi *et al.* (1994) conducted an experiment with 48 genotypes of ridge gourd collected from different regions of India to analyze genetic divergence. Nineteen (19) quantitative characters were selected to study genetic divergence using Mahalanobis D^2 statistics and Tocher method to form cluster. The 58 genotypes were grouped into five clusters but, in general there was no association between geographical distance and genetic divergence. There was substantial variation in cluster means for whole plant sex ratio, fruit number per plant, fruit weight and yield per plant. The inter cluster D^2 value indicated that cluster III was most divergent from the other clusters.

Principal component and grouping analyze of data on 31 plant morphological traits were used to estimate genetic divergence in 15 accessions of *Cucurbita* by Choer *et al.* (2000). It was observed that the accessions dispersed in a bidirectional space way, forming three groups, each on having two subgroups. Grouping analysis by the Ward method showed similar results to those obtained from principal component analysis. The traits that mostly contributed to genetic divergence were presence of thorns on the petiole internode number of the main vine up to the first female flower, fruit shape, fruit diameter, skin texture, predominant skin colour and number of days to the first male flower on the main vine.

Ram *et al.* (2001) performed cluster analysis in 167 pointed gourd genotypes (*Trihosanthes dioica*) collected from different ecogeographic region of India. On the basis of different yield contributing agro morphological traits, the genotypes were grouped into eight clusters which were non-overlapping. Cluster IV comprising the most number of genotypes (37 accessions) and cluster VI comprising the lowest number of genotypes (six accessions). Intra cluster distance ranged from 1.258 in cluster I and 1.655 in cluster VII. Cluster VIII and V were the most diverse as indicated by maximum inter cluster distance between them (6.049). The results indicated the potential for wide scope of varietal improvement through hybridization and selection due to the wide genetic diversity present in the accession studied.

Ramachandran *et al.,* (1981) grouped 25 bitter gourd germplasm into ten clusters based on their D^2 values. The inter-cluster distance value observed was maximum between cluster VI and VIII (8569.31) and the minimum was between cluster II and III (393.62). The co-efficient of variation estimated for different characters among the 10 clusters showed greater role for yield per plant (38.84), fruits per plant (25.68), female flowers per plant (19.82) and fruit length (19.05) in determining the inter-cluster distance. It was further observed that the character yield per plant, fruits per plant and female flowers per plant and fruit length contributed predominantly to divergence.

Kadam and Kale (1987) observed highly significant difference between cultivars suggesting considerable divergence among 30 ridge gourd cultivars. The 30 cultivars were grouped into 20 clusters based on their D^2 values. Cluster A having two cultivars had the lowest intra-cluster D^2 values (8.22) while clusters I which has two cultivars had the highest intra-cluster value of 18.59. The highest inter-cluster distance was observed between clusters E and M (387.11) and it was minimum between cluster D and G (19.79).

Sanwal *et al.* (2008) evaluated thirty eight indigenous collections of chow-chow for eight quantitative and quality traits. On the basis of genetic divergence, relative magnitude of D^2 values thirty-eight genotypes were grouped into seven clusters. The maximum genetic divergence was observed between cluster III and VII followed by cluster II and VI. The cluster V and VI displayed lowest degree of divergence. The minimum intra-cluster distance was exhibited for cluster VI followed by cluster V. However, it was highest for cluster III. The mean values were higher in cluster I and IV for two characters i.e. fruit length and average fruit weight, while cluster II had high mean values for number of fruits/plant.

Ramos *et al.* (2000) evaluated the genetic diversity of 40 squash accessions collected from distinct areas of the Northeast region of Brazil. The data were analyzed using canonic variable and Tocher cluster analysis adopting Mahalanobis D^2 general distance. It was observed that 65% of the accessions were clustered in a group. The disperse results based on the first four canonic variables (71% of total variability) did not permit a correlation between genetic diversity and eco-geographical origin.

Dora (2001) studied eleven genotypes of *Trihosanthes dioica* and the genotypes were grouped into four clusters based on Mahalanobis's D^2 statistics and found that inter cluster distances were greater than intra cluster distances, indicating considerable genetic diversity among genotypes. The highest D^2 value (984.3) was recorded between cluster II and IV.

Masud *et al.* (1995) carried out an experiment to study the genetic divergence among 27 genotypes of pumpkin (*Cucurbita moschata*) collected from eight districts of Bangladesh was group into seven cluster. No relationship was found between genetic divergence and geographic distribution of the genotypes. Maximum inter cluster distance was observed between cluster II and VII and was minimum between V and VI. Number of fruits per plant and yield per plant showed maximum contributed to the total divergence. The results obtained by D^2 analysis were confirmed by principal component analysis.

Chapter III
Materials & Methods

CHAPTER III
MATERIALS AND METHODS

The investigation was carried out at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2008 to March 2009 to study on the genetic diversity, correlation and path analysis in bottle gourd. A brief description about the locations of the experimental site, characteristics of soil, climate, materials, layout and design of the experiment, land preparation, manuring and fertilizing, transplanting of seedlings, intercultural operations, harvesting, data recording procedure, economic and statistical analysis etc., which are presented as follows:

3.1. Experimental site

The research work was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during October 2008 to March 2009.

3.2 Geographical Location

The experimental area was situated at 23°77'N latitude and 90°33'E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004). The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in (Appendix I).

3.3 Climate

Area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Meteorological information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period was presented in Appendix II.

3.4 Characteristics of soil

Soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.0- 6.6 and had organic matter 0.84%. Experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. Physicochemical properties of the soil are presented in (Appendix III).

3.5 Planting materials

Thirty one genotypes of bottle gourd were used for the present research work. The purity and germination percentage were leveled as around 100 and 80, respectively. The genetically pure and physically healthy seeds of these genotypes were collected from Plant Genetic Resources Centre (PGRC) of Bangladesh Agricultural Research Institute (BARI), Gazipur. The name and origin of these genotypes are presented in (Table 1).

3.6 Design and layout of the experiment

The experiment was laid out Randomized Complete Block Design (RCBD) with three replications. The genotypes were distributed into the pit of each block of the prepared layout of the experiment. The thirty one genotypes of the experiment were assigned at random into pits of each replication. The distance maintained spacing pit to pit 3 m. The distance maintained between two blocks was 1 m.

Table 1. Name and origin of thirty one Bottle gourd genotypes used in the present study

Sl. No.	Genotypes No.	BARI ACC Number	Origin
1	G_1	BD-4577	PGRC, BARI
2	G_2	BD-4578	PGRC, BARI
3	G_3	BD-4579	PGRC, BARI
4	G_4	BD-4580	PGRC, BARI
5	G_5	BD-4581	PGRC, BARI
6	G_6	BD-4582	PGRC, BARI
7	G_7	BD-4583	PGRC, BARI
8	G_8	BD-4584	PGRC, BARI
9	G_9	BD-4585	PGRC, BARI
10	G_{10}	BD-4596	PGRC, BARI
11	G_{11}	BD-4597	PGRC, BARI
12	G_{12}	BD-4605	PGRC, BARI
13	G_{13}	BD-4598	PGRC, BARI
14	G_{14}	BD-4599	PGRC, BARI
15	G_{15}	BD-4600	PGRC, BARI
16	G_{16}	BD-4601	PGRC, BARI
17	G_{17}	BD-4602	PGRC, BARI
18	G_{18}	BD-4604	PGRC, BARI
19	G_{19}	BD-4603	PGRC, BARI
20	G_{20}	BD-8965	PGRC, BARI
21	G_{21}	BD-8966	PGRC, BARI
22	G_{22}	BD-8987	PGRC, BARI
23	G_{23}	BD-8988	PGRC, BARI
24	G_{24}	BD-4558	PGRC, BARI
25	G_{25}	BD-4559	PGRC, BARI
26	G_{26}	BD-4560	PGRC, BARI
27	G_{27}	BD-4561	PGRC, BARI
28	G_{28}	BD-4569	PGRC, BARI
29	G_{29}	BD-8950	PGRC, BARI
30	G_{30}	BD-8949	PGRC, BARI
31	G_{31}	BD-8948	PGRC, BARI

Here, PGRC = Plant Genetic Resources Centre, BARI = Bangladesh Agricultural Research Institute

3.7 Poly bag preparation and raising seedling

Due to uncertain rainfall during the period of the study, the seeds were dibbled in Poly bag for higher germination percentage and to get healthy seedlings and when the seedlings become 20 days old; those were transplanted in the main field in the pit. Seeds were sown 15th October, 2008, before sowing seeds were treated with Bavistin for 5 minutes.

3.8 Land preparation

The experiment plot was prepared by several ploughing and cross ploughing followed by laddering and harrowing with tractor and power tiller to bring about good tilth in the first week of October 2008. Weeds and other stables were removed carefully from the experimental plot and leveled properly.

3.9 Pit preparation

After final land preparation, pits of 55 cm × 55 cm × 45 cm were prepared in each block with a spacing of 3 m × 1 m. Pits were kept open in the sun for 7 days to kill harmful insect and microorganisms. To control field cricket 5 mg Furadan was also mixed with the soils of each pit before making it ready for dibbling.

3.10 Manure and fertilizers application

Total cowdung, half of TSP and one third MOP were applied in the field during final land preparation. Remaining TSP and one third MOP and whole gypsum and zinc oxide and one third of urea were applied in pit one week prior to transplantation. Remaining urea and MOP were applied as top dressing in four installments at 20, 40, 60 and 75 days after transplanting. (Table 2) showing doses of manure and fertilizers used in the study.

Table 2. Doses of manure and fertilizers used in the study

Sl. No.	Fertilizer/Manure	Dose
1.	Cowdung	10 ton/ha
2.	Urea	125 kg/ha
3.	TSP	125 kg/ha
4.	MOP	150 kg/ha
5.	Gypsum	75 kg/ha
6.	Zinc Oxide	10 kg/ha

3.11Transplanting of seedlings

Germination of seeds was completed within 12 days and the seedlings of different accessions were planted in the pit on 5th November, 2008. In each pit two seedlings were planted and the soil around the plant was firmly pressed by hand.

3.12 Intercultural operations

The following intercultural operations were done from time to time throughout the cropping season for proper growth and development of the plants.

3.12.1 Thinning and gap filling

Only one healthy seedling was kept per pit for the proper development and avoid crowd environment. For this whatever its need thinning and gap filling was done.

3.12.2 Weeding and mulching

Several weeding and mulching were done as per requirement. At the very first stage weeding was done for ease of aeration and less competition seedling growth and mulch was provided after an irrigation to prevent crust formation and facilitate good aeration.

3.12.3 Irrigation and after-care

In the early stage irrigation was done twice daily by water cane. In mature stage flood irrigation was done when ever it's necessary.

3.12.4 Pesticide application

At the seedling stage red pumpkin beetle attacked tender leaves and also after the initial stage they attacked plants several times for this Malathion and Ripcord was sprayed in the field. In mature stage fruit fly caused severe damage to the fruit. For protection from fruit fly, MSGT (Mashed Sweet Gourd Trap) and Pheromone bait was used along with ripcord, seven powders.

3.13 Harvesting

Fruits were picked on the basis of horticultural maturity, size, color and age being determined for the purpose of consumption as the fruit grew rapidly and soon get beyond the marketable stage, frequent picking was done throughout the harvesting period. Fruits were picked with sharp knife and care was taken to avoid injury of the vine.

3.14 Data recording

Data were recorded on following parameters from the studied plants during the experiment. The details of data recording are given below on individual plant basis.

3.14.1 Plant characteristics

3.14.1.1 Number of branches per vine

Branches per vine were counted and average data was recorded.

3.14.1.2 Leaf length (cm)

Leaf length was measured in three to five leaves in each germplasm in cm and average data was recorded.

3.14.1.3 Leaf Breadth (cm)

Leaf breath was measured in three to five leaves in each germplasm in cm and average data was recorded.

3.14.1.4 Leaf Petiole length (cm)

Leaf petiole length was measured in three to five leaves in each germplasm in cm and average data was recorded.

3.14.1.5 Internodes distance (cm)

Internodes distance was measured of different places in each germplasm in cm and average data was recorded.

3.14.2 Inflorescences characteristics

3.14.2.1 Days to first male flowering

The number of days required for first male flower flowering was counted for three replication separately and average data was recorded.

3.14.2.2 Days to first female flowering

The number of days required for first female flower flowering was counted for three replication separately and average data was recorded.

3.14.2.3 Pedicel length of Male flower (cm)

Pedicel length of male flower was measured in three to five flowers in each germplasm in cm and average data was recorded.

3.14.2.4 Pedicel length of Female flower (cm)

Pedicel length of female flower was measured in three to five flowers in each germplasm in cm and average data was recorded.

3.14.2.5 Ratio of male and female flowers

Male and female flower ratio was recorded in each germplasm.

3.14.3 Fruit characteristics

3.14.3.1 Peduncle length of fruit (inch)

Fruit peduncle length was measured in three to five fruits in each germplasm in inch and average data was recorded during fruit harvest for vegetable use.

3.14.3.2 Fruit length (inch)

Fruit length was measured in three to five fruits in each germplasm in inch and average data was recorded during fruit harvest for vegetable use.

3.14.3.3 Fruit breadth (inch)

Fruit diameter was measured in three to five fruits in each germplasm in inch, then the data was divided by two and average data was recorded during fruit harvest for vegetable use.

3.14.3.4 Fruit weight (Kg)

Weight of three to five fruits in each germplasm during harvest for vegetable use was measured in kilogram (Kg).

3.14.3.5 Number of fruit per plant

The number of fruit per plant was counted and average data was recorded

3.14.3.6 Fruit yield per plant (Kg)

Weight of edible fruits of selected plants from each accession was weighed in kilogram (kg).

3.15.1 Statistical analysis

Mean data of the characters were subjected to multivariate analysis. Univariate analysis of the individual character was done for all characters under study using the mean values (Singh and Chaudhury, 1985) and was estimated using MSTAT-C computer programme. Duncan's Multiple Range Test (DMRT) was performed for all the characters to test the differences between the means of the genotypes. Mean, range and co-efficient of variation (CV%) were also estimated using MSTAT-C. Multivariate analysis was done by computer using GENSTAT 5.13 and Microsoft Excel 2000 software through four techniques viz., **Principal Component Analysis (PCA), Principal Coordinate Analysis** (PCO), Cluster Analysis (CA) and Canonical Vector Analysis (CVA).

3.15.1.1 Estimation of genotypic and phenotypic variances

Genotypic and phenotypic variances were estimated according to the formula given by Johnson *et al.* (1955).

Genotypic variance (σ^2_g) $= \frac{GMS - EMS}{r}$

Where,

GMS = Genotypic mean sum of squares

EMS = Error mean sum of square

r = number of replications

Phenotypic variance (σ^2_{ph}) $= \sigma^2_g + EMS$

Where,

σ^2_g = Genotypic variance

EMS = Error mean sum of square

3.15.1.2 Estimation of genotypic and phenotypic correlation co-efficient

For calculating the genotypic and phenotypic correlation co-efficient for all possible combinations the formula suggested by Miller *et al.* (1958), Johnson *et al.* (1955) and Hanson *et al.* (1956) were adopted.

The genotypic co-variance component between two traits and have the phenotypic co-variance component were derived in the same way as for the corresponding variance components. The co-variance components were used to compute genotypic and phenotypic correlation between the pairs of characters as follows:

Genotypic correlation (r_{gxy}) = $$\frac{\sigma_{gxy}}{\sqrt{(\sigma^2_{gx}\ \sigma^2_{gy})}}$$

Where,

σ_{gxy} = Genotypic co-variance between the traits x and y

σ^2_{gx} = Genotypic variance of the trait x

σ^2_{gy} = Genotypic variance of the trait y

Phenotypic correlation (r_{pxy}) = $$\frac{\sigma_{pxy}}{\sqrt{(\sigma^2_{px}, \sigma^2_{py})}}$$

Where,

σ_{pxy} = Phenotypic covariance between the traits x and y

σ^2_{px} = Phenotypic variance of the trait x

σ^2_{py} = Phenotypic variance of the trait y

3.15.1.3 Estimation of genotypic and phenotypic co-efficient of variation

Genotypic and phenotypic co-efficient of variation were calculated by the formula suggested by Burton (1952)

Genotypic co-efficient of variation (GCV %) = $\sqrt{\frac{\sigma_g^2}{\bar{x}}} \times 100$

Where,

σ^2_g = Genotypic variance

$\bar{x}$ = Population mean

Similarly,

The phenotypic co-efficient of variation was calculated from the following formula.

Phenotypic co-efficient variation (PCV) = $\sqrt{\frac{\sigma^2_{ph}}{\bar{x}}} \times 100$

Where,

σ^2_{ph}= Phenotypic variance

$\bar{x}$ = Population mean

3.15.1.4 Estimation of heritability

Broad sense heritability was estimated (Lush, 1943) by the following formula, suggested by Johnson *et al.* (1955).

$$h^2{}_b\% = \frac{\sigma^2{}_g}{\sigma^2{}_{ph}} \times 100$$

Where,

$h^2{}_b$ = Heritability in broad sense

σ^2_g = Genotypic variance

σ^2_{ph} = Phenotypic variance

3.15.1.5 Estimation of genetic advance

The expected genetic advance for different characters under selection was estimated using the formula suggested by Lush (1943) and Johnson *et al.* (1955).

Genetic advance (GA) = K. $h^2{}_b$. σ_{ph}

$$GA = K.\frac{\sigma^2{}_g}{\sigma^2{}_{ph}}.\sigma_{ph}$$

Where,

K = Selection intensity, the value which is 2.06 at 5% selection intensity

σ_{ph} =Phenotypic standard deviation

$h^2{}_b$ = Heritability in broad sense

σ^2_g = Genotypic variance

σ^2_{ph} = Phenotypic variance

3.15.1.6 Estimation of genetic advance in percent of mean

Genetic advance in percent of mean was calculated from the following formula as proposed by Comstock and Robinson (1952):

$$\text{Genetic advance (\% of mean)} = \frac{\text{Genetic Advance (GA)}}{\text{Population mean } (\bar{x})} \times 100$$

3.15.2 Multivariate analysis

The genetic diversity among the genotypes was assessed by Mahalanobis's (1936) general distance (D^2) statistic and its auxiliary analyses. The parents selection in hybridization programme based on Mahalanobis's D^2 statistic is more reliable as requisite knowledge of parents in respect of a mass of characteristics is available prior to crossing. Rao (1952) suggested that the quantification of genetic diversity through biometrical procedures had made it possible to choose genetically diverse parents for a hybridization programme. Multivariate analysis viz. Principal Component analysis, Principal Coordinate analysis, Cluster analysis and Canonical Vector analysis (CVA), which quantify the differences among several quantitative traits, are efficient method of evaluating genetic diversity. These are as follows:

3.15.2.1 Principal Component analysis (PCA)

Principal Component analysis, one of the multivariate techniques, is used to examine the inter-relationships among several characters and can be done from the sum of squares and products matrix for the characters. Thus, PCA finds linear combinations of a set variate that maximize the variation contained within them, thereby displaying most of the original variability in a smaller number of dimensions. Therefore, Principles components were computed from the correlation matrix and genotypes scores obtained for first components (which has the property of accounting for maximum variance) and succeeding components with latent roots greater than unity. Contribution of the different morphological characters towards divergence is discussed from the latent vectors of the first two principal components.

3.15.2.2 Principal Coordinate analysis (PCO)

Principal Coordinate analysis is equivalent to PCA but it is used to calculate inter unit distances. Through the use of all dimension of p it gives the minimum distance between each pair of the n points using similarity matrix (Digby *et al.*, 1989).

3.15.2.3 Cluster analysis (CA)

Cluster analysis divides the genotypes of a data set into some number of mutually exclusive groups. Clustering was done using non-hierarchical classification. In Genstat, the algorithm is used to search for optimal values of chosen criterion proceeds as follows. Starting from some initial classification of the genotypes into required number of groups, the algorithm repeatedly transferred genotypes from one group to another so long as such transfer improved the value of the criterion. When no further transfer can be found to improve the criterion, the algorithm switches to a second stage which examines the effect of swooping two genotypes of different classes and so on.

3.15.2.4 Canonical Vector analysis (CVA)

Canonical vector analysis (CVA) finds linear combination of original variabilities that maximize the ratio of between group to within group variation, thereby giving functions of the original variables that can be used to discriminate between the groups. Thus, in this analysis a series of orthogonal transformations sequentially maximizing of the ratio of among groups to the within group variations. The canonical vector are based upon the roots and vectors of WB, where W is the pooled within groups covariance matrix and B is the among groups covariance matrix.

3.15.2.5 Calculation of D^2 values

The Mahalanobis's distance (D^2) values were calculated from transformed uncorrelated means of characters according to Rao (1952), and Singh and Chaudhury (1985). The D^2 values were estimated for all possible combinations between genotypes. In simpler form D^2 statistic is defined by the formula

$$D^2 = \sum_{i}^{x} d_i^2 = \sum_{i}^{x} (Y_i^j - Y_j^k)^2 \qquad (j \neq k)$$

Where,

Y = Uncorrelated variable (character) which varies from i = 1 ------to x

x = Number of characters.

Superscript j and k to Y = A pair of any two genotypes.

3.15.2.6 Computation of average intra-cluster distances

Average intra-cluster distances were calculated by the following formula as suggested by Singh and Chuadhury (1985).

$$\text{Average intra-cluster distance} = \frac{\sum D_i^2}{n}$$

Where,

D_i^2 = the sum of distances between all possible combinations (n) of genotypes included in a cluster.

n = Number of all possible combinations between the populations in cluster.

3.15.2.7 Computation of average inter-cluster distances

Average inter-cluster distances were calculated by the following formula as suggested by Singh and Chuadhury (1985).

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

Where,

$\sum D_{ij}^2$ = The sum of distances between all possible combinations of the populations in cluster i and j.

n_i = Number of populations in cluster i.

n_j = Number of populations in cluster j.

3.15.2.8 Cluster diagram

Using the values of intra and inter-cluster distances (D $=\sqrt{D^2}$), a cluster diagram was drawn as suggested by Singh and Chuadhury (1985). It gives a brief idea of the pattern of diversity among the genotypes included in a cluster.

3.15.2.9 Selection of genotypes for future hybridization programme

Divergence analysis is usually performed to identify the diverse genotypes for hybridization purposes. The genotypes grouped together are less divergent among themselves than those, which fall into different clusters. Clusters separated by largest statistical distance (D^2) express the maximum divergence among the genotypes included into these different clusters. Variety (s) or line(s) were selected for efficient hybridization programme according to Singh and Chuadhury (1985). According to them the following points should be considered while selecting genotypes for hybridization programme:

i. Choice of cluster from which genotypes are selected for use as parent (s)
ii. Selection of particular genotype(s) from the selected cluster(s)
iii. Relative contribution of the characters to the total divergence
iv. Other important characters of the genotypes performance

Chapter IV
Results & Discussion

CHAPTER IV
RESULTS AND DISCUSSION

The results obtained from the study are presented and discussed in this chapter. The data pertaining to thirty-one bottle gourd genotypes as well as yield and its contributing characters were computed and statistically analyzed and the results thus obtained are discussed below under the following heads:

1. Genetic parameters
2. Correlation co efficient
3. Path co-efficient analysis
4. Multivariate analysis

4.1 GENETIC PARAMETERS

The analysis of variances indicated that the existence of highly significant variation among the genotypes studied. The mean sum of square, mean, range, variance components, genotypic and phenotypic coefficients of variations, heritability, genetic advance and genetic advance in percent of mean (GAPM) are presented in Table 3. The results are discussed character wise as follows:

4.1.1 Days to first male flowering

Significant differences was observed among all genotypes (207.21) studied for this character (Table 3). The mean performance of days to first male flowering indicated that the maximum duration (90.33) to first flowering was produced by BD-8949 and that of minimum (57.00) by BD-4580 with mean value 73.78 (Appendix IV). Highest genotypic and phenotypic variance was observed 326.92 and 349.06 respectively for days to first male flowering with large environmental influence and difference between the genotypic co-efficient of variation (48.03) and phenotypic co-efficient of variation (49.63) indicating existence of less variation among the genotypes. Heritability for this trait was

Table 3. Genetic parameters of 18 vegetative and yield contributing characters of thirty one bottle gourd genotypes

Character	MSG	%CV	Mean	SE	σ^2g	σ^2e	σ^2p	h^2_b	GCV	PCV	ECV	GA	GAPM
Days of first male flowering	207.21**	2.4	73.78	0.87	326.92	22.14	349.06	93.66	48.03	49.63	12.5	46.2	122.71
Days of first female flowering	484.03**	3.12	84.24	1.32	39.22	4.26	43.48	90.2	32.09	33.79	10.58	15.7	80.46
Number of branches per vine	59.34**	14.28	11.27	0.48	4.84	0.02	4.86	99.62	17.89	17.92	1.1	5.8	47.14
Leaf length (cm)	29.721**	5.88	18.7	0.34	14.14	0.04	14.18	99.69	22.63	22.67	1.26	9.91	59.65
Leaf breadth (cm)	42.60**	7.19	23.01	0.41	1.28	0.02	1.29	98.58	22.87	23.04	2.74	2.96	59.96
Leaf petiole length (cm)	33.58**	8.72	12.01	0.36	68.03	3.13	71.16	95.6	11.18	11.43	2.4	21.29	28.85
Internodes distance (cm)	15.73**	0.85	17.92	0.23	159.04	6.9	165.94	95.84	14.97	15.29	3.12	32.59	38.69
Male flower pedicel length (cm)	51.64**	1.94	9.71	0.43	5.24	0.02	5.26	99.55	12.77	12.79	0.85	6.03	33.63
Female flower pedicel length (cm)	9.75**	2.47	5.66	0.19	17.23	0.03	17.26	99.8	42.72	42.76	1.91	10.95	112.67
Number of male flowers	1002.91**	12.5	37.65	1.92	3.24	0.02	3.26	99.4	31.86	31.95	2.47	4.74	83.86
Number of female flowers	121.93**	10.58	19.52	0.68	13.41	2.34	15.74	85.15	35.14	38.08	14.68	8.92	85.6
Ratio of male & female flowers	1.07**	16.57	1.94	0.07	0.21	0.02	0.23	89.39	22.82	24.13	7.86	1.14	56.95
Number of fruit /plant	42.56**	14.68	10.42	0.41	0.32	0.1	0.42	75.6	29.16	33.54	16.57	1.3	66.93
Fruit weight (kg)	0.65**	7.86	1.99	0.05	18.93	2.59	21.52	87.97	38.61	41.17	14.28	10.77	95.61
Fruit length (inch)	14.56**	1.1	12.29	0.23	9.5	1.21	10.71	88.71	16.49	17.5	5.88	7.67	40.99
Fruit breadth (inch)	42.47**	1.26	16.61	0.39	13.29	2.74	16.02	82.93	15.84	17.39	7.19	8.76	38.08
Fruit peduncle length (inch)	3.85**	2.74	4.94	0.12	10.83	1.09	11.92	90.82	27.42	28.77	8.72	8.28	68.98
Yield per plant (kg)	388.28**	15.75	21.54	1.2	125.55	11.51	137.06	91.6	52.02	54.35	15.75	28.31	131.43

Here, ** indicates significant at 1% level of significance, MSG = Mean sum of squares due to genotypes, CV = Co-efficient of Variation, SE = Standard Error, σ^2e = Environmental variance, σ^2g = Genotypic variance, σ^2p = Phenotypic variance, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, ECV= Environmental coefficient of variation, h^2_b = Heritability, GA = Genetic advance, GAPM= Genetic advance in percent of mean estimated very high (93.66%) and genetic advance (46.20) and genetic advance in percent of mean (122.71) were found high, indicated that the possibility of predominance of additive gene effect. Sharma and Dhankar (1990) observed high heritability (93.47%) along with considerably high genetic advance (26.99) for days to flowering in bottle gourd. Mathew and Khader (1999) also observed high heritability for this trait in snake gourd. Singh *et al.* (2002) also found phenotypic co-efficient of variation higher than genotypic co-efficient of variation in respect to days to first male flower opening in cucumber.

4.1.2 Days to first female flowering

Days to first female flowering showed significant variation among genotype mean square (484.03). The maximum duration (109.00) to first flowering was produced by BD-4601 and that of minimum (59.00) by BD-4580 with mean value 84.24 (Appendix IV). The genotypic variance and phenotypic variance for this trait were 39.22 and 43.48 respectively. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this trait. The genotypic co-efficient of variation (32.09) and phenotypic co-efficient of variation (33.79) were close to each other (Table 3). Heritability for this trait was estimated very high (90.20%) and genetic advance (15.70) and genetic advance in percent of mean (80.46) were found high, revealed that the character is governed by additive gene. Sharma and Dhankar (1990) reported that almost similar estimates of GCV and PCV (13.54 and 14.00) for days to first female flower opening in bottle gourd. Miah *et al.* (2000) and Yadav *et al.* (2009) estimated high GCV and PCV for days to first female flowering. Kadam and Kale (1987) also found high heritability with genetic advance in case of days to flowering.

4.1.3 Number of branches per vine

Mean sum of square for number of branches per vine was significant (59.34) due to genotypes in bottle gourd (Table 3) indicating existence of considerable difference for this trait. The maximum branches was found 25.00 in BD-4569 and the minimum was recorded 6.00 in BD-4599 with mean value 11.27 (Appendix IV). The genotypic variance (4.84) and phenotypic variance (4.86) for this trait were low. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this trait. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 17.89 and 17.92 respectively. Heritability (99.62%) estimates for this trait was high, genotypic advance (5.8) and genotypic advance in percent of mean (47.14) were found moderately high, indicated that the trait is governed by additive gene effects. Narayan *et al.* (1996) also found similar result in bottle gourd. Tyagi (1972) found that the range of genetic variance for the no. of branches per vine varied from 6.2 to 10.1 in bottle gourd. Varghese (1991) noticed high heritability (90.1%) in snake gourd.

4.1.4 Leaf length (cm)

Mean sum of square for leaf length was 29.721 which was highly significant due to genotypes in bottle gourd (Table 3) indicating existence of considerable difference for this trait. The maximum leaf length was found 25.03 in BD-4583 and the minimum was recorded 12.97 in BD-8949 with mean value 18.70 (Appendix IV). The phenotypic variance (14.18) appeared to be higher than the genotypic variance (14.14) suggested considerable influence of environment on the expression of the genes controlling this trait. The genotypic co-efficient of variation (22.63) and phenotypic co-efficient of variation (22.67) were close to each other. Heritability (99.69%) estimates for this trait was very high, genotypic advance (9.91) and genotypic advance in percent of mean (59.65) were found moderately high. Indicating this trait was governed by the additive gene. Gaffar (2008) found high heritability and moderate genetic advance for this trait in sponge gourd. Photograph showing variation of leaf length among different genotypes of bottle gourd in Plate 1a and 1b.

4.1.5 Leaf breadth (cm)

Significant mean sum of square for leaf breadth (42.60) indicated considerable difference among the genotype studied (Table 3). The maximum leaf breadth was found 29.7 in BD-4560 and the minimum was recorded 15.40 in BD-4602 with mean value 23.01 (Appendix IV). The genotypic variance and phenotypic variance were 1.28 and 1.29 respectively. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this character. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 22.87 and 23.04 respectively. Heritability (98.58%) estimates for this trait was high, genotypic advance (2.96) was low and genotypic advance in percent of mean (59.96) was found moderately high, indicated that this character was governed by non-additive gene. Gaffar (2008) found the similar GCV (20.95%) and PCV (23.31%) in sponge gourd. Photograph showing variation of leaf breadth among different genotypes of bottle gourd in Plate 1a and 1b.

4.1.6 Leaf petiole length (cm)

Genotype mean square for leaf petiole length was found significant (33.58) as shown in Table 3. The maximum leaf petiole length was found 20.00 in BD-8987 and the minimum was recorded 8.00 in BD-4559 with mean value 12.00 (Appendix IV). The genotypic variance and phenotypic variance were 68.03 and 71.16 respectively. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling leaf petiole length. The genotypic co-efficient of variation (11.18) and phenotypic co-efficient of variation (11.43) were close to each other. Heritability (95.60%) estimates for this trait was high, genotypic advance (21.29) and genotypic advance in percent of mean (28.85) was found moderately high, indicated that the character was controlled by additive gene. Gaffar (2008) found the similar result in sponge gourd for this trait.

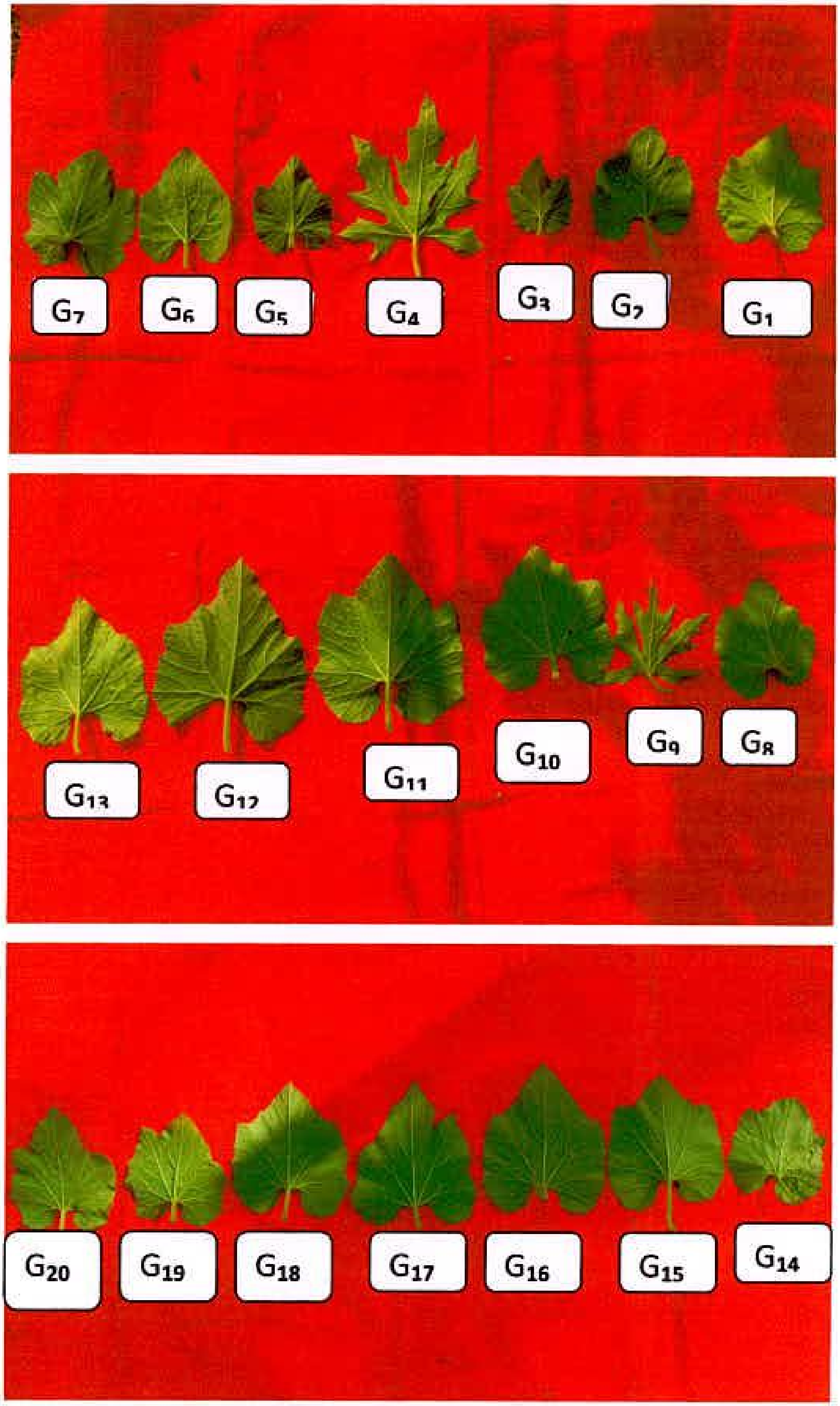


Plate 1a. Showing variation in leaf among different Bottle gourd genotypes (G_1-G_{20})

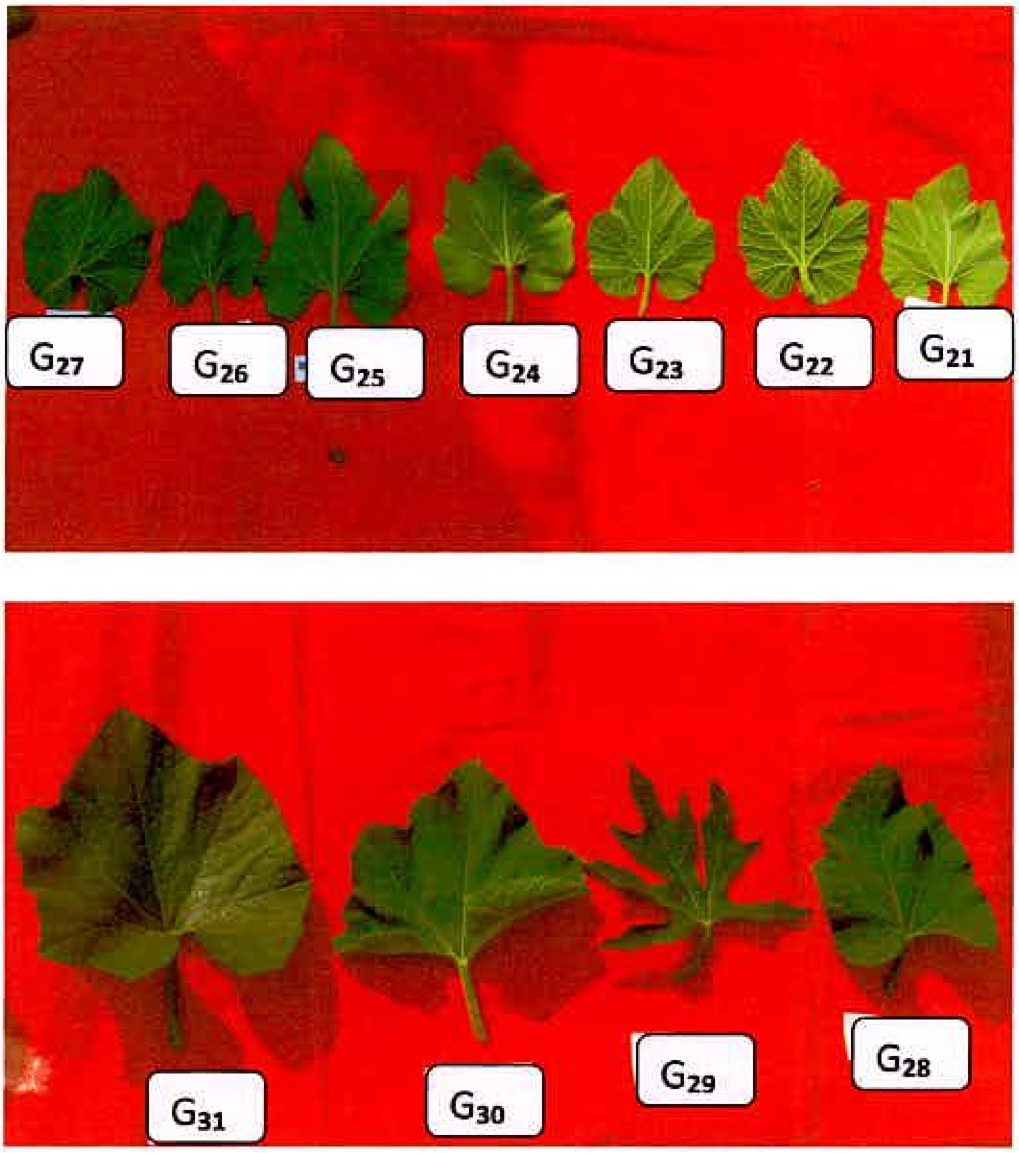


Plate 1b. Showing variation in leaf among different Bottle gourd genotypes (G_{21}-G_{31})

4.1.7 Internodes distance (cm)

Mean sum of square for internodes distance was significant (15.73) due to genotypes in bottle gourd (Table 3) indicating existence of considerable difference for this trait. The maximum internodes distance was found 22.17 in BD-8966 and the minimum was recorded 13.30 in BD-4559 with mean value 17.92 (Appendix IV). The differences in magnitudes in between genotypic (159.04) and phenotypic (165.94) variances was relatively high for the internodes distance indicating large environmental influence on these characters. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 14.97 and 15.29 respectively. Heritability (95.84%) estimates for this trait was high, genotypic advance (32.59) and genotypic advance in percent of mean (38.69) were found moderately high, revealed that character was controlled by additive gene. Gaffar (2008) found the similar heritability (94%) and genetic advance for this trait in sponge gourd. Photograph showing variation of twig among different genotypes of bottle gourd in Plate 2a and 2b.

4.1.8 Male flower pedicel length (cm)

Significant mean sum of square for male flower pedicel length was significant due to genotypes in bottle gourd (Table 3) indicating existence of considerable difference for this trait. The maximum male flowers pedicel length was found 21.00 in BD-4581 and the minimum was recorded 3.50 in BD-4601 with mean value 9.71 (Appendix IV). The genotypic variance was 5.24 and phenotypic variance was 5.26. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this character. The difference between genotypic co-efficient of variation (12.77) and phenotypic co-efficient of variation (12.79) was minimum. Heritability (99.55%) estimates for this trait was very high, genotypic advance (6.03) and genotypic advance in percent of mean (33.63) was found moderately high. Indicating, this character was governed by additive gene effects. Photograph showing variation of male and female flower among some genotypes of bottle gourd in Plate 3.

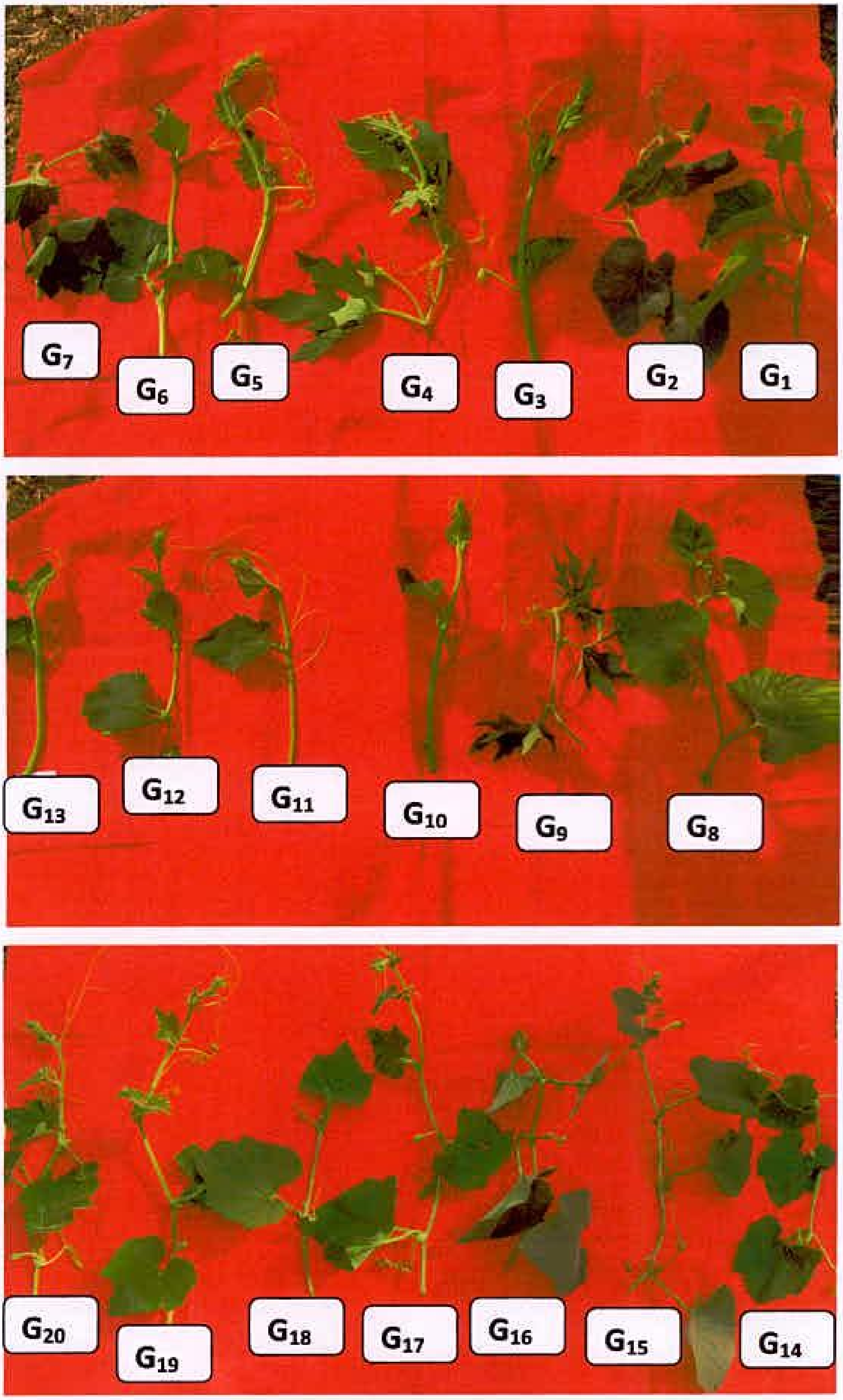


Plate 2a. Showing variation in twig among different Bottle gourd genotypes (G_1-G_{20})

Plate 2b. Showing variation in twig among different Bottle gourd genotypes (G_{21}- G_{31})

Plate 3. Showing phenotypic variation in male and female flower among different genotypes of bottle gourd

4.1.9 Female flower pedicel length (cm)

Mean sum of square for female flower pedicel length was significant (9.75) due to genotypes in bottle gourd (Table 3) indicating the existence of considerable difference for this trait. The maximum female flowers pedicel length was found 9.10 in BD-4596 and the minimum was recorded 3.13 in BD-8950 with mean value 5.66 (Appendix IV). The genotypic variance and phenotypic variance for this trait were 17.23 and 17.26 respectively with minimum differences between them. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this character. The difference between phenotypic co-efficient of variation (42.76) and genotypic co-efficient of variation (42.72) was minimum in case of female flowers pedicel length. Heritability (99.80%) estimates for this trait was very high, genotypic advance (10.95) was moderately high and genotypic advance in percent of mean (112.67) was found very high, indicated that this character was controlled by additive gene effects.

4.1.10 No. of male flower

Significant mean sum of square for no. of male flower indicated considerable difference among the genotypes studied (Table 3). The maximum no. of male flower was found 98.67 in BD-4580 and the minimum was recorded 13.00 in BD-4596 with mean value 37.65 (Appendix IV). The genotypic variance (3.24) and phenotypic variances (3.26) were close to each other. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this character. The genotypic co-efficient of variation was 31.86 and phenotypic co-efficient of variation was 31.95. Heritability (99.40%) estimates for this trait was very high, genotypic advance (4.47) was moderately high and genotypic advance in percent of mean (83.86) was found high, indicated that the trait was governed by additive gene. Singh et al. (2002) also estimated high GCV and PCV for male flowers per plant in ridge gourd.

4.1.11 No. of female flower

Mean sum of square for no. of female flower was significant (121.93) due to genotypes in bottle gourd (Table 3) indicating existence of considerable difference for this trait. The maximum no. of female flower was found 34.00 in BD-8966 and the minimum was recorded 9.00 in BD-4596 with mean value 19.52 (Appendix IV). The differences in magnitudes in between genotypic (13.41) and phenotypic (15.74) variances was relatively high for this trait indicating large environmental influence on these characters. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 35.14 and 38.08 respectively. Heritability (85.15%) estimates for this trait was high, genotypic advance (8.92) was moderately high and genotypic advance in percent of mean (85.60) was found high, revealed that the trait was controlled by additive gene.

4.1.12 Ratio of male and female flower

Significant mean sum of square for ratio of male and female flower (1.07) indicated considerable difference among the genotypes studied (Table 3). The maximum ratio of male and female flower were found 3.55 in BD-4579 and the minimum was recorded 1.29 in BD-8966 with mean value 1.94 (Appendix IV). The genotypic variance and phenotypic variance for this trait were comparatively low (0.21 and 0.23). The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this trait. The phenotypic co-efficient of variation (24.13) was higher than the genotypic co-efficient of variation (22.82), which suggested that environment has a significant role on the expression of this trait. Heritability (89.39%) estimates for this trait was high together with considerable low genetic advance (1.14) and moderately high genetic advance in percent of mean (56.95) indicated that the character was governed by non-additive gene. Gaffar (2008) found significant difference in sponge gourd. Singh et al. (2002) also estimated high GCV and PCV for male flowers per plant in ridge gourd.

4.1.13 Number of fruit per plant

Genotype mean sum of square for number of fruit per plant was found significant (42.56) as shown in **Table 3**. The maximum number of fruit per plant was found 20.00 in BD-4560 and the minimum was recorded 5.00 in BD-4598 with mean value 10.42 (Appendix IV). The genotypic variance (0.32) and phenotypic variance (0.42) for this trait were very low. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this character. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 29.16 and 33.54 respectively which indicated presence of considerable variability among the genotypes. Heritability (75.60%) estimates for this trait was high, genetic advance (1.3) was found low and genetic advance in percent of mean (66.93) was found moderately high, indicated that the character was controlled by additive gene. Rahman *et al.* (1986) found low value of genotypic and phenotypic variance and high GCV (30.47) and PCV (38.61) for this trait in bottle gourd. Sharma and Dhankhar (1990) reported similar heritability (64.23%) and genetic advance in percent of mean (29.30) in bottle gourd for this trait.

4.1.14 Fruit weight (kg)

Mean sum of square for fruit weight was significant (0.65) in bottle gourd (Table 3) indicating existence of considerable difference for this trait. The maximum weight per fruit was found 3.50 in BD-8948 and the minimum was recorded 1.2 in BD-4603 with mean value 1.99 (Appendix IV). The differences in magnitudes in between genotypic (18.93) and phenotypic (21.52) variances was relatively high for this trait indicating large environmental influence on these characters. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 38.41 and 41.17 respectively for fruit weight which indicating that significant variation exists among different genotypes. Heritability (87.97%) estimates for this trait was high together with considerable high genetic advance (10.77) and genetic advance in percent of mean (95.61) indicated that selection for this character would be effective. Saha *et al.* (1992) found similar GCV (39.55) and PCV (41.00) for the fruit weight in pumpkin. This result is in consonance with the findings of Chowdhury and Sharma (2002) in ridge gourd and Rumaran *et al.* (1997) pumpkin. Rahman *et al.* (1986) also found the similar result in bottle gourd.

4.1.15 Fruit length (inch)

Significant mean sum of square for fruit length (14.56) indicated considerable difference among the genotypes studied (Table 3). The maximum fruit length was found 16.03 in BD-8948 and the minimum was recorded 7.03 in BD-4580 with mean value 12.29 (Appendix IV). The genotypic variance and phenotypic variance were 9.50 and 10.71 respectively. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this character. The genotypic co-efficient of variation (16.49) and phenotypic co-efficient of variation (17.50) were close to each other. Heritability (88.71%) estimates for this trait high, genotypic advance (7.67) and genotypic advance in percent of mean (40.99) were found moderately high, indicated that the trait was governed by additive gene and selection for this character would be effective. Rahman *et al.* (1986) indicated minimum difference between GCV and PCV in bottle gourd for fruit length. Mathew and Khader (1999) also reported high heritability for fruit length in snake gourd. Photograph showing variation of fruit length among some genotypes of bottle gourd in Plate 4a and 4b.

4.1.16 Fruit breadth (inch)

Mean sum of square fruit breadth was significant (42.47) due to genotypes in bottle gourd (Table 3) indicating existence of considerable variation for this trait. The maximum fruit breadth was found 13.00 in BD-4560 and the minimum was recorded 5.01 in BD-8965 with mean value 4.10 (Appendix IV). The genotypic variance and phenotypic variance were 13.29 and 16.02

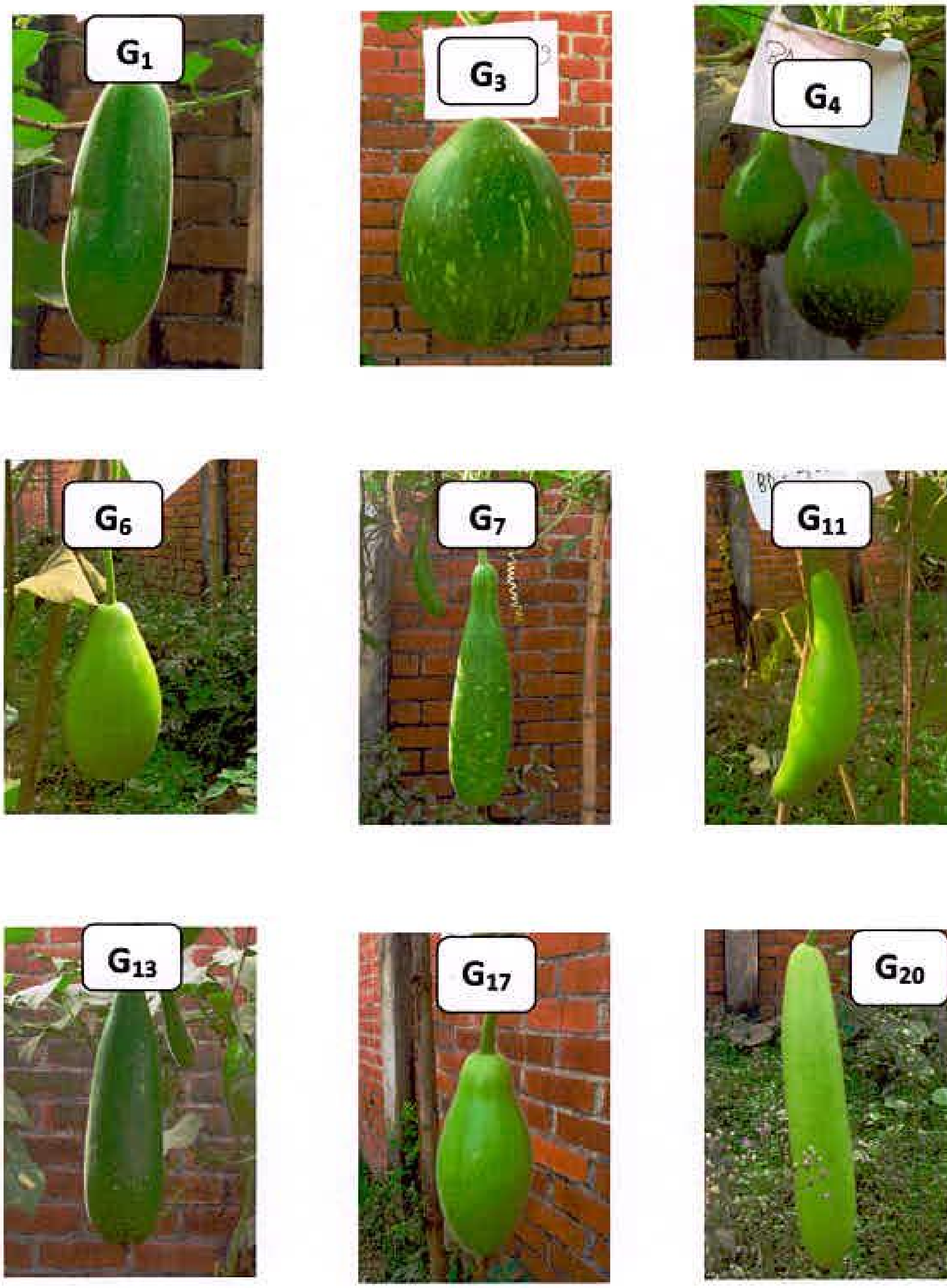


Plate 4a. Showing phenotypic variation in fruits among different genotypes of bottle gourd

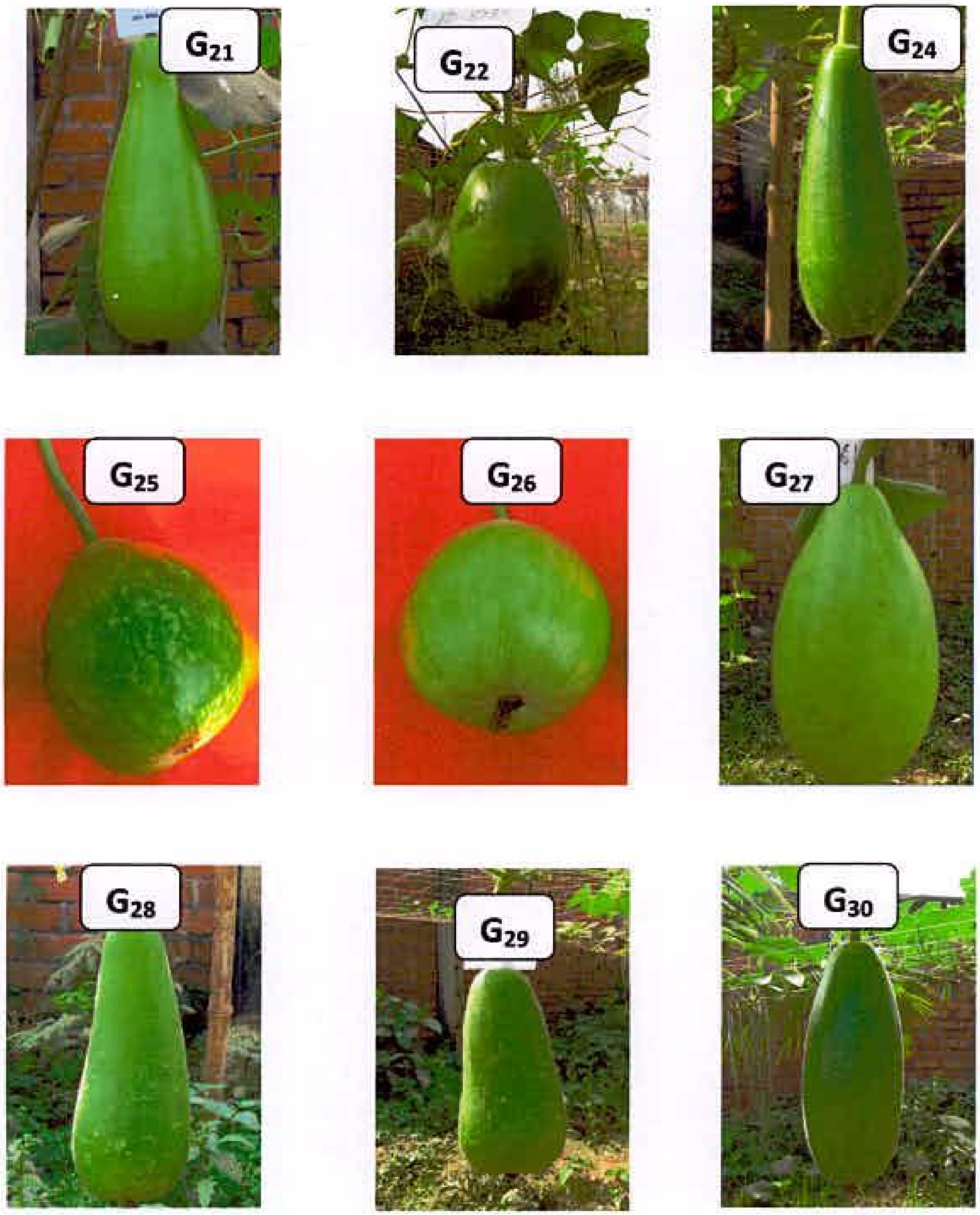


Plate 4b. Showing phenotypic variation in fruits among different genotypes of bottle gourd

respectively. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 15.84 and 17.39 respectively. Heritability (82.93%) estimates for this trait was high along with moderately high genetic advance (8.76) and genetic advance in percent of mean (38.08) indicated that this character was controlled by additive gene effects. Rahman *et al.* (1986) indicated minimum difference between GCV and PCV in bottle gourd for fruit breadth. This result is in consonance with the finding of Saha *et al.* (1992) in pumpkin.

4.1.17 Fruit Peduncle length (inch)

Mean sum of square for fruit peduncle length was significant (3.85) due to genotypes in bottle gourd (Table 3) indicating existence of considerable difference for this trait. The maximum fruit peduncle length was found 7.12 in BD-4584 and the minimum was recorded 3.10 in BD-4603 with mean value 4.94 (Appendix IV). The genotypic variance (10.83) and phenotypic variances (11.92) were close to each other. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this character. The genotypic co-efficient of variation was 27.42 and phenotypic co-efficient of variation was 28.77. Heritability (90.82%) estimates for this trait was high, genotypic advance (8.28) and genotypic advance in percent of mean (68.98) were found moderately high, indicated that this trait was controlled by additive gene. Gaffar (2008) reported almost similar estimates of GCV and PCV (28.47% and 28.52%) and heritability was high (1.00%) with moderate genetic advance (6.59) for peduncle length in sponge gourd.

4.1.18 Yield per plant (kg)

Significant mean sum of square for yield per plant (388.28) indicated considerable difference among the genotypes studied (Table 3). The maximum yield per plant was found 54.13 kg in BD-4560 and the minimum was recorded 7.07 kg in BD-4603 with mean value 21.54 kg (Appendix IV). The differences in magnitudes in between genotypic (125.55) and phenotypic (137.06) variances was relatively high for this trait indicating large environmental influence on these characters. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 52.02 and 54.35 respectively for yield per plant which indicating that significant variation exists among different genotypes. The heritability value (91.60%) as well as genetic advance (28.31) and genetic advance in percent of mean (131.43) were observed very high. The very high heritability with moderate genetic advance provided opportunity for selecting high valued genotypes for breeding programme. This finding also supported Abusaleha and Dutta (1990) findings in cucumber. Narayan *et al.* (1996) also found similar result in bottle gourd.

4.2 CORRELATION CO-EFFICIENT

Yield is a complex product being influenced by several interdependent quantitative characters. Selection for yield may not be effective unless the directly or indirectly influences of other yield components are taken into consideration. When selection pressure is exercised for improvement of any character highly associated with yield, it simultaneously affects a number of other correlated traits. Hence knowledge regarding association of character with yield and among themselves provides guideline to the plant breeder for making improvement through selection provide a clear understanding about the contribution in respect of establishing the association by genetic and non genetic factors. Higher genotypic correlations than phenotypic one might be due to modifying or masking effect of environment in the expression of the character under study (Nandpuri *et al.* 1973). Results of genotypic and phenotypic correlation co-efficient of eighteen yield and its contributing traits of bottle gourd were estimated separately as vegetative character and reproductive character with yield and shown in Table 4 and Table 5 which discussed character wise as follows:

4.2.1 Days to first male flowering

Significant positive relationships were found in both male and female flower for days to first flowering at both genotypic and phenotypic levels (Table 4).

Table 4. Genotypic and phenotypic correlation of nine vegetative characters with yield of thirty one bottle gourd genotypes

Character		Days to first male flowering	Days to first female flowering	Internodes distance (cm)	Male flower pedicel length(cm)	Female flower pedicel length (cm)	Number of branch per vine	Leaf length (cm)	Leaf breadth (cm)	Leaf petiole length (cm)
Days to first female flowering	G	0.713**	-							
	P	0.694**	-							
Internodes distance (cm)	G	-0.192	-0.19	-						
	P	-0.190	-0.187	-						
Male flower pedicel length(cm)	G	-0.088	-0.130	-0.051	-					
	P	-0.084	-0.127	-0.051	-					
Female flower pedicel length (cm)	G	-0.297	-0.286	0.483**	0.134	-				
	P	-0.266	-0.246	0.415**	0.117	-				
Number of branches per vine	G	-0.067	-0.128	-0.275	-0.140	-0.141	-			
	P	-0.078	-0.136	-0.255	-0.134	-0.830**	-			
Leaf length (cm)	G	0.394*	-0.555**	0.248	-0.088	0.166	0.247	-		
	P	-0.371*	-0.519**	0.236	-0.085	0.146	0.226	-		
Leaf breadth (cm)	G	-0.422**	-0.465**	0.269	-0.085	0.280	0.302*	0.892**	-	
	P	-0.387*	-0.438**	0.246	-0.078	0.257	0.270	0.762**	-	
Leaf petiole length (cm)	G	-0.304*	-0.340*	0.236	-0.254	0.065	0.121	0.649**	0.552**	-
	P	-0.281	-0.316*	0.223	-0.242	0.106	0.123	0.578**	0.476**	-
Yield per plant (kg)	G	-0.044	0.065	-0.329*	-0.163	-0.094	0.471**	0.005	0.167	0.047
	P	-0.056	0.057	-0.313*	-0.156	-0.079	0.440**	0.027	0.149	0.040

* indicates significant at 5% level of significance, ** indicates significant at 1% level of significance, G = Genotypic correlation, P = Phenotypic correlation

Highly significant positive association between days to first male and female flowering indicates that the traits are governed by same gene and simultaneous improvement would be effective. But this character showed significant but negative correlation at both genotypic and phenotypic level between this trait and leaf breadth. But this character showed insignificant and negative correlation at both genotypic and phenotypic level between other vegetative traits like internodes distance, male flower pedicel length, female flower pedicel length, number of branches per vine and yield. Results indicated that the increasing the correlation of days to first male flowering with other vegetative traits decreasing the yield in bottle gourd. Khan *et al.* (2008) reported almost similar result in 64 genotypes of pointed gourd. Insignificant association of these traits indicated that the association between these traits is largely influenced by environmental factors. Ananthan and Pappoah (1997) also reported that days of first male flowering was negatively correlated with yield in cucumber. This result is in consonance with the finding of Badade *et al*. (2001) in bottle gourd and Abusaleha and Dutta (1989) in cucumber.

4.2.2 Days to first female flowering

Similar trends of correlation of days to first female flowering between other characters also observed. Here the character showed highly significant and negative correlation at both genotypic and phenotypic level (Table 4) between leaf length, leaf breadth and leaf petiole length. This indicated that if day to first female flowering is increased, then leaf length, leaf breadth and leaf petiole length decreased. The character showed insignificant and negative correlation at both genotypic and phenotypic level between other vegetative traits like internodes distance, male flower pedicel length, female flower pedicel length and number of branches per vine. Insignificant association of these traits indicated that the association between these traits is largely influenced by environmental factors. But only positive correlation of days to first female flowering with yield was observed. Singh *et al.* (1986) also found positive correlation for this trait in pointed gourd.

4.2.3 Internodes distance (cm)

The character showed highly significant and positive relationship with female flower pedicel length at both genotypic and phenotypic levels (Table 4) indicated that if internodes distance is increased, then female flower pedicel length also increased. Negative and significant correlation between yield and internodes distance showed that selection of genotypes with lower internodes distance are expected to yield better. The character showed insignificant and positive relationship with leaf length, leaf breadth and leaf petiole length at both genotypic and phenotypic level. On the other hand this character possessed insignificant and negative correlation with male flower pedicel length and number of branches per vine at both genotypic and phenotypic level.

4.2.4 Male flower pedicel length (cm)

Male flower pedicel length showed positive correlation with only female flower pedicel length at both genotypic and phenotypic level (Table 4). But this character produced insignificant and negative correlation at both genotypic and phenotypic level with number of branches per vine, leaf length, leaf breadth, leaf petiole length and yield indicated that the association among these traits is largely influenced by environmental factors. Reddy and Rao (1984) found similar finding in ribbed gourd.

4.2.5 Female flower pedicel length (cm)

Female flower pedicel length showed insignificant and positive correlation with leaf length, leaf breadth, leaf petiole length at both genotypic and phenotypic level (Table 4). But this character produced insignificant and negative correlation at genotypic level with number of branches per vine and both genotypic level and phenotypic level with yield indicated that the association among these traits is largely influenced by environmental factors. This character produced highly significant and negative correlation at phenotypic level with number of branches per vine. Reddy and Rao (1984) found similar finding in ribbed gourd.

4.2.6 Number of branches per vine

Yield positively and significantly correlated with number of branches per vine indicating that any increase in the number of branches per vine should bring about an enhancement in the yield. The character showed insignificant and positive correlation with leaf length, leaf breadth and leaf petiole length at both genotypic and phenotypic level (Table 4). Badade *et al.* (2001) and Kumar *et al.* (2007) also reported that yield was significantly and positively correlated with number of branches per vine in bottle gourd.

4.2.7 Leaf length (cm)

Leaf length showed significant and positive correlation with leaf breadth and leaf petiole length at both genotypic and phenotypic level (Table 4) revealed that if the leaf length is increased, then leaf breadth and leaf petiole length also increased. But this character produced insignificant and positive correlation at both genotypic and phenotypic level with yield. Li *et al.* (1997) also found similar result in cucumber for this trait.

4.2.8 Leaf breadth (cm)

Leaf breadth also showed significant and positive correlation with leaf petiole length at both genotypic and phenotypic level (table 4) indicated that if the leaf breadth is increased, then leaf petiole length also increased. On the other hand this character produced insignificant but positive correlation with yield at both genotypic and phenotypic level indicated that the association among these traits is largely influenced by environmental factors. Li *et al.* (1997) also found similar result in cucumber for this trait.

4.2.9 Leaf petiole Length (cm)

The character showed positive but insignificant correlation with yield at both genotypic and phenotypic level (Table 4).

4.2.10 Number of male flower

The character number of male flower showed significant and positive correlation with number of female flower at both genotypic and phenotypic level (Table 5) which revealed that if the number of male flower is increased and then number of female flower is also increased. But this character produced significant and negative correlation with ratio of male & female flower and fruit length at both genotypic and phenotypic level indicated that if the number of male flower are increased, then ratio of male and female flower and fruit length are decreased. Insignificant but positive correlation was observed with number of fruit per plant, fruit weight, fruit breadth and yield per plant at both genotypic and phenotypic level. This finding also supported Chadhury and Mandal (1987) findings in cucumber.

4.2.11 Number of female flowers

Number of female flowers showed insignificant but positive correlation with number of fruit per plant, fruit weight and yield per plant at both genotypic and phenotypic level (Table 5). But insignificant and negative correlation of this character with ratio of male and female flower, fruit length, fruit peduncle length and fruit breadth at both genotypic and phenotypic level indicated that the association among these traits is largely influenced by environmental factors. This result is in consonance with the finding of Shah and Kale (2002) in ridge gourd. This finding also supported Chadhury and Mandal (1987) findings in cucumber.

4.2.12 Ratio of male and female flower

It was found that the ratio of male and female flowers showed insignificant and positive correlation with number of fruit per plant, fruit length, fruit breadth and yield per plant at both genotypic and phenotypic level (Table 5). But insignificant and negative correlation of this character with fruit weight and fruit peduncle length at both genotypic and phenotypic level indicated that the association among these traits is largely influenced by environmental

Table 5. Genotypic and phenotypic correlation of eight yield contributing characters on yield of thirty one bottle gourd genotypes

Character		No. of male flowers	No of female flowers	Ratio of male & female flowers	No. of fruit /plant	Fruit weight (kg)	Fruit length (inch)	Fruit breadth (inch)	Fruit peduncle length (inch)
No. of female flowers	G	0.741**	-						
	P	0.693**	-						
Ratio of male & female flowers	G	-0.335*	-0.211	-					
	P	-0.326*	-0.299	-					
No. of fruit /plant	G	0.092	0.052	0.194	-				
	P	0.086	0.071	0.178	-				
Fruit weight (kg)	G	0.102	0.108	-0.067	0.474**	-			
	P	0.085	0.099	-0.064	0.388*	-			
Fruit length (inch)	G	-0.439**	-0.205	0.202	0.052	0.080	-		
	P	-0.427**	-0.192	0.202	0.044	0.077	-		
Fruit breadth (inch)	G	0.073	-0.126	0.069	0.290	0.375*	-0.385*	-	
	P	0.074	-0.120	0.069	0.267	0.357*	-0.384*	-	
Fruit peduncle length (inch)	G	-0.117	-0.013	-0.100	0.137	0.063	0.330*	-0.200	-
	P	-0.110	-0.004	-0.012	0.116	0.066	0.325*	-0.199	-
Yield per plant (kg)	G	0.056	0.192	0.167	0.900**	0.781**	0.136	0.374*	0.064
	P	0.051	0.172	0.160	0.887**	0.737**	0.127	0.359*	0.059

* indicates significant at 5% level of significance, ** indicates significant at 1% level of significance, G = Genotypic correlation, P = Phenotypic correlation

factors. This finding also supported Ananthan and Pappoah (1997) findings in cucumber.

4.2.13 Number of fruit per plant

Yield highly significant and positively correlated with number of fruit per plant at both genotypic and phenotypic level (Table 5) indicating that any increase in number of fruit per plant should bring an enhanced in the yield. Number of fruit per plant showed highly significant and positive correlation with fruit weight at both genotypic and phenotypic level revealed that if the trait is increased, then fruit weight also increased. The character number of fruit per plant showed insignificant and positive correlation with fruit length, fruit peduncle length, fruit breadth. Kumar *et al.* (2007), Badade *et al.* (2001) also reported that yield was significantly and positively correlated with number of fruit per plant in bottle gourd. The finding also supported Narayan *et al.* (1996) finding in bottle gourd for this trait.

4.2.14 Fruit weight (kg)

The trait, fruit weight showed highly significant and positive correlation with yield and fruit breadth at both genotypic and phenotypic level (Table 5) indicated that if the fruit weight is increased, then the fruit breadth and yield are also increased. The character also showed positive but insignificant correlation with fruit length and fruit peduncle length at both genotypic and phenotypic level. Rumaran *et al.* (1997) also reported in respect to average fruit weight in ridge gourd and pumpkin respectively. Narayan *et al.* (1996) also found similar result in bottle gourd for this trait.

4.2.15 Fruit length (inch)

Positive and significant correlation of fruit length was found with fruit peduncle length and yield per plant at both genotypic and phenotypic level (Table 5) indicated that if the fruit length is increased, then fruit peduncle length also increased. But significant and negative correlation of this character with fruit breadth was observed at both genotypic and phenotypic level indicated that if the fruit length is increased, then fruit breadth is decreased. The finding also supported Badade *et al.* (2001) findings for fruit length in bottle gourd. Kumar *et al.* (2007) also found significant correlation for this trait in bottle gourd.

4.2.16 Fruit breadth (inch)

Yield positively and significantly correlated with fruit breadth at both genotypic and phenotypic level (Table 5) revealed that any increased in the trait should bring about an enhancement in the yield. But insignificant and negative correlation of this character with fruit peduncle length at both genotypic and phenotypic level indicated that the association among these traits is largely influenced by environmental factors. The finding also supported Rahman *et al.* (1986) finding for this trait in bottle gourd. Miah *et al.* (2000) also found similar result for this trait in bitter gourd.

4.2.17 Fruit Peduncle length (inch)

Fruit Peduncle length showed positive correlation with yield per plant at both genotypic and phenotypic level (Table 5).

4.3 PATH CO-EFFICIENT ANALYSIS

Partitioning of genotypic correlation of different genotype, yield and its contributing traits in bottle gourd are shown in Table 6 and Table 7 and discussed character wise as follows:

4.3.1 Days to first male flowering

Days to first male flowering showed the negative direct effect (-0.084) on yield (Table 6). The character also showed the maximum positive indirect effect through leaf length (0.278) followed by internodes distance (0.057), days to female first flowering (0.055) and male flower pedicel length (0.009). The negative indirect effect of this character on yield via leaf breadth (-0.292) was the highest followed by leaf petiole length (-0.038), number of branches per vine (-0.022) and female flower pedicel length (-0.006) which finally

Table 6. Path analysis of nine vegetative characters on yield of thirty one bottle gourd genotypes

Character	Days to first male flowering	Days to first female flowering	Internodes distance (cm)	Male flower pedicel length (cm)	Female flower pedicel length (cm)	Number of branches per vine	Leaf length (cm)	Leaf breadth (cm)	Leaf petiole length (cm)	Genetic correlation with yield
Days to first male flowering	**-0.084**	0.055	0.057	0.009	-0.006	-0.022	0.278	-0.292	-0.038	-0.044
Days to first female flowering	-0.060	**0.077**	0.056	0.013	-0.006	-0.042	0.392	-0.322	-0.043	0.065
Internodes distance (cm)	0.016	-0.015	**-0.296**	0.005	0.010	-0.091	-0.175	0.187	0.030	-0.329*
Male flower pedicel length(cm)	0.007	-0.010	0.015	**-0.103**	0.003	-0.046	0.062	-0.059	-0.032	-0.163
Female flower pedicel length (cm)	0.025	-0.022	-0.143	-0.014	**0.021**	-0.047	-0.117	0.194	0.008	-0.094
Number of branches per vine	0.006	-0.010	0.081	0.014	-0.003	**0.332**	-0.174	0.209	0.015	0.471**
Leaf length (cm)	0.033	-0.043	-0.073	0.009	0.004	0.082	**-0.706**	0.618	0.082	0.005
Leaf breadth (cm)	0.035	-0.036	-0.080	0.009	0.006	0.100	-0.630	**0.693**	0.069	0.167
Leaf petiole length (cm)	0.026	-0.026	-0.070	0.026	0.001	0.040	-0.458	0.382	**0.126**	0.047
									Residual effect	0.777

* indicates significant at 5% level of significance, ** indicates significant at 1% level of significance, Residual effect, R = 0.777

made insignificant negative correlation between days to first male flowering and yield per plant (-0.044). Miah *et al.* (2000) also found similar result for this trait in bitter gourd.

4.3.2 Days to first female flowering

Days to first female flowering showed a positive direct effect (0.077) on yield (Table 6). This character, also showed the highest positive indirect effect through leaf length (0.392) followed by internodes distance (0.056) and male flower pedicel length (0.013) on yield. The character also produced negative indirect effect on yield via leaf breadth (-0.322), days to first male flowering (-0.060), leaf petiole length (-0.043), number of branches per vine (-0.042), and female flower pedicel length (-0.006). The cumulative effects of these characters produced a positive genotypic correlation on yield (0.065). The finding also supported Parhi *et al.* (1995) findings in bitter gourd for this trait. Miah *et al.* (2000) also found similar result for this trait in bitter gourd.

4.3.3 Internodes distance (cm)

It was found that internodes distance showed the negative direct effect (-0.296) on yield (Table 6). The character also showed the maximum positive indirect effect through leaf breadth (0.187) followed by leaf petiole length (0.030), days to first male flowering (0.016) female flower pedicel length (0.010) and male flower pedicel length (0.005). The negative indirect effect of this character on yield via leaf length (-0.175) was the highest followed by number of branches per vine (-0.091) and days to first female flowering (-0.015) which finally made significant negative correlation between internodes distance and yield per plant (-0.329). Figure 1 showing Path diagram of yield and its contributing traits in thirty one genotypes of Bottle gourd.

4.3.4 Male flower pedicel length (cm)

Male flowering pedicel length showed a negative direct effect (-0.103) on yield (Table 6). This character also showed the highest positive indirect effect through leaf length (0.062) followed by internodes distance (0.015) and days

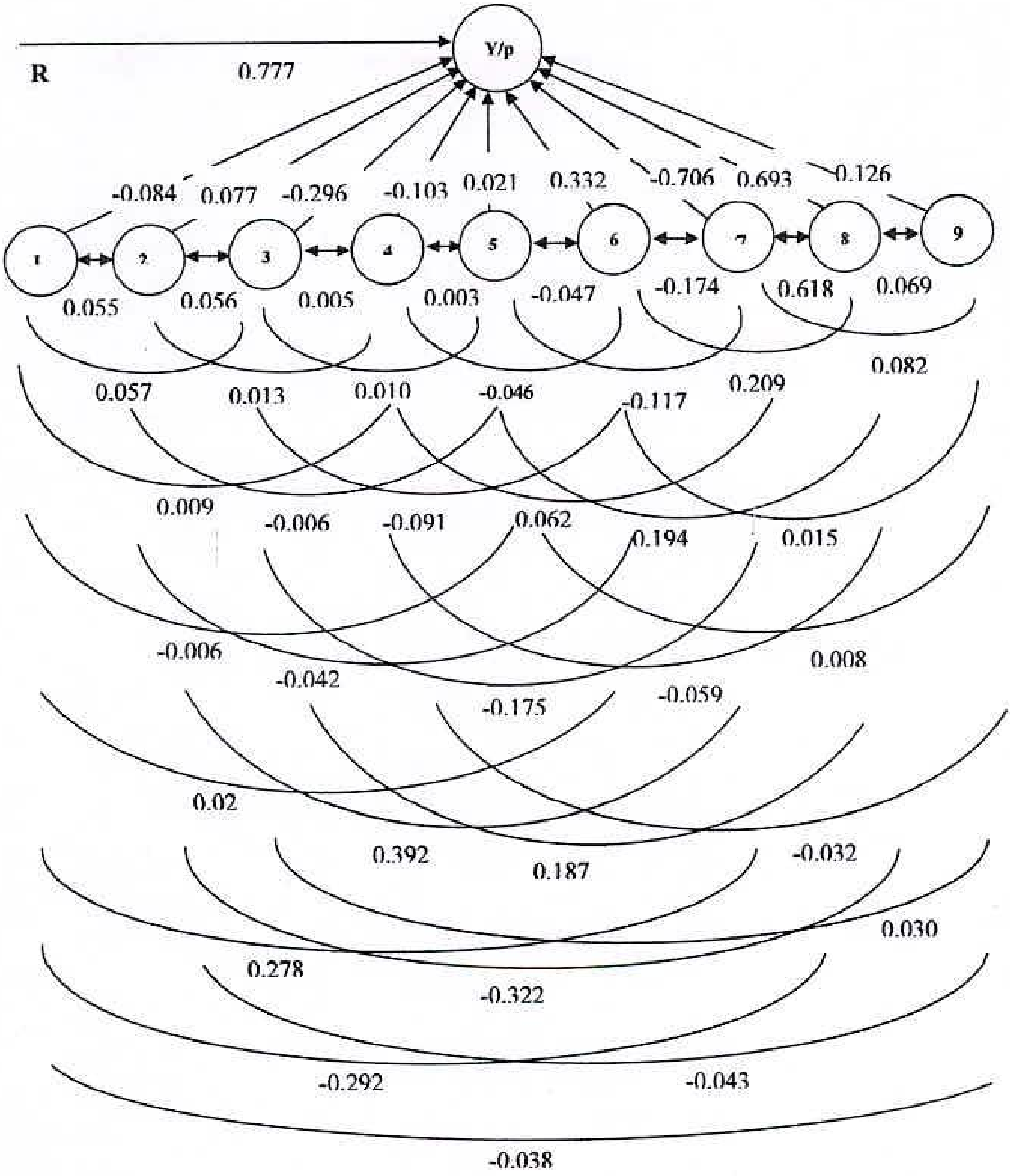


Fig. 1. Path diagram of nine yield and yield contributing characters of thirty one bottle gourd genotypes

1= Days to first male flowering, 2 = Days to first female flowering, 3 = Internodes distance, 4 = Male flow pedicel length, 5 = Female flower pedicel length, 6 = No. of branches / vine, 7 = Leaf length, 8 = Leaf breadth, 9 Leaf petiole length, Y/P = Yield per plant, R = Residual effect to first male flowering (0.007). The character also produced the negative indirect effect on yield via leaf breadth (-0.059), number of branches per vine (-0.046), leaf petiole length (-0.032) and days to first female flowering (-0.010). The cumulative effects of these characters produced a negative genotypic correlation on yield (-0.163).

4.3.5 Female flower pedicel length (cm)

Male flowering pedicel length showed a positive direct effect (0.021) on yield (Table 6). This character also showed the highest positive indirect effect through leaf breadth (0.194) followed by days to first male flowering (0.025) and leaf petiole length (0.008). The character also produced the negative indirect effect on yield via internodes distance (-0.143), leaf length (-0.117), number of branches per vine (-0.047) and days to first female flowering (-0.022). The cumulative effects of these characters produced a negative genotypic correlation on yield (-0.094). This discrepancy with present finding might be due to environmental variation.

4.3.6 Number of branches per vine

Number of branches per vine showed the positive direct effect (0.332) on yield (Table 6). This character also showed high positive and significant genotypic correlation with yield per plant (0.471) due to moderately high indirect effect through leaf breadth (0.209) followed by followed by internodes distance (0.081), leaf petiole length (0.015), male flower pedicel length (0.014) and days to first male flowering (0.006). Significant genotypic correlation coefficients between number of branches per vine and yield further strengthened their reliability in the process of selection for higher yield. But the negative indirect effect through leaf length (-0.174), days to first female flowering (-0.010) and female flower pedicel length (-0.003) was observed on yield. Kumar *et al.* (2007) also found positive direct effect on yield for this trait in bottle gourd.

4.3.7 Leaf length (cm)

Leaf length showed negatively direct effect (-0.706) on yield (Table 6). This character, however, showed positive indirect effect through leaf breadth (0.618), leaf petiole length (0.082), number of branches per vine (0.082), days to first male flowering (0.033), male flower pedicel length (0.009) and female flower pedicel length (0.004). The negative indirect effect via internodes distance (-0.073) followed by days to first female flowering (-0.043) which were contributed to result insignificant positive genotypic correlation with yield per plant (0.005). Li *et al.* (1997) also found similar result in cucumber for this trait.

4.3.8 Leaf breadth (cm)

Leaf breadth showed a positive direct effect (0.693) on yield (Table 6). This character, however, showed also positive indirect effect through number of branches per vine (0.100), leaf petiole length (0.069), days to first male flowering (0.033), male flower pedicel length (0.009) and female flower pedicel length (0.006). The negative indirect effects were also observed via leaf length (-0.630) followed by internodes distance (-0.080) and days to first female flowering (-0.036) which were contributed to result insignificant positive genotypic correlation with yield per plant (0.167). Li *et al.* (1997) also found similar result in cucumber for this trait.

4.3.9 Leaf petiole Length (cm)

Leaf petiole length showed a positive direct effect (0.126) on yield (Table 6). This character showed positive indirect effect through leaf breadth (0.382) followed by number of branches per vine (0.040), days to first male flowering (0.026), male flower pedicel length (0.026) and female flower pedicel length (0.001). But the negative indirect effect through leaf length (-0.458), internodes distance (-0.070) and days to first female flowering (-0.026) which finally made insignificant positive correlation between leaf petiole length and yield per plant (0.047). Li *et al.* (1997) also found similar result in cucumber for this trait.

4.3.10 Number of male flower

Number of male flower showed a negative direct effect (-0.009) on yield (Table 7). This character, however, showed also positive indirect effect through number of fruit per plant (0.063), fruit weight (0.046), fruit peduncle length (0.010) and fruit breadth (0.002). The negative indirect effects were also observed via fruit length (-0.038) followed by ratio of male and female flower (-0.014) and number of female flower (-0.003) which were contributed to result insignificant positive genotypic correlation with yield per plant (0.056). This finding also supported Chadhury and Mandal (1987) findings in cucumber.

4.3.11 Number of female flower

Number of female flower produced a negative direct effect (-0.004) on yield (Table 7). The character, however, showed also some positive indirect effect through number of fruit per plant (0.182), fruit weight (0.046), fruit peduncle length (0.010) and fruit breadth (0.002). The negative indirect effects were also observed via fruit length (-0.038) followed by ratio of male and female flower (-0.014) and number of female flower (-0.003) which were contributed to result insignificant positive genotypic correlation with yield per plant (0.192). This finding also supported Chadhury and Mandal (1987) findings in cucumber. Figure 2 showing Path diagram of yield and its contributing traits in thirty one genotypes of Bottle gourd.

4.3.12 Ratio of male & female flower

Ratio of male & female flower showed a positive direct effect (0.042) on yield (Table 7). This character, however, showed also positive indirect effect through number of fruit per plant (0.132), fruit length (0.018), number of male flower (0.003), number of female flower (0.001), fruit breadth (0.001) and fruit peduncle length (0.001). The negative indirect effects were also observed only via fruit

Table 7. Path analysis of eight yield contributing characters on yield of thirty one bottle gourd genotypes

Character	No. of male flowers	No. of female flowers	Ratio of male & female flowers	No. of fruit per plant	Fruit weight (kg)	Fruit length (inch)	Fruit breadth (inch)	Fruit peduncle length (inch)	Genetic correlation with yield
No. of male flowers	**-0.009**	-0.003	-0.014	0.063	0.046	-0.038	0.002	0.010	0.056
No. of female flowers	-0.007	**-0.004**	-0.009	0.182	0.049	-0.018	-0.003	0.001	0.192
Ratio of male & female flowers	0.003	0.001	**0.042**	0.132	-0.030	0.018	0.001	0.001	0.167
No. of fruit /plant	-0.001	-0.001	0.008	**0.680**	0.215	0.005	0.006	-0.011	0.900**
Fruit weight (kg)	-0.001	0.000	-0.003	0.322	**0.453**	0.007	0.008	-0.005	0.781**
Fruit length (inch)	0.004	0.001	0.008	0.035	0.036	**0.087**	-0.008	-0.027	0.136
Fruit breadth (inch)	-0.001	0.001	0.003	0.197	0.170	-0.033	**0.021**	0.017	0.374*
Fruit Peduncle length (inch)	0.001	0.000	0.000	0.093	0.028	0.029	-0.004	**-0.083**	0.064
								Residual effect	0.117

* indicates significant at 5% level of significance, ** indicates significant at 1% level of significance, Residual effect, R = 0.117

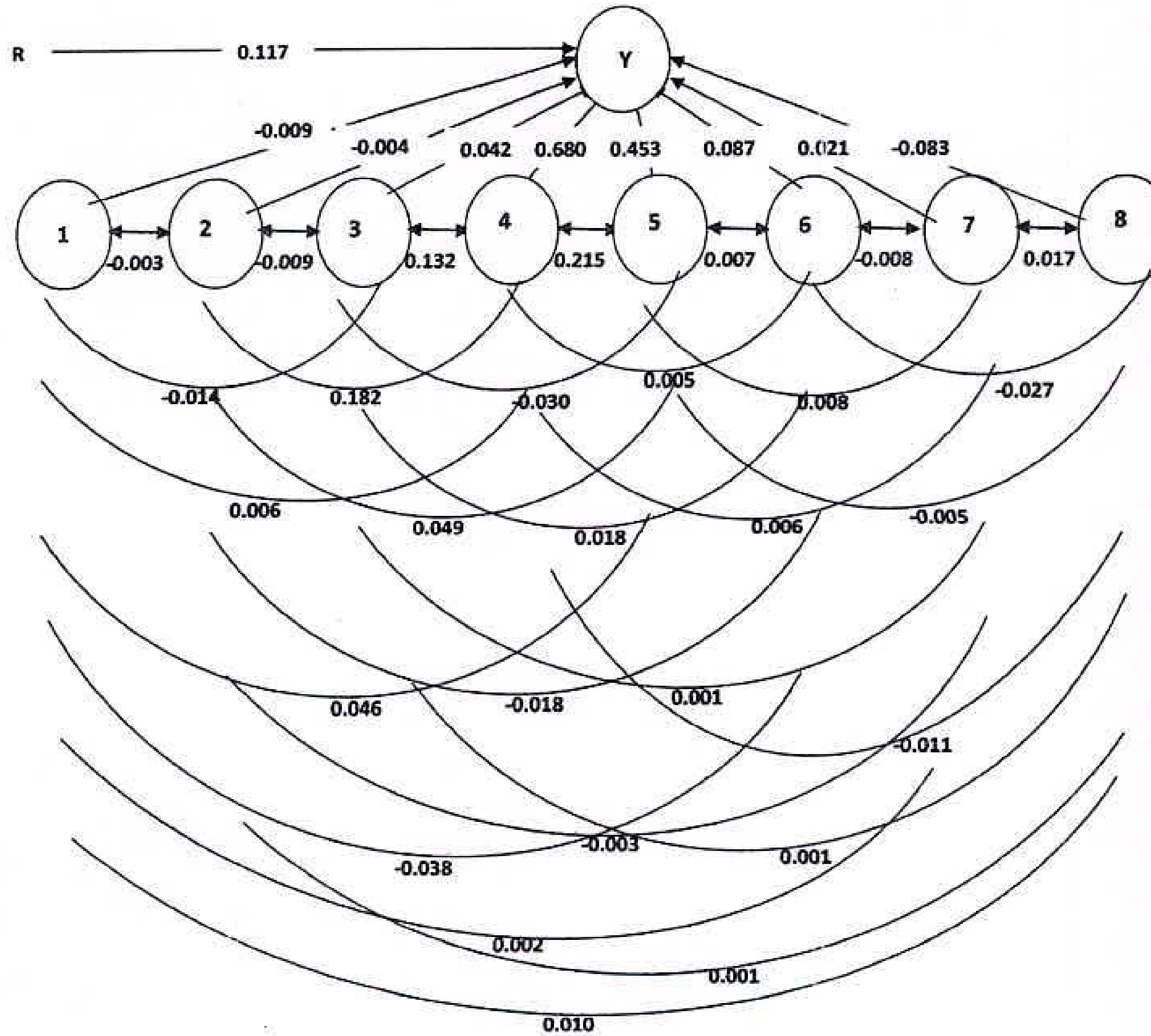


Fig. 2. Path diagram of eight yield and yield contributing characters of thirty one bottle gourd genotypes

1= No. of male flower, 2 = No. of female flower, 3 = Ratio of male & female flower, 4 = No. of fruit /plant, 5 = Fruit weight, 6 = Fruit length, 7 = Fruit breadth, 8 = Fruit Peduncle length, Y = Yield and R=Residual effect

4.3.13 Number of fruit per plant

Number of fruit per plant had the highest positive direct effect on yield (0.680) (Table 7). The character produced positive indirect effect via fruit weight (0.215), ratio of male and female flower (0.008), fruit breadth (0.006) and fruit length (0.005). But the negative indirect effect via fruit peduncle length (-0.011) fallowed by number of male flower (-0.001) and number of female flower (-0.001) were also observed. The balanced total association is positive and highly significant with yield per plant (0.900). So direct selection based on this traits would be effective to increase the yield of this crop. The finding supported Narayan *et al.* (1996) findings in bottle gourd for this trait. The result is in agreement with those of Mondal *et al.* (1989) in water melon, Rahman *et al.* (1986) and Kumar *et al.* (2007) in bottle gourd and Kumaran *et al.* (1998) in pumpkim.

4.3.14 Fruit weight (kg)

Weight per fruit had the positive direct effect (0.453) on yield (Table 7). This character also showed positive effect indirect effect through number of fruit per plant (0.322), fruit breadth (0.008) and fruit length (0.007). But negative indirect effect through fruit peduncle length (-0.005), ratio of male and female flower (-0.003) and number of male flower (-0.001) were also found. However, all these effects contributed to result significant positive genotypic correlation with grain yield per plant (0.781). Significant genotypic correlation between fruit weight and yield further strengthened their reliability in the process of selection for higher yield. The result is in consonance with the finding of Kumaran *et al.* (1998) in pumpkim for this trait. The result is in also agreement with those of Rahman *et al.* (1986) and Narayan *et al.* (1996) finding for this trait in bottle gourd.

4.3.15 Fruit length (inch)

Fruit length showed positively direct effect (0.087) on yield (Table 7). This character, however, showed positive indirect effect through fruit weight (0.036), number of fruit per plant (0.035), ratio of male and female flower

(0.008), number of male flower (0.004) and number of female flower (0.001). The negative indirect effects were also observed via fruit peduncle length (-0.027) and fruit breadth (-0.008) which were togetherly contributed to result insignificant positive genotypic correlation with yield per plant (0.136). Miah *et al.* (2000) also found similar result in bitter gourd.

4.3.16 Fruit breadth (inch)

Fruit breadth showed positively direct effect (0.021) on yield (Table 7). This character, however, showed positive indirect effect through number of fruit per plant (0.197), fruit weight (0.170), fruit peduncle length (0.017), ratio of male and female flower (0.003) and number of female flower (0.001). The negative indirect effects were also found fruit length (-0.033) and number of male flower (-0.001) which were contributed to result significant positive genotypic correlation with yield per plant (0.374). The result is in also agreement with those of Rahman *et al.* (1986) in bottle gourd and Parhi *et al.* (1995) in bitter gourd. Chadhury and Mandal (1987) and Mondal *et al.* (1989) also found similar result for fruit breadth in cucumber and water melon respectively.

4.3.17 Fruit Peduncle length (inch)

Fruit peduncle length showed negative direct effect on yield (-0.083) (Table 7). This character, however, showed positive indirect effect through number of fruit per plant (0.093), fruit length (0.029), fruit weight (0.028) and number of male flower (0.001). The only negative indirect effect was observed via fruit breadth (-0.004) which were contributed to result insignificant positive genotypic correlation with yield per plant (0.064).

4.4 MULTIVARIATE ANALYSIS

4.4.1 Principal component analysis (PCA)

Principal component analysis was carried out with thirty-one genotypes of bottle gourd. First three Eigen values for three principal coordination axes of genotypes accounted for 55.35% variation (Table 8). A two dimensional scattered diagram (Fig. 3) was developed on the basis of the principal component score; Z_1 and Z_2 score (Appendices V).

4.4.2 Principal coordinates analysis (PCO)

The results obtained from principal coordinate analysis showed that the highest inter genotypic distance was observed between genotypes G4 and G10 (2.738) followed by G1 and G10 (2.579) and the lowest distance was observed (0.730) between genotypes G11 and G13 followed by the distance (0.733) between genotypes G6 and G8 (Table 9). The difference between the highest and the lowest inter genotypic distance indicated the moderate variability among the 31 genotypes of bottle gourd. The highest intra-cluster distance was recorded in cluster II (1.33) containing ten genotypes BD-4578, BD-4581, BD-4584, BD-585, BD-4600, BD-4602, BD-4604, BD-4603, BD-8988 and BD-4559. The lowest intra-cluster distance was observed in cluster I (1.12) having two genotype viz. BD-4577 and BD-4580. It favored to decide that intra-group diversity was the highest in cluster II and the lowest in cluster I. Cluster III having six genotypes viz. BD-4596, BD-4605, BD-4599, BD-4601, BD-8948 and BD-8949 and had an intra-cluster distance 1.15. Cluster IV having eight genotypes viz. BD-4579, BD-4583, BD-4582, BD-4597, BD-4598, BD-8965, BD-4561 and BD-8950 and had an intra-cluster distance 1.21. The cluster V consisted five genotypes viz. BD-4569, BD-8987, BD-4558, BD-4560, BD-8966 and had the intra-cluster distance 1.27 (Table 10 and 12).

4.4.3 Non-hierarchical clustering

The computations from covariance matrix gave non-hierarchical clustering among thirty one genotypes of bottle gourd and grouped them into five clusters. Gaffar (2008) reported similar number of clustering in 15 sponge gourd genotypes. Quamruzzaman *et al.* (2008) reported four clusters, Badade *et al.* (2001) ten clusters in bottle gourd. The clustering pattern obtained coincided with the apparent grouping patterns performed by PCA. So the results obtained through PCA were confirmed by non-hierarchical clustering.

Table 8. Eigen values and percent contribution of 18 yield contributing characters of thirty one bottle gourd genotypes

Character	Eigen value	% contribution	Cumulative variation
Days of first male Flowering	4.433	24.63	24.63
Days of first female Flowering	3.134	17.41	42.04
Number of branches per vine	2.396	13.31	55.35
Leaf length (cm)	1.899	10.55	65.90
Leaf breadth (cm)	1.465	8.14	74.04
Leaf petiole length (cm)	0.998	5.54	79.58
Internodes distance (cm)	0.768	4.27	83.85
Male flower pedicel length (cm)	0.715	3.97	87.82
Female flower pedicel length (cm)	0.586	3.26	91.08
No. of male flowers	0.334	1.85	95.43
No. of female flowers	0.286	1.59	97.02
Ratio of male &female flowers	0.450	2.50	93.58
No. of fruit per plant	0.222	1.23	98.25
Fruit weight (kg)	0.157	0.87	99.12
Fruit length (inch)	0.100	0.56	99.68
Fruit breadth (inch)	0.035	0.19	99.87
Fruit Peduncle length (inch)	0.019	0.11	99.98
Yield per plant (kg)	0.004	0.02	100

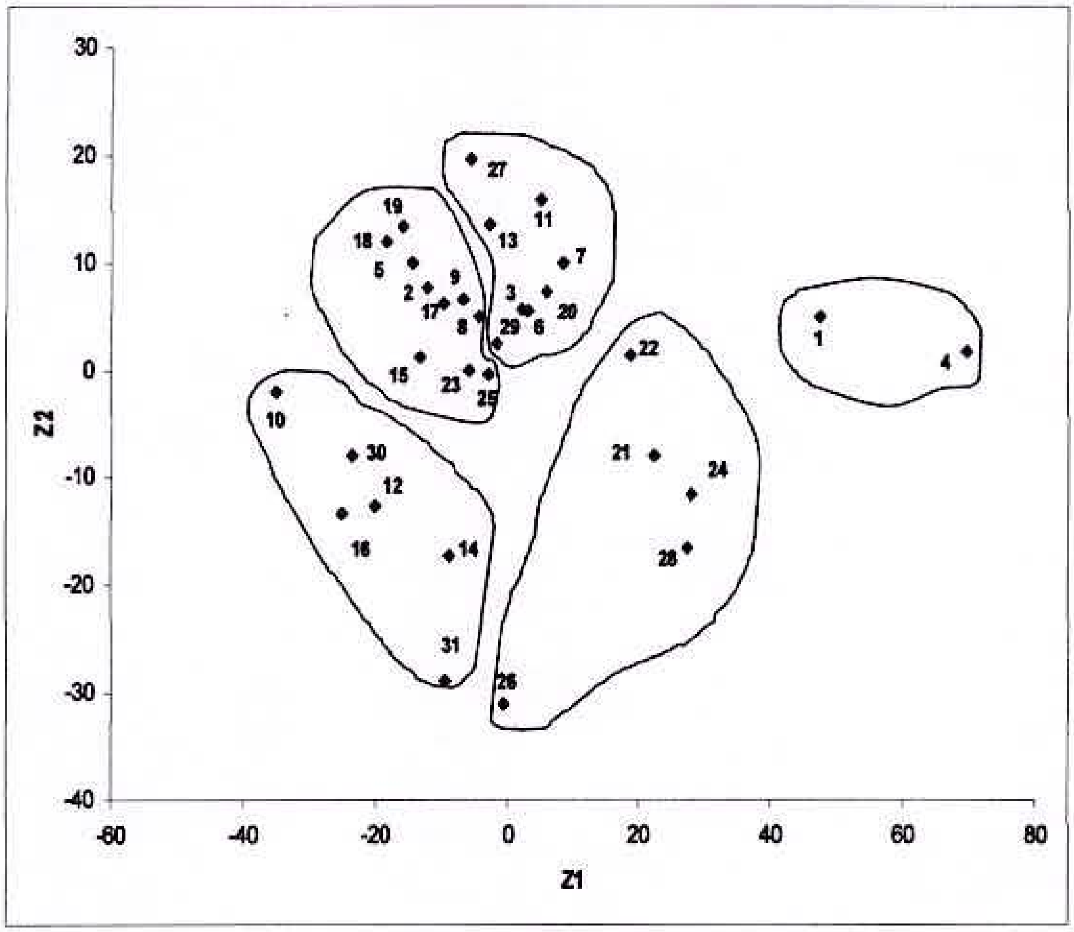


Fig. 3. Scattered diagram of thirty one bottle gourd genotypes superimpose cluster

Table 9. Ten highest and ten lowest inter genotypic distance among the thirty one bottle gourd genotypes

Sl. No.	Genotypic combination	Distances
A. 10 highest inter genotypic distance		
1	G4 - G10	2.738
2	G1 - G10	2.579
3	G19 - G26	2.490
4	G 5 - G28	2.482
5	G5 - G21	2.409
6	G18 - G26	2.345
7	G2 - G28	2.337
8	G1 - G26	2.329
9	G19 - G28	2.326
10	G13 - G31	2.286
B. 10 lowest inter genotypic distance		
1	G11 - G13	0.730
2	G6 - G8	0.733
3	G13 - G19	0.778
4	G15 - G23	0.801
5	G6 - G15	0.812
6	G24 - G28	0.828
7	G6 - G9	0.851
8	G12 - G30	0.871
9	G7 - G20	0.888
10	G6 - G23	0.893

Table 10 represents the clusters occupied by 31 genotypes of bottle gourd. It explains that cluster II contained the highest number of genotypes ten, cluster IV constitute by eight genotypes, cluster III constitute by six genotypes and cluster V constitute by five genotype and cluster I having only two genotypes. Cluster II was composed of BD-4578, BD-4581, BD-4584, BD- 4585, BD-4600, BD-4602, BD-4604, BD-4603, BD-8988 and BD-4559. The genotypes of cluster II are collected from Plant Genetic Resource Centre, BARI, Gazipur. Cluster mean for 18 traits are presented in (Table 11). From the table (11), it was observed that the mean value of cluster II ranked first for internodes distance (11.25). Cluster IV was formed by eight genotypes viz. BD-4579, BD-4583, BD-4582, BD-4597, BD-4598, BD-8965, BD-4561 and BD-8950. They were collected from Plant Genetic Resource Centre, BARI, Gazipur. This cluster was unable to lead in respect of the highest cluster mean value for maximum characters. Among 18 characters cluster V produced the maximum cluster mean for the seven characters viz. number of branches per vine (17.50), leaf length (21.57), leaf petiole length (14.40), male flower pedicel length (6.59) no. of fruit per plant (15.60), fruit width (18.85) and yield per plant (34.75). Similarly, cluster I ranked first for leaf breadth (26.75), female flower pedicel length (20.00), number of male flowers (91.34), number of female flowers (29.00) and ratio of male and female flowers (3.18). Cluster III had six genotypes named BD-4596, BD-4605, BD-4599, BD-4601, BD-8948, BD-8949 were collected from Plant Genetic Resource Centre, BARI, Gazipur. The highest cluster mean value was achieved for five characters viz. days to first male flowering (54), days to first female flowering (101.67), fruit weight (2.38), fruit length (14.40) and fruit peduncle length (5.33).

4.4.4 Canonical variate analysis

Canonical variate analysis was done to compute the inter-cluster Mahalanobis's D^2 values. Statistical distances represent the index of genetic diversity among the clusters. The highest inter-cluster distance was observed (Table 12 or Figure 4) between cluster I and cluster III (23.65) followed by between cluster I

Table 10. Distribution of thirty one bottle gourd genotypes in five clusters

Cluster	No. of genotypes	Designation
I	**2**	BD-4577, BD-4580
II	**10**	BD-4578, BD-4581, BD-4584, BD- 585, BD-4600, BD-4602, BD-4604, BD-4603, BD-8988, BD-4559
III	**6**	BD-4596, BD-4605, BD-4599, BD-4601, BD-8948, BD-8949
IV	**8**	BD-4579, BD-4583, BD-4582, BD-4597, BD-4598, BD-8965, BD-4561, BD-8950
V	**5**	BD-4569, BD-8987, BD-4558, BD-4560, BD-8966

Table 11. Cluster mean of 18 characters of thirty one bottle gourd genotypes

Character	I	II	III	IV	V
Days of first male Flowering	58.00	73.30	83.50	75.79	66.20
Days of first female Flowering	66.50	87.70	101.67	77.67	74.00
Number of branches per vine	9.00	8.83	11.83	10.50	17.50
Leaf length (cm)	19.98	17.42	16.15	20.09	21.57
Leaf breadth (cm)	26.75	20.72	21.49	24.13	26.13
Leaf petiole length (cm)	13.00	10.60	11.17	12.62	14.40
Internodes distance (cm)	10.00	11.25	8.71	9.04	8.82
Male flower pedicel length (cm)	4.00	6.05	6.21	4.57	6.59
Female flower pedicel length (cm)	20.00	17.84	16.18	19.02	17.59
No. of male flowers	91.34	27.90	26.28	37.83	49.00
No. of female flowers	29.00	17.03	16.33	17.71	27.40
Ratio of male &female flowers	3.18	1.68	1.64	2.26	1.83
No. of fruit /plant	8.50	8.70	13.00	7.87	15.60
Fruit weight (kg)	2.30	1.85	2.38	1.70	2.20
Fruit length (inch)	9.03	11.92	14.40	12.53	11.48
Fruit breadth (inch)	18.51	17.12	15.46	14.98	18.85
Fruit Peduncle length (inch)	4.27	5.00	5.33	4.91	4.68
Yield per plant (kg)	19.20	15.89	31.47	13.49	34.75

Table 12. Average intra- and inter-cluster distances of 31 bottle gourd genotypes

Cluster	I	II	III	IV	V
I	**1.12**				
II	18.34	**1.33**			
III	23.65	7.17	**1.15**		
IV	16.64	6.16	11.57	**1.21**	
V	17.50	6.65	9.99	8.97	**1.27**

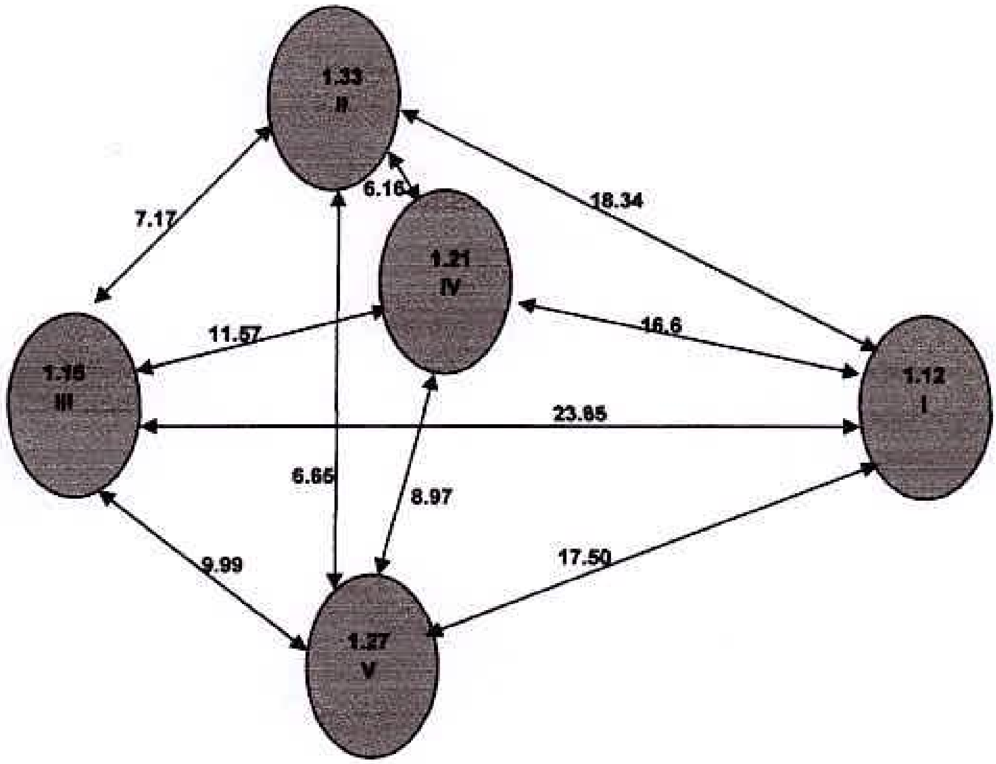


Fig. 4. Diagram showing intra- and inter-cluster distances of thirty one genotypes of bottle gourd

and cluster II (18.34) and between cluster I and cluster V (17.50). The higher inter-cluster distances between these clusters indicate to obtain wide spectrum of segregating population if parents chosen from these distant clusters are used for hybridization program. However, the highest inter-cluster distance was observed between clusters I and III indicated the genotypes in these clusters were far diverged than those of other clusters. Similarly, the lowest inter-cluster distance was observed between the cluster II and cluster IV (6.16).

Moderate or intermediate distance was found between cluster III and cluster IV (11.57). On the other, the highest intra-cluster distance was found in cluster II (1.33) followed by cluster V (1.27). The lowest intra-cluster distance was observed between in cluster I (1.12). The inter cluster distances were found much higher than the intra cluster distances suggesting wider genetic diversity existed among the genotype of different groups . Quamrzzaman *et al.* (2008) obtained longer inter-cluster distances than the intra-cluster distances in a multivariate analysis.

Result of different multivariate analysis were superimposed in figure 3 from which it may be concluded from the above results that different multivariate techniques supplemented and confirmed one another.

As per scatter diagram the genotypes were apparently distributed into five clusters. It was also revealed that the genotypes of cluster I were more diverse from the genotypes of cluster III. Islam *et al.* (2004) also observed the similar result. It is assumed that maximum amount of heterosis will be manifested in cross combination involving the genotypes belonging to most divergent clusters. However, for a practical plant breeding, the objective is not only high heterosis but also to achieved high-level production. In the present study the maximum distance existence between cluster I and cluster III. But considering the yield and duration crosses involving cluster I and III may be exhibit high heterosis for yield. Main and Bahl (1989) reported that the parents separated by D^2 values of moderate magnitude generally showed higher heterosis.

4.4.5 Contribution of characters towards divergence of the genotypes

The values of Vector I and Vector II are presented in Table 13. Vector I obtained from PCA expressed that days to first male flowering (0.3785), days to first female flowering (0.3649), internodes distance (0.0478), male flower pedicel length (0.0719), fruit length (0.2003) and fruit peduncle length (0.0467) were major characters that contribute to the genetic divergence. It was the reflection of first axis of differentiation. In vector II days to first male flowering (0.0279), days to first female flowering (0.1008), number of branches per vine (0.3340), leaf breadth (0.0457), male flower pedicel length (0.1770), number of female flower (0.0847), number of fruit per plant (0.5048), fruit weight (0.3610), fruit length (0.0996), fruit width (0.1345) fruit peduncle length (0.0540) and yield per plant (0.5296) showed their important role toward genetic divergence. Negative values in both vectors for leaf length, leaf petiole length, female flower pedicel length, number of male flowers and ratio of male and female flowers had lower contribution towards the divergence.

4.4.6 Selection of genotypes as parent for future hybridization programme

Selection of genetically diverse parents is an important step for hybridization program. So the genotypes were to be selected on the basis of specific objectives. A high heterosis could be produced from the crosses between genetically distant parents (Falconer, 1960; Moll *et al.*, 1962; Ramanujam *et al.*, 1974; Ghaderi *et al.*, 1984).

Considering the magnitude of cluster mean and agronomic performance the genotype G_4 (BD-4580) for minimum days of first male and female flowering from cluster I; G_{31} (BD-8948) for maximum fruit length and fruit weight from cluster III; G_{26} (BD-4560) for maximum number of fruit per plant and fruit breadth and G_{28} (BD-4569) for maximum number of branches per vine from cluster V were found promising. Therefore considering group distance and other agronomic performance the inter genotypic crosses between G_4 (BD-4580) and G_{31} (BD-8948); G_4 (BD-4580) and G_{26} (BD-4560); G_4 (BD-4580)

Table 13. Latent vectors for 18 principal component characters of thirty one bottle gourd genotypes

Character	Vector I	Vector II
Days of first male Flowering	0.3785	0.0279
Days of first female Flowering	0.3649	0.1008
Number of branches per vine	-0.1321	0.3340
Leaf length (cm)	-0.3303	-0.0269
Leaf breadth (cm)	-0.3406	0.0457
Leaf petiole length (cm)	-0.2652	-0.0008
Internodes distance (cm)	0.0478	-0.1035
Male flower pedicel length (cm)	0.0719	0.1770
Female flower pedicel length (cm)	-0.1465	-0.2952
No. of male flowers	-0.3886	-0.0703
No. of female flowers	-0.3298	0.0847
Ratio of male &female flowers	-0.2272	-0.1918
No. of fruit /plant	-0.1036	0.5048
Fruit weight (kg)	-0.0202	0.3610
Fruit length (inch)	0.2003	0.0996
Fruit breadth (inch)	-0.1065	0.1345
Fruit peduncle length (inch)	0.0467	0.0540
Yield per plant (kg)	-0.0743	0.5296

and G_{28} (BD-4569); G_{31} (BD-8948) and G_{28} (BD-4569); G_{31} (BD-8948) and G_{26} (BD-4560) may be suggested for future hybridization program.

Chapter V
Summary & Conclusion

CHAPTER V
SUMMARY AND CONCLUSION

The present experiment was carried out in the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh to evaluate the field performance, variability, character association and genetic divergence of thirty-one bottle gourd genotypes using morphological characters.

The field experiment was laid out in Randomized Complete Block Design (RCBD) with three (3) replications. Data on different characters were recorded and analyzed statistically. The analysis of variance of all the traits was computed and significant differences were found among the accessions in respect of different characters studied. The maximum value in respect of days to first male flowering (90.33days) was observed in G_{30} (BD-8949) and minimum days (57days) to first male flowering was recorded in G_4 (BD-4580). Genotype number G_{16} (BD-4601) recorded the maximum value (109 days) days to first female flowering and lowest days to first female flowering (59 days) was recorded in G_4 (BD-4580). In respect of nunber of branches per vine, genotype no. G_{28} (BD-4569) recorded the highest value (25) and genotype no. G_{14} (BD-4599) counted the lowest value (6). Genotype no. G_7 (BD-4583) is the highest leaf length (25.03 cm) and genotype no. G_{30} (BD-8949) is the lowest leaf length (12.97 cm) was counted. In case of leaf breadth, the highest value (29.7cm) was recorded in G_{26} (BD-4560) and the lowest value was (15.4cm) recorded in G_{17} (BD-4602). In respect of leaf petiole length, highest value (20 cm) was observed in G_{22} (BD-8987) and the genotype no. G_{25} (BD-4559) had the smallest petiole length of (8.00 cm). In case of internodes distance, the highest value (22.17 cm) was observed in G_{21} (BD-8966) and the lowest value (13.3 cm) was observed in G_{25} (BD-4559). Genotype no. G_5 (BD-4581) is the highest male flower pedicel length (21 cm) and genotype no. G_{16}

(BD-4601) is the lowest male flower pedicel length (3.5 cm) was counted. Genotype no. G_{10} (BD-4596) is the highest female flower pedicel length (9.1 cm) and genotype no. G_{29} (BD-8950) is the lowest female flower pedicel length (3.13 cm) was counted. In case of no. of male flower, the highest value (98.67) was observed in G_4 (BD-4580) and the lowest value (13) was observed in G_{10} (BD-4596). In case of no. of female flower, the highest value (34) was observed in G_{21} (BD-8966) and the lowest value (9) was observed in G_{10} (BD-4596). In case of ratio of male and female flowers, the highest value (3.55) was observed in G_3 (BD-4579) and the lowest value (1.29) was observed in G_{21} (BD-8966). Genotype no. G_{26} (BD-4560) is the highest no. of fruit per plant (20) and genotype no. G_{13} (BD-4598) is the lowest no. of fruit per plant (5) was counted. In respect of fruit length, longest fruit (16.03 inch) was observed in G_{31} (BD-8948) and the genotype no. G_4 (BD-4580) had the smallest length of (7.03 inch). In case of fruit diameter, the highest value (26 inch) was observed in G_{26} (BD-4560) and the lowest value (10.03 inch) was observed in G_{20} (BD-8965). In respect of fruit peduncle length, longest peduncle length (7.12 inch) was observed in G_8 (BD-4584) and the genotype no. G_{19} (BD-4603) had the smallest length of (3.1 inch).In case of average weight per fruit, the highest value (3.5 kg) was observed in G_{31} (BD-8948) and the lowest value (1.2 kg) was observed in G_{19} (BD-4603). The highest average yield per plant (54.13 kg) was in G_{26} (BD-4560) and the lowest yield per plant (7.07 kg) was recorded in G_{19} (BD-4603).

The phenotypic variance was higher than the corresponding genotypic variance in all the characters, indicating greater influence of environment on the expression of these characters. The maximum differences between phenotypic and genotypic coefficient of variation were 33.54 7% and 29.16% respectively which indicated that the no. of fruit per plant mostly depended on environmental effect. The highest estimated heritability among eighteen yield contributing characters 99.8%, 99.69%, 99.62% and 99.55% was in female flower pedicel length, leaf length, number of branches per vine and male flower pedicel length. The lowest heritability was 75.6% in number of fruit per plant. The maximum genetic advance was observed in respect of days of first male flowering (46.2) and followed by maximum value was 28.31 in respect of genetic advance for yield per plant among eighteen characters of bottle gourd genotypes. The maximum genetic advance in percent of mean (GAMP) was obtained for yield per plant (131.43%) and the lowest was for male flower pedicel length (33.63%).

Multivariate analysis was carried out through principal component analysis (PCA), principal coordinate analysis (PCO), cluster analysis, and canonical vector analysis (CVA) using Genstat 5.13 software programme. The first three principal characters with Eigen values were contributed 55.35% variation toward divergence. As per as PCA, D^2 and cluster analysis using the genotypes were grouped into five different clusters. Cluster I, II, III, IV and V comprised two, ten, six, eight and five genotypes, respectively.

The maximum inter-cluster distance was observed between cluster I and III (23.65) followed by the distance between clusters I and II (18.34), I and V (17.50), I and IV (16.64). The lowest inter-cluster distance was observed between cluster II and IV (6.16) followed by II and V (6.65).

The highest intra-cluster distance was identified in cluster II (1.33) and the lowest intra-cluster distance was observed in cluster I (1.12). Genotypes included in cluster V were suitable for fruit diameter (18.85 inch) and no. of fruit per plant (15.60). Cluster III had the highest mean for days to first male flowering (83.50 days) and days to first female flowering (101.67 days).

Findings of the present study indicated significant variation among the genotypes for all the character studied. Considering diversity pattern and other field performances, the genotypes G_{28} (BD-4569), G_{26} (BD-4560) from cluster V, G_{31} (BD-8948) from cluster III and G_4 (BD-4580) from cluster I could be best choice as suitable parents for efficient hybridization programme. The inter genotypic crosses between G_4 (BD-4580) & G_{31} (BD-8948); G_4 (BD-4580) & G_{28} (BD-4569); G_4 (BD-4580) & G_{26} (BD-4560); G_{31} (BD-8948) & G_{28} (BD-4569), and G_{31} (BD-8948) & G_{26} (BD-4560) might be suitable choice for future hybridization programme.

The result of the present study revealed that a wide variability exists among the collected bottle gourd genotypes. In addition, there was also genotypic variability of different yield contributing characters with yield of bottle gourd. From the findings of the present study, the following conclusions could be drawn:

i. Wide range of genetic diversity existed among the bottle gourd genotypes. That variability could be used for future breeding programme of bottle gourd in Bangladesh.

ii. Selection procedure would be applied for desired characters such as days to first male flower, first female flower and increase number of branches per vine, fruit length, fruit breadth, number of fruits per plant to develop high yielding varieties.

iii. Further collection of bottle gourd germplasm would be continued for getting more variability and desired traits in bottle gourd.

References

REFERENCES

Abdel, H. A., Gaffer A. K. and Alam, A. M. (1982). Inheritance of growth habit and female flowering traits in watermelon. *Egyptian J. Genet. Cyt.* **11**(2): 275-280.

Abusaleha and Dutta, O. P. (1989). Interrelationship of yield components in cucumber. *Veg. Sci.*, **15** (1):75-85.

Abusaleha and Dutta, O. P. (1990). Studies on variability, heritability and scope of improvement in cucumber. *Haryana J. Hort. Sci.*, **19** (3-4):349-352.

Ananthan, M. and Pappoah, C.M. (1997). Combining ability and correlation studies in cucumber (*Cucumis sativus* L.). *South Indian Hort.*, **45** (1&2): 57-58.

Anonymous, (1988a). Review of vegetable crop programme Mennonite Central Committee (MCC), Bangladesh. Pp. 26-35.

Anonymous, (1988b). Crop Status Report. Christian Reformed Worlds Relief Committee, Bogra. pp. 124-127.

Anonymous, (2004). FAO Irrigation and Drainage Paper. Food and Agriculture Organization of the United Nations, Rome, Italy, **3**: 80-82.

Arora. S. K, Pandita, M. L., Partap P. S. and Sidhu, A. S. (1983). Variability and correlation studies in sponge gourd *(Luffa cylindrica* Roem). *Haryana Agric. Univ. J. Res.* **XIII** (1): 146-149.

Badade, D. S., Warade, S. D. and Gaikwad, S. K. (2001). Genetic divergence in Bottle gourd. *J. Maharashtra Agril. Univ.*, **26**(2):137-139.

Banerjee, M. K. and Mangal, J. L. (1986). Chemicals in prolonging keeping quality of vegetables A Review. *Haryana J. Hort. Sci.* **15**(3-4):249-254.

Banik, B. R. (2003). Variability, Gene action and Heterosis in snake gourd (*Trichosanthes anguina* L.). Ph. D. Thesis, Department of Genetics and Plant Breeding. Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur. Pp. 1-60.

BBS. (2005). Year Book of Agricultural Statistics of Bangladesh, (1997). Bangladesh Bureau of Statistics. Ministry of Planning. Govt. of the People's Republic of Bangladesh. Dhaka.

BBS. (2008). StatisticalYearbook of Bangladesh 2008. Bangladesh Bureau of Statistics. Ministry of Planning. Govt. of the People's Republic of Bangladesh. Dhaka.

Bose,T. K and Som, M.G. (1986). Vegetable crops in India, Naya Prokash, Calcutta, India. pp: 91-164.

Burton, G. W. (1952). Quantitative inheritance in grass pea. Proc. 6^{th} grassl. Cong. 1: 277-283.

Burton, G. W. and de Vane, E.H. (1953). Estimating the heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agron. J.* **45**: 478-481.

Chadhury, M. L. and Mandal, G. (1987). Correlation and path analysis in cucumber (*Cucumis sativus* L.). *Haryana J. Hort. Sci.*, **16** (3&4): 269-273.

Chezhiyan, N. (1984). Studies on the performance of certain indigenous varieties of water melon (*Citrullus vulgaris* Schard). *South Indian Hort.* **32**(3): 163-166.

Choer, E., Kharakwal, H. B. and Silva, J. B. (2000). Genetic divergence evaluation in accessions of *Cucurbita spp*. through multivariate analysis. *Agropecuaria clima Temperado*. **3**(2): 213-219. [Cited from CAB Abst., 2000/08-2002/07].

Chowdhury, D. and Sharma, K. C. (2002). Studies on variability, heritability, genetic advance and correlation in ridge gourd (*Luffa acutangula* Roxb.). *Hort. J.*, **15**(3): 53-58.

Chowdhury, M. A., Vandenberg, V. and Warkentin, T. (2002). Cultivator identification and genetic relationship among selected breeding lines and cultivars in chick pea (*Cicer arietinum* L).*Euphytica*, **127**(3): 317-325.

Comstock, R. E. and Robinson, H. F. (1952). Genetic parameters their estimation and significance. Proc. of 6^{th} Int. Grassland Cong. **1**:128-291.

Decker-Walters, Deena, Staub, Jack, Lopez-Sese, Ana, and Nakata, E. 2001. Diversity in landraces and cultivars of bottle gourd (*Lagenaria siceraria*: Cucurbitaceae) as assessed by random amplified polymorphic DNA. *Genetic Resources and Crop Evolution,* **48**(4):369–380.

Digby, P., Galway, N. and Lane, P. (1989). GENSTAT 5: A Second Course. Oxford Science. Oxford Science Publications, Oxford. P 103-108.

Doijode, S. D. and Sulladmath, U. V. (1986). Genetic variability and correlation studies in pumpkin (*Cucurbita moschata* Poir.). *Mysore J. Agril. Sci.*, **20** (1): 59-61.

Dora, D. K., (2001). Genetic divergence in pointed gourd (*Trichosanthes dioica* Roxb.). *Veg. Sci.*, **28**(2): 170-171.

Falconer, D. S. (1960). Introduction of quantitative genetics. Oliver and Boud. London. p. 304.

Gaffar, A. (2008). Characterization and genetic diversity of sponge gourd (*Luffa cylindrica* L.). MS Thesis. Dept. Genet. and Plant Breed., Sher-e-Bangla Agricultural University, Dhaka.

Gaur, P., Gupta, C. and Kishore, H. (1978). Studies on genetic divergence in potato. *Euphytica*, **27**:361-368.

Ghaderi, A., Adams, M. W. and Nassib, A. M. (1984). Relationship between genetic distance and heterosis for yield and morphological traits in dry edible bean and febabean. *Crop Sci.* **24**: 37-42.

Gopalan, C., Rama Sastri, B. V. and Balasubramanian, S. C. (1982). Nutritive Value of Indian Foods, Indian Council of Medical Research, Nation Institute of Nutrition, Hyderabad.

Griffing, B. and Lindstone, E.W. (1954). A study of combining abilities of corn inbreeds having varying proportion of corn germplasm. *Agron. J.*, **46**(4): 454-460.

Grubben G. J. H. (2004). Vegetables, Backhuys Publishers, Leiden. pp: 354-357.

Hanson, C. H., Robinson, H. F. and Comstock, R. E. (1956). Biometrical studies of yield in Segregation population of Korean Lespedza. *Agron J.*, **48**: 268 -272.

Harhsawardhan, C. and Ram, H. H. (2003). Genetic diversity studies in musk melon. *Ann. Agril. Res.*, **24**(2): 345-349.

Hazra, P., Ghosh, R. and Nath, S. (2003). Identification of important yield components in pointed gourd (*T. anguina* Roxb). *Crop Res. Hisar.*, **25**(2): 244-252.

Hossain, M. S. (1996). Floral biology of ridge gourd. MS Thesis, Dept. Genet. And Plant Breed., IPSA, Salna, Gazipur.

Islam, M. N. (1993). Studies on heterosis and combining ability in bottle gourd. M.Sc. Thesis, Dept. Genet. and Plant Breed., Bangladesh Agricultural University, Mymensingh, Bangladesh.

Islam, M. R., Faruquei, M. A. B., Bhuiyan, M. A. R., Biswas, P. S. and Salam, M. A. (2004). Genetic diversity in irrigated rice. *Pak. J. Biol. Sci.* **7**(2): 226-229.

Johnson, H. W., Robinson, H. F. and Comstock, R. I. (1955). Estimates of genetic and environmental variabilaity in soybean. *Agron J.*, **47**(2): 314-318.

Kabir, M. E. (2007). Genetic variability, correlation and path analysis of pointed gourd (*Trichosanthes dioica* Roxb.) MS Thesis, Dept. of Horticulture and Post Harvest Technology. Sher-e-Bangla Agricultural University. Abstract.

Kadam, P. Y. and Kale, R. I. (1987). Genetic variability in ridge gourd. *J. Maharashtra Agril. Univ.*, **12**(2): 242-243.

Karuppaiah, P., Kavitha, R. and Senthilkumar, P. (2005). Divergent analysis in bitter gourd (*Momordica charantia*). Palani Paramount Publications. *Indian J. of Hort.* **46**(2): 314-319.

Khan, A. S. M. R., Rabbani, M. G., Siddique, M. A. and Hossain, M. I. (2008). Study on genetic diversity of pointed gourd using morphological characters. *Bangladesh J. Agril. Res.* **33**(3):607-616.

Kumar, S., Singh, R. and Pal, A. K. (2007). Genetic variability, heritability, genetic advance, correlation coefficient and path analysis in bottle gourd (*Lagenaria siceraria* L.). *Indian J. Hort.,* **64** (2):163-168.

Kumaran, S. S., Natarajan, S. and Thamburoj, S. (1998). Correlation and path analysis studies in pumpkin (*Cucurbita moschata* poir.). *South Indian Hort.*, **46** (3&6): 138-142.

Li, J. W., Sun, S. R. and Rer, Y. H. (1997). Study on genetic correlation, path analysis of the main agronomic characters of cucumber. *Acta Agril. Univ., Henamensis*. **31**(3): 244-247.

Lush, J. L. (1943). Animal Breeding Plans. Iowa State Press, Ames, Iowa, p. 437.

Mahalanobis, P. C. (1936). On the generalized distance in statistics. *Proc. Nat. Inst. Sci., India* **2***:* 49-55.

Main, M. A. K. and Bahl, P. N. (1989). Genetic divergence and hybrid performance in chickpea. *Indian J. Genet.* **49**: 119-124.

Mangal, J. L. Dixit, J. Pandita, and A.S. Sidhu. (1981). Genetic variability and correlation studies in bitter gourd *(Momordica charantia* L). *Indian J. Hort*. **38**: 94-98.

Mannan, M. A. (1992). Studies on variability, genetic parameters and correlation in bitter gourd. MS Thesis, Dept of Genet. Plant Breed., Bangladesh Agricultural University, Mymensingh, Bangladesh.

Masud, M. A. T., Chuwdhury, M. A. Z., Hossain, M. A. and Hossain, S. M. M. (1995). Multivariate analysis in pumpkin (*Cucubita moschata*). *Bangladesh J. Plant. Breed. genet.*, **8**(1&2):45-50.

Masud, M. A. T., Habib, A. K. M. A., Ahmed, S. U. and Hossain, S. M. M. (2001). Genetic diversity in sponge gourd (*Luffa cylindrica*). *Bangladesh J. Plant. Breed. Genet.,* **14**(2): 37-41.

Masud, M.A.T., Rashid, M.H., Chowdhury, M.A.Z. and Uddin, M.S. 2006. Combining ability and heterosis in bottle gourd (*Lagenaria siceraria* Mol. Standl). *Bangladesh J. Plant. Breed. Genet.*, **19**(1):41-44.

Mathew, S. M., Gopalakrishan, P. K. and Peter, K. V. (1986). Genetic distance among five botanical varieties of *Cucumis melo*. *Agric. Res. J.*, Kerala, **24**(2): 195-196.

Mathew, S. S. and Khader, K. M. A. (1999). Genetic studies in snake gourd (*Trichosanthes anguina* L.). *J. Trop. Agril.*, **37**(1-2): 71-72.

Miah, M. A., Rahman, M. M., Uddin, M. S., Rahman, A. K. M. M. and Ullah, M. H. (2000). Genetic association in bitter gourd. *Bangladesh J. Sci. Tech.*, **2**(1): 21-25.

Miller, P. J., Williams, J. C., Robinson, H. F. and Comstock, R. E. (1958). Estimation of genotypic and environmental variance and co-variance in upland cotton and their implications in selection . *Agron. J.* 50: 126 – 131.

Moll, R. H., Salhawana, W. S. and Robinson, H. F. (1962). Heterosis and genetic diversity in soybean. *J. Oilseed Res.* **4**(1): 103-107.

Mondal, S. N., Rashid, A., Inouve, K., Hossain, A. K. M. A. and Hossain, M. A. (1989). Genetic variability, correlation and path co-efficient analysis in watermelon. *Bangladesh J. Plant Breed. Genet.*, **2**(1): 31-35.

Murty, B. R. and Arunachalam, I. J. (1966). The nature of genetic divergence in relation to breeding system in crop plants. *Indian J. Genet.* , **26**:188-198.

Narayan, R., Singh, S. P., Sharma, D. K. and Rastogi, K. B. (1996). Genetic variability and selection parameters in bottle gourd (*Lagenaria siceraria* L.). *Indian J. Hort.*, **53** (1):53-58

Nandpuri, B. S., Singh, S. and Lal, T. (1973). Studies on the genetic variability and correlation of some economic characters in tomato. *J. Res.* **10**: 316-21.

Pandit, M. K., Mahato, B. and Sarkar A. (2005).Genetic variability, heritability and genetic advance for some fruit characters and yield in bottle gourd (*Lagenaria siceraria* Molina. Standl.). International Symposium on the Socio-Economic Impact of Modern Vegetable Production Technology in Tropical Asia. ISHS Acta Horticulturae 809.

Parhi, G., Mishra, H. N. and Mishra, R. S. (1995). Correlation and path-coefficient studies in bitter gourd (*Momordica charantia* L.). *Indian J. Hort.,* **52** (2):132-136.

Prasad, L., Gautam, N. C. and Singh, S. P. (1988). Studies on genetic variability and character association in watermelon (*Citrullus lanatus*). *Veg. Sci.*, **15** (1): 86-94.

Prasad, V. S. R. K. and Singh, D. P. (1989). Studies on heritability, genetic advance and correlations in ridge gourd (*Luffa acutangula*, Roxb). *Indian J. Hort*. **46**(3): 390-394.

Prasad, V. S. R. K. and Singh, D. P. (1990). Genetic variability and heritability studies in sponge gourd (*Luffa aegyptica* Mill.). *Haryana J. Sci.* **19**(1-2): 222-224.

Prasad, V. S. R. K. and Singh, D. P. (1992). Estimates of heritability, genetic advance and association between yield and its components in cucumber (Cucumis sativus L). *Indian J. Hort.* **49**(1): 62-69.

Prasad, V. S. R. K., Singh, D. P. and Singh, R. P. (1993). Biological divergence in the land races of Indian Cucumber (*C. sativus*). *Indian J. Hort.*, **50** (1): 63-65.

Quamruzzaman, A. K. M., Rashid, M. A., Ahmad, S., Rahman, M. M. and Talukder, M. A. H. (2008). Multivariate analysis on the quantitative characters of bottle gourd (*Lagenaria siceraria* (Mol.) Standl.). *Bangladesh J. Agri.* **33**(1): 9-14.

Quamruzzaman, A. K. M., Rahman, M. H., Islam, M. N., Rahman, S. M. L. and Sarker, B. C. (2008). Genetic diversity in land races of ridge gourd. *Bangladesh Res. Pub. J.*, **1** (1): 5-12.

Quamruzzaman, A. K. M., Rashid, M. A., Masud, M. A. T. and Uddin, M. N. (2009). Heterosis in bottle gourd. *Bangladesh J. Agril. Res*. **34**(3): 465-472.

Rahman, A. K. M., Das, M. K. and Haque, M. M. (1986). Variability, correlation and path co-efficient analysis in bottle gourd *(Lagenaria vulgaris* L.). *Bangladesh J. Agri.* **11**(3): 13-19.

Rahman, M. M., Dey, S. K. and Wazuddin, M. (1990). Yield, yield components and plant characters of several bitter gourd, ribbed gourd, bottle gourd and sweet gourd genotypes. *BAU Res. Prog*. **4**: 117-127.

Rahman, M. M., Dey, S. K. and Wazuddin, M. (1991). Study of yield, yield components and vine characters of some cucurbit genotypes. *BAU Res. Prog*. **5 A**: 75-86.

Rajendran, P. C. (1985). Crop improvement in watermelon. Ph. D. Thesis. Tamil Nadu Agril. Univ. Tamil Nadu, India. pp. 75-90.

Ram, D., Kallo, G. and Singh, M. (2001). Cluster analysis in pointed gourd (*Trichosanthes dioica* Roxb.). *Veg. Sci*., **28**(1): 67-68.

Ramachandran, C (1978). Genetic variability, correlation studies and path coefficient analysis in bitter gourd (*Momordica charantia* L.). M.Sc. Thesis Keralla. Agril. Uni. Thrissure, Kerala.

Ramachandran, C. and Gopalkrishan. (1979). Correlation and regression studies in bitter gourd .*Indian J. Agric. Sci*. **49**:850-854.

Ramachandran, C., Gopalkrishan, P. K. and Peter, K. V. (1981). Genetic divergence in bitter gourd. *Veg. Sci*. **7**: 100-104.

Ramanujam, S., Tiwary, A. S. and Mehra, R. B. (1974). Genetic divergence and hybrid performance in mungbean. *Theor. Appl. Genet.* **44**(5): 211-214.

Ramos, S. S. R., Queiroz, M. A., Casali, V. W. D. and Cruz, C. D. (2000). Genetic diversity of squash germplasm from northeast of Brazil. *Horticulture Brasileira*, **18**(3): 195-199. [Cited from CAB Abst., 2000/08-2002/07].

Rana, T. K., Vashistha, R. N. and Pandita, M. L. (1986). Genetic variability and heritability studies in pumpkin. *Haryana J. Hort. Sci.* **15**(1-2): 71-75.

Rao, C.R. (1952). Advanced Statistical Methods in Biometrical Research. John Wiley and Sons, New York. pp. 45-110.

Rao, B. N., Rao, P. V. and Reddy, B. M. M. (2000). Correlation and path analysis in segregating population of ridge gourd. *Crop Res. Hisar*, **20**(2): 338-342.

Raseed, M. M., Nabi, S. A., Rasul, M. G. and Mian, M. A. (2002). Genetic divergence in pumpkin (*Cucurbita moschata*). *Bangladesh J. Plant. Breed. Genet.*, **15**(1): 39-41.

Rashid, M. M. (1993). Sabji Biggan (in Bengali), 1st edn, Bangla Academy, Bangladesh. pp: 265-275.

Rashid, M. M. (2000). Genetic divergence in pumpkin. MS Thesis, Dept. Genet. Plant. Breed., Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur, P. 85.

Reddy, K. S. and Rao, M. R. (1984). Studies on heritability, genetic advance and character association in ribbed gourd. *South Indian Hort.*, **32**(2): 97-100.

Robinson, H.F., Comstock, R.E. and Harvey, P.H. 1949. Estimates of heritability and degree of dominance in corn. *Agron. J.* **41**: 253-59.

Rumaran, S., Walterajan, S. and Suraj, S. T. (1997). Genetic variability in pumpkin. *South Indian Hort*. J., **45** (1&2): 10-12.

Saha, R. R., Mitra, B. N., Hossain, A. E., Jamaluddin, M. and Hoque, A. M. M. M. (1992). Genetic variability, character association and path co-efficient analysis in pumpkin (*Cucurbita moschata* L). *Bangladesh Hort. J.* **20** (1): 59-62.

Sanwal, S. K., Yadav, R. K., Singh, P. K. and Rai, N. (2008). Variability and genetic diversity studies in indigenous chow-chow genotypes of northeast India. *Indian J. Hort*. **65**(2) [Cited from Abst., http://www.indianjournals.com].

Sarkar, S. K., Marity, T. K. and Som, N. G. (1999). Correlation and path coefficient studies in pointed gourd (*Trichosanthes dioica* Roxb.). *Indian J. Hort.*, **56**(3): 252-255.

Shah, S. R. and Kale, P. N. (2002). Yield component association analysis in ridge gourd. *J. Maharashtra Agril. Univ.*, **27**(2): 197-198.

*Sharma, N. K. and Dhankhar, B. S. (1990).Variability studies in bottle gourd (*Lagenaria siceraria *Standl). Haryana J. Hort. Sci.* **19**(3-4):305-312.

Sharma, A., Vidyasagar, K. and Pathania, N. K. (2000). Studies on combining ability for earliness and marketable fruit yield in cucumber (*Cucumis sativus* L.). *Himachal. J. Agril. Res.*, **26**(1 & 2): 54-61.

Sidhu, A. S. and Gautam, N. C. (1985). Genetic divergence and hybrid performance in water melon. *Indian J. Agril. Sci.*, **55**: 459-461.

Singh, H. N., Srivastava, J. P. and Prasad, R. (1977). Genetic variability and correlation studies in bitter gourd. *Indian J. Agri. Sci.* **47**(12): 604-607.

Singh, R. K. and Chaudhury, B. D. (1985). Biometrical methods of quantitative genetic analysis. *Haryana J. Hort. Sci.*, **12** (2): 151-156.

Singh, V. P., Singh, K. and Jaiswal, R. C. (1986). Genetic variability and correlation studies in pointed gourd (*T. dioica* Roxb.). *Narendra Deva J. Agric. Res.*, **1**(2): 120-124.

Singh, R. V., Verman, T. S. and Thakur, P. C. (2002). Characters association in cucumber. *Haryana J. Hort. Sci.*, **31** (1&2): 91-93.

Singh, R. V. and Ram, D. (2003). Correlation and path analysis in musk melon. *Indian J. Hort.* **50**(2): 124-128.

Srivastava, V. K., and Srivastava, L. S. (1976). Genetic parameters, correlation coefficient and path co-efficient analysis in bitter gourd. *Indian J. Hort.* **33**(1): 66-70.

Sureshbabu, V. (1989). Divergence studies in pumpkin. MS Thesis, Kerala Agril. University. Thrissure, Kerala.

Swamy, K. R. M., Dutta, O. P., Ramachander, P. R. and Wahi, S. D. (1984). Interrelationships among yield and other quantitative characters in musk melon (*Cucumis melo* L.). *South India Hort.* **32**(6): 334-339.

Sych, Z. D. (1990). Results of watermelon breeding material. Ovoshchevodstvo-i-Bakhehevodstvo, **35**: 67-69. [Cited from CAB Abstract].

Thakur, M. R. and Choudhury, B. (1965). Inheritance of some quantitative characters in *Luffa acutangula* Roxb. 1. Study on heritability of some economic charcters. *Indian J. Hort.* **22**: 184-189.

Thakur, J. C. and Nandpuri, K. S. (1974). Studies on variability and heritability of some important qualitative characters in water melon (*Citrullus lanatus* Thumb. Mansf). *Veg. Sci.* **1**: 1-8.

Thamburaj, S. and Singh, N. (2003). Vegetables and Tuber Crops and Spices. ICAR, New Delhi. pp. 271-72.

Tyagi, I. D. (1972). Vriability and correlation studies in bottle gourd (*Lagenaria siceraria*). *Indian J. Hort.* **29**(20): 219-222.

Varalaksmi, B., Reddy, Y. N. and Reddy, B. M. (1994). Genetic divergence in ridge gourd (*Luffa acutangula* Roxb.). *J. Genet. Breed.*, **48**(2): 131-134.

Varghese, P. (1991). Heterosis in snake gourd (*Trichosanthes andguina* L.). MS Thesis, Kerala Agricultural University. Kerala, India. pp. 37-60.

Vashistha, R. N., Partap, P. S. and Pandita, M. L. (1983). Studies on variability and heritability in water melon (*Citrullus lanatus* (Thunb) Mansf.). *Haryana Agric. Univ. J. Res.* **13** (2): 319-324.

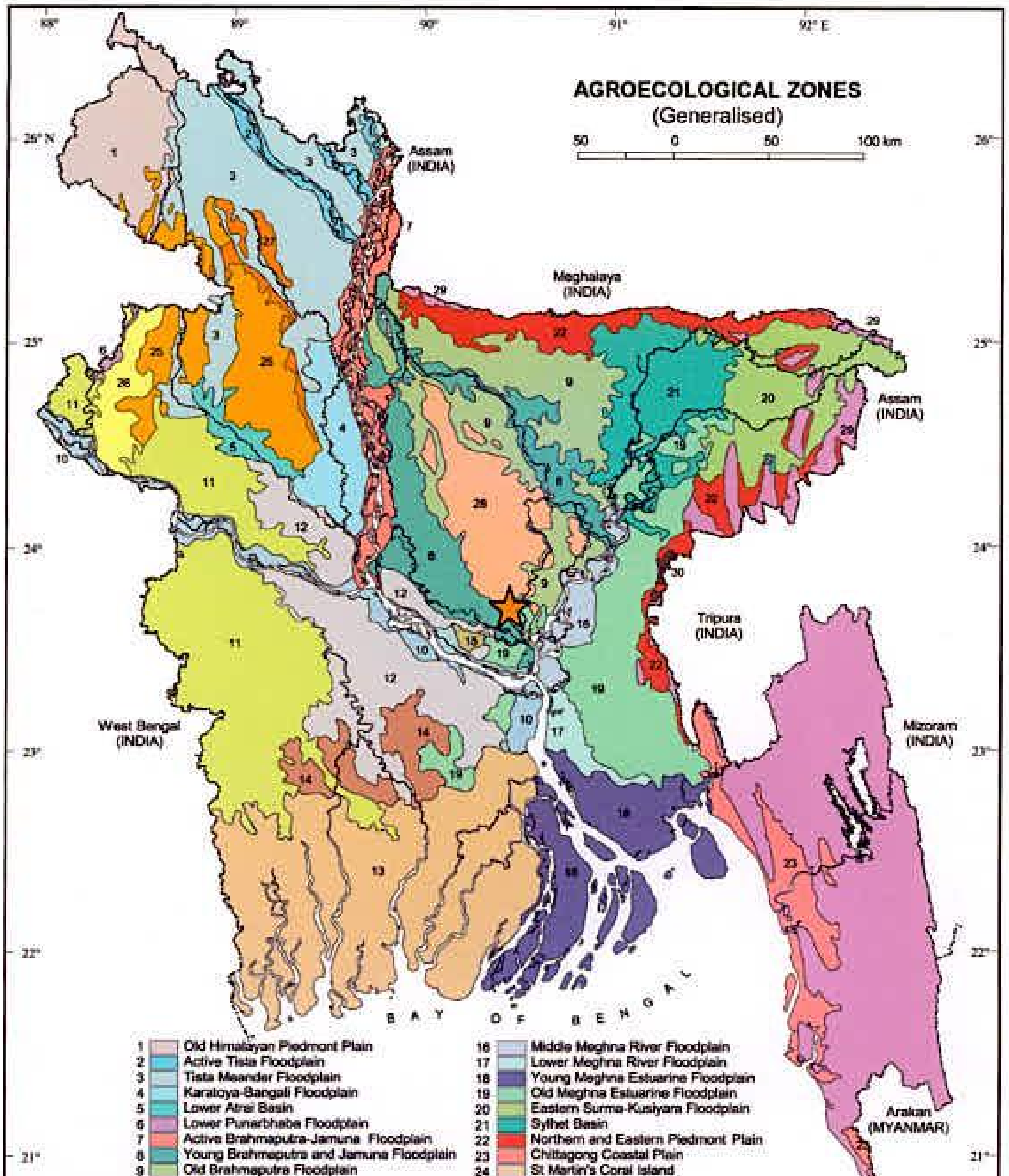
Vijay, O. P. (1987). Genetic variability, correlation and path analysis in muskmelon (*Cucumis melon* L.). *Indian J. Hort.*, **44** (3&4): 233-238.

Yadav, Y. C., Kumar, S., Bisen, B. and Dixit, S. K. (2009). Genetic variability, heretability and genetic advance for some traits in cucumber. *Indian J. Hort*. **66**(4): 54-56.

Appendices

APPENDICES

Appendix I. Map showing the experimental site under study



★ The experimental site under study

Appendix II. Monthly average Temperature, Relative Humidity and Total Rainfall of the experimental site during the period from October, 2008 to March, 2009

Month	Air temperature (°c)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (hr)
	Maximum	Minimum			
October, 2008	34.8	18.0	77	227	5.8
November, 2008	32.3	16.3	69	0	7.9
December, 2008	29.0	13.0	79	0	3.9
January, 2009	28.1	11.1	72	1	5.7
February, 2009	33.9	12.2	55	1	8.7
March, 2009	34.6	16.5	67	45	7.3
April, 2009	35.8	20.3	65	88	8.3

Source: Bangladesh Metrological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Morphological, physical and chemical characteristics of initial soil (0-15 cm depth) of the experimental site

A. Physical composition of the soil

Soil separates	%	Methods employed
Sand	36.90	Hydrometer method (Day,1915)
Silt	26.40	Do
Clay	36.66	Do
Texture class	Clay loam	Do

B. Chemical composition of the soil

Sl. No.	Soil characteristics	Analytical data	Methods employed
1	Organic carbon (%)	0.82	Walkley and Black, 1947
2	Total N (kg/ha)	1790.00	Bremner and Mulvaney, 1965
3	Total S (ppm)	225.00	Bardsley and Lanester, 1965
4	Total P (ppm)	840.00	Olsen and Sommers, 1982
5	Available N (kg/ha)	54.00	Bremner, 1965
6	Available P (kg/ha)	69.00	Olsen and Dean, 1965
7	Exchangeable K (kg/ha)	89.50	Pratt, 1965
8	Available S (ppm)	16.00	Hunter, 1984
9	pH (1 : 2.5 soil to water)	5.55	Jackson, 1958
10	CEC	11.23	Chapman, 1965

Source: Soil Resource and Development Institute (SRDI), Dhaka

Appendix IV. Mean performance of different parameters of thirty one bottle gourd genotypes

Genotypes	Days to first male flowering	Days to first female flowering	No. of branch per vine	Leaf length (cm)	Leaf breadth (cm)	Leaf petiole length (cm)	Internode distance (cm)	Male flower pedicel length (cm)	Female flower pedicel length (cm)
BD-4577	59.00	74.00	6.00	18.00	24.50	9.50	21.00	10.50	3.50
BD-4578	77.00	92.00	7.00	13.33	16.10	7.20	20.13	19.15	3.50
BD-4579	74.00	83.00	10.00	17.50	22.50	10.20	21.10	11.50	3.50
BD-4580	57.00	59.00	12.00	21.97	29.00	16.50	19.00	9.50	4.50
BD-4581	72.00	82.00	6.00	16.60	22.00	9.50	18.97	21.00	9.00
BD-4582	68.33	74.00	7.00	18.00	21.10	10.00	17.10	8.13	4.53
BD-4583	75.00	81.00	8.00	25.03	27.00	19.23	22.00	11.03	5.53
BD-4584	70.00	92.00	9.00	21.17	25.17	14.00	20.00	10.00	5.00
BD-4585	72.00	74.67	10.00	15.00	19.13	9.50	15.17	10.17	8.50
BD-4596	84.00	105.00	15.00	16.30	19.50	12.00	16.00	15.11	9.10
BD-4597	69.00	71.67	12.00	19.50	25.50	13.00	18.50	12.06	6.00
BD-4605	77.00	105.00	17.00	16.37	26.50	9.50	17.20	7.00	6.17
BD-4598	82.00	81.00	12.00	19.67	25.13	11.47	18.00	6.50	5.87
BD-4599	81.67	109.00	6.00	14.27	20.33	8.10	17.27	5.10	4.97
BD-4600	76.00	90.00	7.00	17.47	19.00	9.97	19.13	4.17	4.13
BD-4601	89.00	109.00	12.00	20.00	23.50	13.30	16.10	3.50	4.47
BD-4602	77.00	88.33	11.33	15.53	15.40	10.50	15.20	10.00	4.00
BD-4604	81.00	93.00	8.00	20.13	23.10	8.00	20.00	11.80	8.97
BD-4603	77.00	92.00	10.00	18.50	23.70	14.70	17.50	7.97	7.90
BD-8965	82.00	82.00	12.00	20.50	26.20	16.87	21.50	6.00	3.50
BD-8966	61.67	64.00	15.00	22.40	26.63	16.27	22.17	4.97	6.00
BD-8987	63.33	76.33	8.00	22.00	25.83	20.00	16.33	8.13	6.50
BD-8988	67.00	92.00	10.00	15.00	18.27	12.97	19.00	4.17	3.50
BD-4558	70.00	77.67	20.00	20.00	26.00	10.03	16.00	14.00	6.90
BD-4559	64.00	81.00	10.00	21.50	25.30	9.70	13.30	14.10	5.97
BD-4560	72.00	77.00	20.00	23.33	29.70	11.30	17.50	9.00	7.10
BD-4561	75.00	62.67	11.00	24.00	26.00	12.13	16.90	12.13	4.50
BD-4569	64.00	75.00	25.00	20.13	22.50	14.40	15.97	8.00	6.47
BD-8950	81.00	86.00	12.00	16.50	19.63	8.10	17.10	5.00	3.13
BD-8949	90.33	95.00	12.00	12.97	16.00	9.00	15.00	10.03	5.03
BD-8948	79.00	87.00	9.00	17.00	23.13	15.10	15.50	11.50	7.50
Mean	73.78	84.24	11.27	18.70	23.01	12.00	17.92	9.71	5.66
Maximum	90.33	109	25	25.03	29.7	20	22.17	21	9.1
Minimum	57	59	6	12.97	15.4	8.00	13.3	3.5	3.13

Appendix IV. Mean performance of different parameters of thirty one bottle gourd genotypes (Cont'd)

Genotypes	No. of male flower	No. of female flower	Ratio of male & female flower	No. of fruit / plant	Fruit weight (Kg)	Fruit length (inch)	Fruit diameter (inch)	Fruit Peduncle length (inch)	Yield / plant (kg)
BD-4577	84.00	25.00	3.37	7.00	2.50	11.03	17.03	4.50	17.43
BD-4578	30.00	18.00	1.66	7.00	2.00	11.03	22.00	3.50	13.93
BD-4579	42.00	12.00	3.55	8.00	2.17	11.50	23.10	4.50	16.73
BD-4580	98.67	33.00	3.00	10.00	2.10	7.03	20.00	4.03	20.97
BD-4581	21.33	10.33	2.07	8.00	2.00	12.00	21.12	4.17	15.87
BD-4582	35.00	18.00	1.96	10.00	1.97	11.05	19.13	7.00	19.80
BD-4583	47.33	16.00	3.01	9.00	1.43	13.12	12.00	6.50	12.70
BD-4584	34.67	20.00	1.74	7.00	2.25	13.50	16.47	7.12	15.68
BD-4585	25.00	19.00	1.33	9.00	2.10	12.10	15.17	6.92	18.93
BD-4596	13.00	9.00	1.46	11.00	1.80	14.13	16.10	5.14	19.77
BD-4597	35.00	22.67	1.55	7.00	1.25	15.00	13.17	4.53	8.92
BD-4605	25.67	15.00	1.72	13.00	2.20	14.80	15.00	6.70	28.57
BD-4598	35.00	23.00	1.52	5.00	1.63	13.50	12.50	3.50	8.27
BD-4599	42.00	25.00	1.69	15.00	2.10	13.87	13.67	6.12	31.53
BD-4600	26.00	19.00	1.38	9.00	2.30	13.30	14.67	6.13	20.67
BD-4601	25.00	19.00	1.32	12.00	2.37	14.27	12.80	5.81	28.50
BD-4602	30.00	21.00	1.43	7.00	2.17	10.11	12.02	4.00	15.23
BD-4604	25.00	13.00	1.95	7.00	1.30	14.00	15.12	5.03	9.03
BD-4603	25.00	15.00	1.66	6.00	1.20	12.00	15.03	3.10	7.07
BD-8965	46.33	20.00	2.39	9.00	1.50	16.00	10.03	5.47	13.47
BD-8966	44.00	34.00	1.29	15.00	2.18	15.10	16.10	5.50	32.67
BD-8987	49.00	28.00	1.75	10.00	2.12	9.50	20.10	5.10	21.13
BD-8988	33.00	18.00	1.87	12.00	1.60	12.09	22.50	4.97	19.07
BD-4558	64.00	27.00	2.38	16.00	1.90	9.02	18.00	4.13	30.27
BD-4559	29.00	17.00	1.73	15.00	1.57	9.07	17.12	5.02	23.40
BD-4560	30.00	16.00	1.91	20.00	2.70	11.50	26.00	4.50	54.13
BD-4561	21.00	14.00	1.49	6.00	1.63	10.00	15.60	3.50	9.77
BD-4569	58.00	32.00	1.81	17.00	2.10	12.27	14.03	4.17	35.57
BD-8950	41.00	16.00	2.61	9.00	2.00	10.03	14.30	4.27	18.27
BD-8949	23.00	14.00	1.74	12.00	2.30	13.30	15.17	4.20	27.87
BD-8948	29.00	16.00	1.90	15.00	3.50	16.03	20.00	4.00	52.57
Mean	37.65	19.52	1.94	10.42	1.99	12.29	4.10	4.94	21.54
Maximum	98.67	34	3.55	20	3.5	16.03	26.00	7.12	54.13
Minimum	13	9	1.29	5	1.2	7.03	10.03	3.1	7.07

Appendix V. Principal component score thirty one genotypes of Bottle gourd

SL NO.	Z1	Z2
G 1	47.24	4.93
G 2	-12.33	7.61
G 3	2.14	5.7
G 4	69.59	1.73
G 5	-14.59	9.97
G 6	3.17	5.42
G 7	8.17	9.89
G 8	-4.39	4.88
G 9	-6.73	6.57
G 10	-34.97	-2
G 11	5.03	15.85
G 12	-20.26	-12.65
G 13	-2.87	13.55
G 14	-8.88	-17.23
G 15	-13.37	1.09
G 16	-25.21	-13.3
G 17	-9.85	6.26
G 18	-18.53	11.91
G 19	-16.02	13.41
G 20	5.85	7.28
G 21	22.2	-7.94
G 22	18.59	1.43
G 23	-5.76	-0.06
G 24	27.91	-11.48
G 25	-2.89	-0.36
G 26	-0.59	-31.07
G 27	-5.6	19.6
G 28	27.33	-16.53
G 29	-1.64	2.42
G 30	-23.7	-8.02
G 31	-9.57	-28.83