GENETIC DIVERSITY AND CHARACTERS ASSOCIATION IN BOTTLE GOURD (*Lagenaria siceraria* L.)

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GENETIC DIVERSITY AND CHARACTERS ASSOCIATION IN BOTTLE GOURD (*Lagenaria siceraria* L.)

BY

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CERTIFICATE

This is to certify that thesis entitled, " ***GENETIC DIVERSITY AND CHARACTERS ASSOCIATION 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 bona fide research work carried out by* ***Md. Azizul Islam*** *Registration No.* ***18-09103*** *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.

(Prof. Dr. Firoz Mahmud)
Supervisor

Dated: December, 2020
Place: Dhaka, Bangladesh

DEDICATED

TO

MY PARENTS

SOME COMMONLY USED ABBREVIATIONS

FULL WORD	ABBREVIATION
Agriculture	Agric.
Agricultural	Agril.
Agronomy	Agron.
Agro-Ecological Zone	AEZ
Analysis of variance	ANOVA
And others	*et al.*
Bangladesh	BD
Bangladesh Agricultural Research Institute	BARI
Bangladesh Bureau of Statistics	BBS
By the way	Via
Centimeter	cm
Degree Celsius	^{o}C
Degrees of Freedom	df
Environmental variance	σ^2 e
Food and Agricultural Organization	FAO
Genetic Advance	GA
Genotypic coefficient of variation	GCV
Genotypic variance	σ^2 g
Gram	G
Heritability in broad sense	h^2 b

SOME COMMONLY USED ABBREVIATIONS (Contd.)

FULL WORD	ABBREVIATION
Indian Agricultural Research Institute	IARI
International Center for Agricultural Research in Dry Areas	ICARDA
Kilogram	Kg
Mean sum of square	MS
Meter	m
Murate of Potash	MP
Namely	Viz
Number	No.
Phenotypic variance	$\sigma^2 p$
Percentage of Coefficient of Variation	CV%
Percentage	%
Phenotypic coefficient of variation	PCV
Randomized Complete Block Design	RCBD
Sher-e-Bangla Agricultural University	SAU
Square meter	m^2
Triple Super Phosphate	TSP
Journal	J.

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GENETIC DIVERSITY AND CHARACTERS ASSOCIATION IN BOTTLE GOURD (*Lagenaria siceraria* L.)

BY

MD. AZIZUL ISLAM

ABSTRACT

The experiment was carried out using seventeen genotypes of bottle gourd (*Lagenaria siceraria* L.) at the experimental field of Sher-e-Bangla Agricultural University during March, 2019 to September, 2019. The main objective of the experiment was to measure the genetic variability among the genotypes for yield and yield related contributing characters in bottle gourd. It helps to select the desirable parents (genotypes) for developing new desired breeding populations. Among the genotypes, there were significant variations for all the traits studied here. It was observed that, the high genotypic co-efficient of variation (GCV) was related to 100 seed weight (28.61), number of seed per fruit (27.31), number of primary branches (26.46), fruit length (24.06), and yield per plant (21.62). On the other hand, the low genotypic co-efficient of variation (GCV) was observed for days to first male flowering (1.58), days to first fruit harvest (1.94), days to first female flowering (2.01), tendril length (5.54) and seed length (5.76). In all cases, it clearly indicated that, phenotypic variances were higher than the genotypic variances. The highest heritability was found in 100 seed weight (81.48). But the low genetic advance in percent of mean was observed in days to first male flowering (1.65) which indicated the involvement of non-additive gene effects and these effects were responsible for the expression of this characters, such kind of traits might not be considered for selection. On the other hand, the high genetic advance in percent of mean was observed for 100 seed weight (53.21) and number of primary branches (48.73) per plant with high heritability which indicated the active involvement of additive gene control and selection for such kind of characters would be highly effective for genetic improvement. The highly significant positive correlation was found with days to first female flowering (0.960). The maximum direct contribution towards yield was fruit weight (0.879) followed by no of fruit per plant (0.861). The highest intra cluster distance was found in cluster I (0.992) and the lowest was found in cluster II (0.628). Among five clusters the highest inter cluster distance was observed between cluster I and cluster II (0.364) and the lowest between cluster V and cluster III (0 .004). Considering all the characters related to yield along with associate characters, the genotypes Diana, BG-7092 and BG- 6818 might be selected as the most promising genotypes for future breeding programme.

CHAPTER I
INTRODUCTION

Bottle gourd (*Lagenaria siceraria* L.) which belongs to Cucurbitaceae family is an important vegetable grown for its tender fruits both on homestead gardens and farms. Bottle gourd is known as Lau in locality. It is also known as calabash gourd, trumpet gourd, white flowered gourd and zucca melon. The bottle gourd can be easily separated from other pumpkin varieties for its white flowers and characteristic fruit, seed and leaf shapes (Cutler and Whitaker., 1967). This cucurbit vegetable contains chromosome number of 2n = 22. It is monoecious and cross-pollinated crop maintaining extreme amount of variation for many economically important traits. It is a winter seasonal vegetable but can be grown year-round, fast growing vegetable. It was widely spread across the world before Columbus discovered America, due to spontaneous dispersion by ocean currents (Whitaker *et al*., 1961). It is characterized as a tropical and sub-tropical vine type vegetable which is native to Africa. But actually, the original home of the species is genuinely not known. It's widely cultivated in South and Southeast Asia, China and Africa. This vine type herbaceous vegetable may grow up to 5 meters. Flowers are simple, alternate containing 3-7 separated lobes with velvety structure because of the fine hair. The male flowers and female flowers are white in colour and remain separate in the same plant. Triangular and rectangular shaped seeds are found with greyish to whitish colour containing large amount of amino acid and micronutrient as compared to fruits, excepts calcium, zinc, cobalt and chromium. From the consideration of nutritive point of view, bottle gourd can be the example of rich fruit vegetables containing considerable amount of water, carbohydrate, protein, minerals, fiber and energy. It is good for people suffering from biliousness and indigestion (Thumburaj and Singh., 2003). Besides nutritive value, its different parts possess large number of medicinal properties (Desai and Musmade., 1998). The juice of bottle gourd is effective for cardiac problems. Sweets, pickles (especially on hills), kofta, petha, halwa, Kopoorkand, Paratha and Rayata etc. different type of food items can be made from bottle gourd. It is gaining popularity as a healthy food because of its easy digestibility, diuretic and cardiatonic effects (Rahaman *et al*., 2011).

Being a cross pollinated vegetable, bottle gourd possesses huge variation among their existing varieties as well as in their native or wild genotypes. But in Bangladesh based

on this crop desired comprehensive research has not performed. By incorporating effective breeding programme, the yield potentiality of this crop needs to be improved. India is one of the centers of diversity of bottle gourd endowed with a variety of diverse germplasm (De-Candole., 1882). The diversified varieties and genotypes have various characters act upon their yield. These yields and yield contributing characters are of great importance in modern breeding programs. And these improvements are depending on both quantitative characters and qualitative characters. The assessments and activities of genetic variability, heritability and genetic advance for yield and its components may be helpful in selection of some useful materials from the existing quantitative and qualitative characters of the population. That's why evaluation of a collection of bottle gourd from different parts of India revealed genetic diversity for various qualitative (Mathew *et al*., 2011) and quantitative characters (Singh *et al*., 2015). As a result, the magnitude of the genetic variability in existing crop species of bottle gourd provides basic knowledge of effective selection of total variance and this variance may be phenotypic variance as well as genotypic variance to the total variance. However, the advancement of genetic activities helps to predict the particular intensity of selection. For field trial, selection of individual genotypes is made based on their phenotypic characters, but their genotypic change is made before through involving modern genetic technologies in order to improve the permanent characters of the population. Without variability in the population selection may not be effective. When genetic fraction of the observed variation incorporates in the population then the ultimate desired outcomes respond to selection. Now in the content of Bangladesh, collection and evaluation of bottle gourd genotypes from different parts of Bangladesh will be helpful for identifying superior genotypes but the earliness and yield potentiality of this crop can be improved through an effective breeding program. So, studies on variability along with heritability and genetic advance of different varieties helps to predict inheritance pattern of various characters. Correlation among yield and its components and their relative contributions to yield will be of great value in planning of a breeding program. Therefore, the present investigation was undertaken with a view to work out phenotypic and genotypic coefficient of variation, heritability, genetic gain, association of important genetic traits and path analysis between components of yield in the seventeen genotypes of bottle gourd, so as to make effective selection for improvement of this crop.

Bangladesh is an agricultural country. Considering the economic point of view, Rice monoculture dominates the cropping system in Bangladesh. But monoculture of rice for prolonged periods has led to a number of serious physical and biological problems. Actually, excess amount of rice production may make up the necessity of carbohydrate but it leads to the shortages of others vitamins and minerals. Consequently, a large percentage of people of Bangladesh are suffering from severe malnutrition (Allard *et.al*, 2013). If enough vegetables are not provided to the people, the nutritional deficiency will be to a greater extend. So, production of bottle gourd may be the effective alternative one. The present study was therefore, undertaken in estimating the amount of variation, the correlation coefficients and path-coefficient in the seventeen genotypes of bottle gourd with the following objectives:

A. To determine the nature and magnitude of genetic variability, heritability and genetic advance for effective selection of bottle gourd

B. To estimate correlation and path-coefficient of different yield and yield contributing characters of the genotypes

C. To identify the most divergent genotypes for further breeding programme

CHAPTER II

REVIEW OF LITERATURE

2.1 Variability, Heritability and Genetic Advance

Chandrashekhar *et al*. (2017) conducted a field experiment to study the genetic parameters for yield and yield attributes in bottle gourd based on thirty two genotypes with three replications in Randomized Block Design and came to a decision that A wide range of variability along with high estimates of PCV and GCV was observed for number of nodes per plant, internode length, node at which first female flower appearance, weight of the fruit (g), fruit length (cm), fruit diameter (cm), flesh thickness (mm), rind thickness (mm), yield per plant (kg) and total yield (t ha-1), indicating high variability available among the germplasm for these characters for further improvement. High heritability coupled with high genetic advance as per cent of mean was observed for total vine length (m), number of primary branches per plant, number of nodes per plant, internode length (cm), days to first male flower appearance, node at which first female flower appears, number of fruits per plant, weight of the fruit (g), fruit length (cm), fruit diameter (cm), flesh thickness (mm), rind thickness (mm), yield per plant (kg), total yield (t ha-1) and total soluble solids. Therefore, these characters had additive gene effect was the final output of the experiment.

Ghorpade *et al*. (2018) had a fair outlook on phenotypic and genotypic coefficient of variation, heritability (broad sense) and genetic advance per cent of mean for 4 qualitative attributes in 21 different genotypes of bottle gourd and observed that Significant differences among the genotypes were observed for all the characters under study. The PCV and GCV values were high for Carbohydrate, Protein and T.S.S. High heritability and high genetic advance were observed for characters like ascorbic acid, carbohydrate, protein and T.S.S.

Sharma *et al*. (2008) had a huge diversified study acting upon randomized block design with three replications comprising 16 genotypes of bottle gourd. Observations were recorded for morphological characters. Therefore, the mean performance of the genotypes revealed a wide range of variability for all the traits. Highest variation was in vine length in Narendra Shivani (342.52cm), whereas the minimum vine length was

recorded in Samrat (141.88cm). Maximum number of primary branches per vine was in Narendra Shivani (58.34) but the lowest in Narendra Rashmi-1 (17.71)., The lowest internodal length was noted in NS-421 (10.62cm) but the maximum number of internodes per vine under NS-421 (19.32cm)., Significant differences were found among the genotypes with regard to fruit set percentage. The higher fruit set percentage was noticed in Narendra Shivani (87.71%) and Narendra Dharidar-1 (68.66%) composed the lowest percentage. The significantly higher yield in Narendra Shivani (311.53q/ha) comprising the lowest yield was in Narendra Jyoti (101.86q/ ha).

Keya karmokar (2014) conducted an experiment acting upon fifteen genotypes of bottle gourd (*Lagenaria siceraria* L.) at the experimental field of Sher-e-Bangla Agricultural University and found significant variation among all the genotypes. She found High genotypic coefficient of variation (GCV) was for yield per plant, number of seed per fruit, days to first male flowering and fruit length whereas low genotypic co-efficient of variation (GCV) was observed for seed length, seed breadth and fruit weight. Phenotypic variances were higher than the genotypic variances in all the cases were her overall observation.

Trivedi *et al*. (2015) intimately studied the growth contributing characters of biofield treated bottle gourd (*Lagenaria siceraria*) at their vegetative aspects up to the contribution of yield. The overall results suggest that the biofield energy treatment on bottle gourd results an improved overall growth of plant and yield, which may enhance flowering and fruiting per plant. The biofield energy treatment could be an alternate method to improve the crop yield in agricultural science.

Mladenovic *et al*. (2012) has worked on the determination of genetic variability from a wide range of bottle gourd (*Lagenaria siceraria* L.) for intraspecific variation of the plant, fruit and seed morphology based on 13 genotypes to detect direct result of the preference for ornamental use that favored certain shapes and sizes of the fruit, which has not significantly changed over the centuries.

Deepthi *et al*. (2016) evaluated twenty-three genotypes and one check variety of bottle gourd to study the genetic variability, heritability and potential for screening suitable genotypes for future improvement programmes and obtained the involvement of

additive gene effect comprising tendril length (cm), number of primary branches, days to first male flower appearance, node at first male appeared, number of fruits per vine, fruit weight (g), fruit length (cm), fruit diameter (cm), yield per vine (kg), total yield (t/ha), number of seeds and 100 seed weight (g) characters.

Jain *et al*. (2013) carried out an experiment consisting of 40 genotypes with two checks (Narendra Rashmi, Narendra Dharidar) observing 12 economic traits of bottle gourd (*Lagenaria siceraria*) and noticed that moderate to high coefficients of variations were recorded for yield of marketable fruits (kg/plant) (36.87%), Estimate of heritability in broad sense ranged from low (58%) for days to first staminate flower anthesis to very high (99%) for fruit length/polar length. Moderately high genetic advance as per cent of mean were recorded for number of primary branches per vine at the time of last harvest (30.79%).

Thakur (2015) conducted an experiment on twenty-two bottle gourd genotypes evaluating for different quantitative characters and found that among twenty-two genotypes, the genotype 2012 BOG VAR 4 was noted for earliness (25 DAT) for days to 50% flowering and the same genotype was also noted for early male and female flowering i.e., 16.26 and 25.66 DAT. The genotype 2010 BOGVAR 3 exhibited early fruit setting (31.93 DAT) and also noted for early harvesting i.e., 41.33 DAT. Maximum number of fruits per plant (14.83) was recorded in NDBG 104. Studies revealed that the genotypes 2012 BOG VAR 6, 2012 BOG VAR 4, 2011BOG VAR 3, 2010 BOG VAR 3 and NDBG 104 were found to be promising for earliness and fruit yield.

Damor *et al*. (2016) studied to elucidate the genetic variability, heritability and genetic advance in forty bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] genotypes grown in Randomized Complete Block Design in two replications comprising sixteen characters. The overall result was phenotypic coefficient of variation (PCV) was somewhat higher than genotypic coefficient of variation (GCV) for all the characters. High heritability combined with high genetic advance was observed for the characters first male flowering node number, first female flowering node number, length of pedicel, fruit length, fruit girth, fruit weight, number of fruits per plant, fruit yield per plant for effective selection of genotypes.

Sultana *et al*. (2018) studied to elucidate thirty-nine genotypes of bottle gourd [*Lagenaria siceraria* (Mol.) Standl] in randomized complete block design with three replications and observed highest GCV (35.57%) and PCV (35.62%) were observed for fruit length. The differences between GCV and PCV were high for fruit number plant-1 and days to first male flower open indicating environmental influences. High heritability associates with high estimates of genetic advance in percent of mean were noted for length of fruit, yield, girth of fruit and number of fruits plant-1 which indicates the presence of additive gene effect.

Masud *et al*. (2006) performed 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. Variability was 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%).

Sharma and Dhankar (1990) indicated based on practical experiment 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).

Quamruzzaman *et al*. (2009) constructed a field experiment to study about heterosis in bottle gourd in a set of 13 F, 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 (F1) 10 x 17 and 19

x 26 manifested highest heterosis over mid-parent (73.1"A) and better parent (61.8%) respectively, for yield per plant.

Pandit *et al*. (2005) experimented acting on fifteen genotypes of bottle gourd (*Lagenaria siceraria* Molina. Stand) 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 inbreeds for yield/plant were BCBG-7, 17, 19 and 33.

Narayan *et al*. (1996) observed a deep evaluation on genetic variability, heritability in broad sense, genetic advance in 25 diverse populations of bottle gourd. A Wide 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) observed based on field experiment about 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.

Rahman *et al*. (1991) made a report that male flower was 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.

Rumaran *et al*. (1997) studied upon 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.

Kumar *et al*. (2007) conducted a field experiment working on 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 fruits per vine, fruit weight, 100 seed weight and fruit yield per vine.

Asmaul Husna (2009) conducted an experiment with thirty-one genotypes of bottle gourd in Sher-e Bangla Agricultural University Research Field at Agargaon, Dhaka. She found that mean sum for leaf length was 29.721 which highly significant due to genotypes of bottle gourd 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.

Asmaul Husna (2009) reported based on a field performance in bottle gourd that leaf breadth showed significant and positive correlation with leaf petiole length at both genotypic and phenotypic level indicated if the leaf breadth is increased then leaf petiole length also increased. On the other hand, this character produced insignificant and positive correlation with yield at both and phenotypic level revealed that the association among this trait is largely influenced by environmental factors.

Grubben (2004) observed that leaf petiole length is 2.5 to 12.5 cm in bottle gourd.

Asmaul Husna (2009) stated a significant mean square for leaf petiole length which was (33.58) in bottle gourd. The maximum leaf petiole length was observed 20.00 in BD-8987 and the minimum was recorded 8.00 in BD-4559 with mean value 12.00 in bottle gourd.

Asmaul Husna (2009) noticed in bottle gourd that mean performance of days to first male flowering showed the maximum duration (90.33) to first flowering was produced by BD-8949 and that the minimum duration (57.00) by BD-4580 with mean value 73.78.

Sharma and Dhankhar (1990) observed almost similar estimation 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.

Bose and Som (1986) constructed 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).

Rahman *et al*. (1991) reported that it may observe male flower 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.

Samsun Naher (2014) estimated a significant mean sum of square for pedicel length that was (4.437) in genotypes of pumpkin. The maximum pedicel length was observed 7.33 in G2 (BD 2203) and minimum was 2.63 recorded in G5 (BD 2212) with mean value 4.56. The phenotypic variance (1.53) appeared to be slightly higher than genotypic variance (1.45) suggested that less influence of environment on the

expression of this gene controlling this trait. The genotypic co-efficient of variation (26.46%) and phenotypic co-efficient of variation (27.12%) were close to each other. Asmaul Husna (2009) found similar result in bottle gourd.

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

Tyagi (1972) constructed a field experiment using twenty-five inbreeds 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*. (1986) stated that 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).

Asmaul Husna (2009) conducted an experiment on bottle gourd and maximum number of fruits per plant was found 20.0 in BD-4560 and the minimum was recorded 5.00 in BD-4598 with mean value 10.42.

Asmaul Husna (2009) experimented on bottle gourd and founded maximum fruit length 16.03 in BD-8948 and the minimum recorded 7.03 in BD-4580 with mean value 12.29.

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; Prasad 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).

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). Prasad and Singh (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

Keya karmokar (2014) constructed an experiment based on fifteen genotypes of bottle gourd (*Lagenaria siceraria* L.) at the experimental field of Sher-e-Bangla Agricultural University and found significant variation among all the genotypes. She observed that highly significant positive correlation was found with fruit length and fruit weight

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 vine, vine length, nodes no. of first female flower, length of edible fruit and no. of fruit per vine.

Sultana et al. (2018) experimented based on field research to elucidate thirty-nine genotypes of bottle gourd [*Lagenaria siceraria* (Mol.) Stand] in randomized complete block design with three replications and obtained that yield were positively and significantly correlated with fruit weight, 100 seed weight, branch plant-1 and number of fruits plant-1. Negative associations of yield were noted with days to first male and

female flower open, days to harvest and length of fruit.

Asmaul Husna (2009) reported in bottle gourd (*Lagenaria siceraria* L.) genotypes that leaf breadth showed significant and positive correlation with leaf petiole length at both genotypic and phenotypic level indicated if the leaf breadth is increased then leaf petiole length also increased. On the other hand, this character produced insignificant and positive correlation with yield at both and phenotypic level revealed that the association among this trait is largely influenced by environmental factors.

Badade *et al*. (2001) conducted an experiment to study the correlation of bottle gourd (*Lagenaria vulgaris*) genotypes in which yield was found significantly and positively correlated with number of branches 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 insignificant correlation with fruit yield.

Narayan *et al*. (1996) studied correlation analysis performing on 25 diverse populations of bottle gourd. Correlation coefficient indicated 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.

2.3 Path Co-efficient

Keya karmokar (2014) stated an experiment based on fifteen genotypes of bottle gourd (*Lagenaria siceraria L*.) at the experimental field of Sher-e-Bangla Agricultural University. In case of path co-efficient analysis, she obtained that maximum direct contribution toward yield per plant fruit length followed by fruit weight. The highest intra cluster distance was found in cluster III and lowest was found in cluster IV.

Among five clusters the highest inter cluster distance was observed between cluster IV and cluster V and the lowest between cluster I and cluster II.

Gulshan Ara *et al*. (2014) experimented applying twenty-eight bottle gourd (*Lagenaria siceraria*) genotypes for path co-efficient analysis incorporating five clusters and found maximum inter-cluster distance was between cluster III and cluster I, and the minimum was between cluster IV and II. The overall output was the crosses between the genotypes LS001, LS002, LS007, LS010, LS013, LS016, LS017, LS028 of cluster II and LS018, LS023 in cluster V would exhibit maximum heterosis.

Sultana *et al*. (2018) conducted an experiment based on thirty-nine genotypes of bottle gourd [*Lagenaria siceraria* (Mol.) Standl] in randomized complete block design with three replications and came to a decision that Path analysis revealed that fruits plant-1 (0.93) and weight of fruit (0.467) had very high positive effect on fruit yield ton ha-1.

Kumar *et al*. (2007) stated a field 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 fruits per vine had positive direct effect on fruit yield per vine.

Narayan *et al*. (1996) studied path-coefficient analysis acting upon 25 diverse populations of bottle gourd. Path coefficient analysis revealed that maximum weight should he 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 precisely on 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**.**

Asmaul Husna (2014) reported in bottle gourd (*Lagenaria siceraria* L.) genotypes showed that Path co-efficient analysis revealed maximum direct contribution towards yield per plant with vegetative traits of no. of branches per vine.

2.4 Genetic Diversity

For cross pollinated crops genetic diversity is likely to be the most importance tool to qualify variability of any genotype. (Geiffing and Lidstorm, 1954; Murty and Arunachalam, 1966)

Biometrical procedures make the quantification of genetic diversity more reliable to choose genetically diverse plants which leads to a successful hybridization programme (Rao, 1952). D^2 analysis (originally Outlined by Mahalanobis, 1936 and extended by Rao, 1952) is one of the potential methods of estimating the degree of genetic diversity. The wide diversity of genotypes can be estimated 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 accumulating the degree of divergence among biological population-based on multiple characters.

Genetic divergence using Mahalanobis D^2 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 22 characters viz. vine length, number of branches, fruit per vine, length and diameter of fruit and yield per vine.

Quamruzzaman *et al*. (2001) Studied multivariate analysis involving the quantitative characters among seventeen genotypes of bottle gourd (*Lagenaria siceraria*). The genotypes were constellated into four 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.

CHAPTER III
MATERIALS AND METHODS

The overall experiment was performed at the research field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March, 2019 to September, 2019 based on the topic Genetic Variability and Characters Association in bottle gourd. The locations of the experimental site, characteristics of soil, climate, materials, introducing genotypes, field layout, design of the experiment, land preparation, manuring and fertilizing, transplanting of seedlings, intercultural operations, harvesting, data recording procedure, economic and statistical analysis etc. are represented clearly. Details of the methodology of the study followed during the research period are presented in this chapter.

3.1. Experimental site

The experiment was conducted at the experimental field of genetics and plant breeding department during the period from March, 2019 to September, 2019. **Plate 1** represents the experimental site.

3.2. Geographical location

The experimental field was occupied the location at 23°74'N latitude and 90°35'E longitude which is 8.6 meter above from the sea level. The field was situated at the Madhupur Tract, AEZ- 28. The formation of the soil was developed by Madhapur clay and dissected sediments from the small hillocks of the region. The geographical site was shown in the map of AEZ of Bangladesh in **Appendix 1**.

3.3. Experimental design and treatments

The experiment was laid out in a split plot with three replications. Seventeen varieties were assigned in main plots and were arranged in 51 sub-plots. The whole experiment was conducted in 300 m^2 area and constructed RCBD design. Seedlings were raised in polybag under strong supervision and after 20 days they were transplanted in the main field maintaing plant-plant distance 3m and row-row distance 2.5m maintaining 0.5m drainage facilities. Main plot of the research field was divided into 51 sub plots containing 17 bottle gourd varieties.

A

B

Plate I. Showing experimental site (A & B)

3.4.Planting materials

Seventeen genotypes of bottle gourd were incorporated for the present research work. The purity and germination percentage were leveled as around 100 and 80, respectively. The healthy, vigorous and genetically pure seeds were collected from Laal Seed, Gazipur, Dhaka. Now the collected seed tag with its source is represented below:

Table 1. Name and source of seventeen bottle gourd genotypes used in the present study

SL NO	Name of the genotypes	Source
1	BG- 6309	Laal Teer Seed limited, Gazipur, Dhaka
2	Martina	Laal Teer Seed limited, Gazipur, Dhaka
3	BG- 7092	Laal Teer Seed limited, Gazipur, Dhaka
4	BG- 6820	Laal Teer Seed limited, Gazipur, Dhaka
5	BG- 6813	Laal Teer Seed limited, Gazipur, Dhaka
6	BG- Barsha	Laal Teer Seed limited, Gazipur, Dhaka
7	BG- 6829	Laal Teer Seed limited, Gazipur, Dhaka
8	Diana	Laal Teer Seed limited, Gazipur, Dhaka
9	Tafsi	Laal Teer Seed limited, Gazipur, Dhaka
10	BG- 6824	Laal Teer Seed limited, Gazipur, Dhaka
11	BG- 6520	Laal Teer Seed limited, Gazipur, Dhaka
12	BG-6523	Laal Teer Seed limited, Gazipur, Dhaka
13	BG-6527	Laal Teer Seed limited, Gazipur, Dhaka
14	BG- 6307	Laal Teer Seed limited, Gazipur, Dhaka
15	BG-6818	Laal Teer Seed limited, Gazipur, Dhaka
16	BG- Arosh	Laal Teer Seed limited, Gazipur, Dhaka
17	BG- Nico	Laal Teer Seed limited, Gazipur, Dhaka

3.5.Climate

The research field was located at sub-tropical climatic zone which is characterized by high temperature, high relative humidity and heavy rainfall in Kharif season (March - September). **Appendix II** represents the meteorological information related to research activities regarding temperature, relative humidity, rainfall and sunshine hours.

3.6.Characteristics of soil

The soil of the research field was general type of soil characterizing shallow red brown under Tejgaon series. Clay loam textured soil occupies at the upper region along with yellowish brown mottles at the deeper part. Soil pH ranged 5.47 up to 5.63 containing fair enough organic matter. The field was flat prevailing available irrigation and drainage facilities. Physicochemical properties of the soil were described at **Appendix III.**

C

D

Plate 2. Seedling polybag preparation (C), Seedlings in poly bag (D)

3.7. Polybag Preparation and Seedling Raising

Seeds of bottle gourd were dibbed in polybag for initial nourishment because of uncertainty of rainfall during the period of experiment held. Raising seedlings in polybags also provided privilege of higher percentage of germination. In order to get vigorous seedling partial shade and irrigation were also provided. When the seedlings were at the age containing three leaves, they were ready for transplanting in the main field.

3.8. Land preparation

The selected experimental field was first opened at l5 days before laying out the experimental plots. The land was prepared well with the tractor drawn disk plough followed by harrowing and laddering up to a good tilth. The soil was well dried in sun in order to remove the excess moisture from soil because of removing the risk of getting rotten the roots of the seedlings. The clods were broken and weeds and stubbles of the previous crops were collected and removed from the field during the land preparation.

3.9. Bed preparation

After the final land preparation, it is required to make bed in order to transplant the seedlings to make them productive in the main field. In order to make the desirable bed at first earthing up was done remaining a drain in order to facilitate the removing water stagnancy. Because tender bottle gourds are very much water sensitive. Water stagnancy cause damage to the tender roots and leading to death. After that small pit were made to transplant the single seedling in each pit. The height of the pit was little higher than the bed. The pit is the most essential part in where organic fertilizer as well as chemical fertilizer were mixed for the nourishment of the growing seedlings.

3.10. Fertilizer application

Recommended doses of fertilizer for bottle gourd were used in this experiment, for all varieties of bottle gourd 30 kg N, 30 kg p and 60 kg K per hectare were applied. All fertilizers were applied during the final land preparation. Fifteen days ahead of transplanting the seedlings the whole amount of organic matter and cow dung were applied. Different fertilizer was applied in the form of urea, TSP, MP and the two third of the urea was applied as basal dose along with the rest fertilizers. The remaining urea was applied the pit of individual. Fertilizer dose source of nutrients were as follows:

Table 2. Applied fertilizer doses in the present field experiment

Fertilizer	Recommended Doses (ton/ha)
Cow dung	10
TSP	125
Urea	125
MOP	150
Gypsum	75

E

Plate 3. Field view after transplanting

F

Plate 4. Field view at vegetative stage

3.11. Seedling transplanting

The seedlings were raised out of the main field in an area under strong supervision in order make them able to transplant in the main field. Seeds were sown in the polybags and provided desired water and sunlight. After few days later the seeds were spouted

and gradually growing at the desirable shape. When the seedlings were two leaves containing, they were ready to transplant. Before transplanting to the main field, the tender seedlings were provided at the open sunlight in order to harden them for the main field. About after 21 days the seedlings were ready to transplant in the main field. Partial shade was given to the entire field in order to save the seedlings from the scorching heat of sun. Otherwise, the tender seedlings will be dehydrated and wilted. As a result, the young seedlings will lead up to death. At the main field the pits were pre-prepared and after removing the polybags from the seedlings the individual seedling was planted at the pit. The base portion of the seedling was pressed at the soil tightly to have them straight and support of bamboo sticks were also provided with them.

3.12. Crop management

3.12.1. Irrigation

After transplanting the seedlings in the main field, it was required to irrigate. For this reason, irrigation was done by floating jars in order to irrigate the base portion of the seedlings as well as to get wet the rest entire portion of the seedlings. Flooding irrigation was not provided to protect the young seedlings from water stagnancy. Water stagnancy may be got rotten the young roots of the seedlings as a result the seedlings may lead up to death. After a few days later when the seedlings were coped with the soil a flooding irrigation was done in order to moisten the whole field but special drainage facilities were made to remove water stagnancy also. Then after the whole life time of the productive stage of bottle gourd irrigation was done as per required.

3.12.2. Weeding

Weeding was done thrice time at the main field during the growing season. First weeding was done 7 days after transplanting in order to make room for vigorous establishment of the growing seedlings. Second weeding was done after 20 days of transplanting in order to reduce the competition of up taking nutrients from the soil among the growing seedlings and weeds. Third weeding was done after 30 days of transplanting as it was required.

3.12.3. Pesticide Application

After transplanting the seedlings in the main field, the tender seedlings were bent down by rotting the base portion of the seedlings. For protecting them from getting rotten,

atistine was sprayed mixing with water. At the seedling stage red pumpkin beetles were attacked the young leaves and for that ripcord was sprayed in the main field.

3.13. Sampling procedure and data collection:

Three replications of each 17 genotypes of bottle gourd were randomly selected for data collection at different level of maturity for the time being of related parameters. Before collecting data from the field level days to physical maturity was considered under supervision. The data collection procedure was started from opening of primary branches and leads up to the last harvesting of fruits and counting 100 seed weight after harvesting.

The following parameters were observed and calculated-

Internode length:

Internode length was measured in centimeter from the starting point of the internode up to the last end of each selected plant. This measurement was taken when the bottle gourd plants were mature enough at their productive stage from the middle portion of the plant.

Tendril length:

As bottle gourd is under Cucurbitaceae family, it contains tendrils which are used for the support of the plant. These tendrils were also measured in centimeters by uncoiling by hand.

Number of primary branches:

When the first flowering was held then the number of primary branches were counted from the individual plant to make a qualitative estimation of genotypes / varieties.

Sex ratio:

Sex ratio is also a qualitative trait. As bottle gourd is monoecious plant, the male and female flowers are produced at the same plant. So, in order to have a prediction of cross pollination and percentage of pollination, male flowers and female flowers from individual plants were used for counting.

Petiole length:

The measuring unit of petiole length was centimeter. Male petiole and female petiole were estimated separately. The measurement was started from the attached point with the main trunk up to the point from where blooming part of flower was started.

Female ovary diameter:

The pre shaped fruit of bottle gourd was found only on female flowers is known as ovary. The ovary was estimated in centimeter from vigorously produced one.

Number of fruits / plants:

Numbers of fruits were recorded at maturity stage. There are four harvests were done for collecting the total amount of fruits in each individual plant as well as in the individual variety.

Fruit length:

Fruit length was recorded from base point up to the tip of the fruit in centimeter unit.

Fruit diameter:

Fruit diameter was measured from the middle portion of the fruit in the unit of centimeter.

Fruit weight:

At maturity of harvesting time the weight of the individual fruits was recorded in kilogram unit.

Seed length:

Seed length was taken after harvest. The measurement was taken from lower point of seed up to the top in centimeter.

Seed diameter:

Seed diameter was estimated in centimeter from the middle portion of the seed.

Seed thickness:

Seed thickness was taken after harvest.

100 seed weight:

From each fruit hundred seeds were taken randomly from reserved sample and weighed.

Number of seed / fruits:

Number of seed per fruit was measured manually after harvest.

Plate 5. Showing harvest of fruits and their different shape and colour

Harvest index:

Harvest index (HI) was calculated by dividing economic yield by biological yield of plant in each plot by multiplying with 100 and expressed in percentage.

$$\text{Harvest index (\%)} = \frac{Economic\ \text{Yield}}{Biological\ \text{Yield}} \times 100$$

3.14. Statistical analyses:

The data were analyzed by partitioning the total variance with the help of computer by using GENSTAT program. The treatment means were compared using Duncan's Multiple Range Test (DMRT) at $P \leq 5\%$ level. The statistical analysis was carried out to use multivariate methods to estimate average performance and then predict hybrid performance. In this case, it is not necessary to make crosses. Furthermore, a large number of materials may be successfully evaluated (Hallaunder and Miranda Filho, 1981).

3.15. Genetic Diversity Analysis

3.15.1. Principal Component Analysis (PCA)

Principal Component Analysis is the method by which the identifying patterns in data and expressing the data in such a way that it highlights the similarities and differences among the genotypes under supervision. It is a multivariate technique which derives a small number of linear combinations (principal components) of a set of variables that retain as much of the information in the original variables as possible.

3.15.2. Clustering

Clustering is the method for grouping genotypes of similar kind based on desired objectives. It's also a multivariate process of analysis. This method is now popular (first used by Tryon, 1939) method to analyze the genetic diversity. Cluster analysis is an exploratory data analysis tool whose members are close to one another on various aspects.

3.15.3. Cluster Diagram

Cluster diagram analysis a line diagram is constructed with the help of D^2. The squire roots of average intra and inter cluster D^2 value are constructed in the cluster diagram. This diagram provides information on the following aspects:

- ❖ It indicates the genetic diversity in a simple understandable manner.
- ❖ The number of clusters represents the number of groups in which the genotypes can be classified on the basis of D^2 analysis.

- ❖ The distance between two clusters in the cluster diagram represents the degree of diversification. The higher the distance between two cluster the greater the divergence and vice versa.
- ❖ The genotypes remaining in the same cluster are more closely related then those belonging to another cluster. In other words, the genotypes grouped together in one cluster are less divergent than those which are placed in different cluster.
- ❖ The diagram represented the brief idea of the patter diversity among the genotypes and relationships between different genotypes included in the cluster.

3.15.4. Selection of Genotypes for Future Hybridization Programme

In order to select the genotypes for future hybridization programme, the considerable parameters are related to yield (kg), number of fruits per plant, color of fruit and presence, number of primary branches, node number of first male flower, no. of flower per days to first flowering, weight per fruit (kg), percent insect infestation of plants, fruit length (cm), fruit diameter (cm), number of seed per fruit, days to germination etc.

CHAPTER IV

RESULTS AND DISCUSSION

In the present investigation the data was collected from seventeen diverse bottle gourd genotypes on twenty-one traits related to vegetative, reproductive and yield components parameters emphasizing growth and yield. The study was carried out to find out the phenotypic and genotypic variability, co-efficient of variation, heritability, genetic advance, genetic advance of mean, correlation, path analysis and genetic diversity among different genotypes to estimate the direct and indirect effect of yield contributing traits on yield. This chapter comprises the presentation and discussion of the findings obtained from the study. The data were subjected to biometrical analysis and results obtained are presented below under the following headings:

- Characterization
- Genetic variability
- Correlation coefficient analysis
- Path coefficient analysis
- Genetic diversity analysis

4.1 Characterization of bottle gourd

4.1.1 Morphological characterization

4.1.1.1 Fruits colour

Fruit colour is one of the most important traits in bottle gourd on the basis of consumer preference marketing. Generally light green, green, deep green, white spotted green and whitish colour fruits are commonly found in the market. In the present study, fruit colour could be classified into distinct groups like light green, white spotted green, deep green and white. Among the seventeen genotypes, six genotypes (BG- 6820, BG- Barsha, BG- Diana, BG- 6824, BG- 6520 and BG- 6523) produced deep green fruits and another four genotypes (BG- 6309, BG- Martina, BG- Tafsi and BG- Arosh) produced white spotted green fruits; four genotypes (BG- 6307, BG- 6527, BG- 6813 and BG- Nico) produced light green fruits and the rest three genotypes (BG- 7092, BG- 6829 and BG- 6818) produced white fruits. (Table:3) (Plate: 6)

4.1.1.2 Fruits Shape

In marketing sector as per consumers demand fruit shape is an important feature. Various types of bottle gourds are available in the market. From the seventeen-genotypes under supervision round, elongate and oblong shaped bottle gourds were observed. The genotypes i.e., BG- 6309, BG- Martina, BG- 7092, BG- 6813, BG-Barsha, BG- 6824, BG- 6523, BG- 6307, BG- Arosh and BG- Nico were elongate shaped genotypes; BG- 6820**,** BG- Diana, BG- Tafsi and BG- 6520, BG- 6527 genotypes were oblong shaped bottle gourds and in the remaining genotypes i.e. BG-6829 and BG- 6818 round shaped bottle gourds were found. (Table3) (Plate 6) .

Table.3. Characterization of 17 bottle gourd genotypes

No of genotypes	Name of genotypes	Fruit colour	Fruit shape	Seed colour
1	**BG- 6309**	White spotted green	Elongate	Deep brown
2	**Martina**	White spotted green	Elongate	Light brown
3	**BG- 7092**	White	Elongate	White
4	**BG- 6820**	Deep green	Oblong	Deep brown
5	**BG- 6813**	Light green	Elongate	Deep brown
6	**BG- Barsha**	Deep green	Elongate	Deep brown
7	**BG- 6829**	White	Round	Light brown
8	**Diana**	Deep green	Oblong	Deep brown
9	**Tafsi**	White spotted green	Oblong	Light brown
10	**BG- 6824**	Deep green	Elongate	Deep brown
11	**BG- 6520**	Deep green	Oblong	Light brown
12	**BG- 6523**	Deep green	Elongate	Light brown
13	**BG- 6527**	Light green	Oblong	Deep brown
14	**BG- 6307**	Light green	Elongate	Deep brown
15	**BG- 6818**	White	Round	Black
16	**BG- Arosh**	White spotted green	Elongate	Light brown
17	**BG- Nico**	Light green	Elongate	Deep brown

Plate 6. Showing fruits of different genotypes

4.1.1.3 Seed color

Variation of colour is also found in the seed. Dark brown, light brown, black and white colored seeds are commonly found in bottle gourd. In the present study light brown, dark brown, black and white colored seed were observed. Genotypes BG- 6309, BG- 6820, BG- 6813, BG- Barsha, BG- Diana, BG- 6824, BG- 6527, BG- 6307 and BG- Nico produced deep brown seeds; Another BG- Martina, BG- 6829, BG- Tafsi, BG- 6520, BG- 6523 and BG- Arosh produced light brown seeds, white seeds were produced by BG- 7092 and black seeds were produced by BG- 6818 (Table3) (Plate 7)

4.2 Genetic variability

The analysis of variance indicated that the existence of highly significant variation among the genotype studied. The mean, range, mean sum of square, variance components, genotypic and phenotypic co efficient of variance, heritability, genetic advance, genetic advance in percent of mean are presented in Table 4.

4.2.1. Days to first male flowering

Days to first male flowering showed significant variation among genotype with mean sum of square (4.75) (Table 4). The maximum duration was observed 58.66 days in BG-6527 and the minimum duration was 54.33 in BG- Tafsi with mean value 56.53 (Table 5). The difference between phenotypic variance (3.15) and genotypic variance (0.80) was with large environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 1.58% and 3.14% respectively. Singh and Lal (2005) in their study reported similar result. Heritability showed low (25.51%) with low genetic advance (0.93) and low genetic advance in percent of mean (1.65) revealed that which indicated character was controlled by non-additive genes therefore the selection based on this character would not be effective.

Table 4. Estimation of genetic parameters

Characters	Range	Mean	Sum of Square (MS)	Phenotypic variance	Genotypic variance	PCV (%)	GCV (%)	Heritability (%)	GA	GA (%)
Days to first male flowering	53-60	56.53	4.75*	3.15	0.80	3.14	1.58	25.51	0.93	1.65
Days to first female flowering	58-65	61.12	6.00**	2.99	1.50	2.83	2.01	50.37	1.79	2.93
Internode length (cm)	8.68-17.36	13.44	8.08**	4.63	1.72	16.01	9.76	37.14	1.65	12.25
Tendril length (cm)	13.74-28.46	20.55	11.15^{ns}	8.56	1.30	14.24	5.54	15.14	0.91	4.44
Sex ratio (male)	3-7	4.67	2.29**	1.34	0.48	24.79	14.80	35.62	0.85	18.19
Sex ratio (female)	3-7	5.25	1.69**	1.07	0.31	19.69	10.58	28.83	0.61	11.70
Male petiole length (cm)	5.4-12.65	9.47	7.13**	3.24	1.95	18.99	14.72	60.12	2.23	23.52
Female petiole length (cm)	6.9-15	9.53	3.38^{ns}	2.70	0.34	17.24	6.10	12.54	0.42	4.45
Female ovary diameter (cm)	2-6.2	3.69	1.61**	0.85	0.38	24.95	16.79	45.29	0.86	23.27
Number of primary branches	33-10	19.06	82.68**	31.82	25.43	29.60	26.46	79.93	9.29	48.73
Days to first fruit harvest	75-83	79.35	14.19*	9.47	2.36	3.88	1.94	24.90	1.58	1.99
No of fruit per plant	3-7	4.27	2.84**	1.36	0.74	27.24	20.18	54.88	1.32	30.79
Fruit length (cm)	20.4-56	36.69	254.66**	98.79	77.93	27.09	24.06	78.89	16.15	44.03
Fruit diameter (cm)	21-52	32.70	127.90**	56.55	35.68	23.00	18.27	63.09	9.77	29.89
Fruit weight (kg)	0.654-2.62	1.48	0.33**	0.13	0.10	24.54	21.48	76.61	0.57	38.72
Seed length (cm)	1.4-2.3	1.80	0.06*	0.04	0.01	10.75	5.76	28.67	0.11	6.35
Seed diameter (cm)	0.5-1.3	0.88	0.08**	0.03	0.02	20.97	16.37	60.95	0.23	26.33
Seed thickness (cm)	0.2-0.5	0.35	0.01**	0.01	0.003	22.61	15.39	46.32	0.08	21.57
100 seed weight (gm)	5-19	11.57	35.37**	13.45	10.96	31.70	28.61	81.48	6.16	53.21
No of seed per fruit	111-523	206.76	11161.70**	4785.57	3188.07	33.46	27.31	66.62	94.94	45.92
Fruit yield per plant (kg)	3.048-10.92	6.17	6.63**	3.06	1.78	28.36	21.62	58.12	2.10	33.96

Table 5. Mean performance of 17 bottle gourd genotypes

Variety	Days to first male flowering	Days to first female flowering	Internode length (cm)	Tendril length (cm)	Sex ratio (male)	Sex ratio (female)	Male petiole length (cm)	Female petiole length (cm)	Female ovary diameter (cm)	Number of primary branches
BG-6309	57.00 a-e	60.33 c-f	11.24 ef	22.10 a-c	5.00 bc	5.66 ab	8.63 e-g	7.86 c	3.03 d-f	11.00 f
BG-Martina	58.00 ab	60.66 b-f	13.65 a-f	22.17 a-c	4.66 b-d	5.33 a-c	10.21 a-e	8.56 bc	2.93 ef	15.00 ef
BG-7092	56.33 a-f	62.33 a-c	14.25 a-d	20.08 b-d	6.00 ab	4.66 bc	10.65 a-d	9.40 a-c	3.36 c-f	21.33 bc
BG-6820	55.66 b-f	63.33 a	12.24 c-f	21.71 a-c	3.00 e	5.00 bc	7.53 gh	10.40 a-c	3.53 c-f	22.33 bc
BG-6813	55.33 c-f	59.66 ef	15.38 ab	20.24 a-d	4.66 b-d	6.00 ab	11.66 a	10.33 a-c	4.10 b-d	19.33 cd
BG-Barsha	57.33 a-d	61.33 a-e	14.82 a-c	21.29 a-c	4.33 c-e	6.66 a	11.13 a-c	9.30 a-c	3.50 c-f	21.33 bc
BG- 6829	57.66 a-c	62.00 a-d	14.04 a-e	16.66 d	3.33 de	5.33 a-c	9.76 b-f	9.90 a-c	2.43 f	15.66 de
BG-Diana	56.66 a-f	60.00 d-f	13.65 a-f	22.63 ab	6.66 a	6.66 a	6.13 h	8.26 c	5.23 a	16.33 de
BG- Tafsi	54.33 f	59.33 ef	16.30 a	20.28 a-d	4.33 c-e	5.33 a-c	9.16 d-g	11.33 a	3.10 d-f	16.00 de
BG-6824	56.66 a-f	62.33 a-c	15.42 ab	18.04 cd	4.66 b-d	4.00 c	8.20fg	8.80 a-c	4.10 b-d	13.33 ef
BG-6520	56.66 a-f	62.66 ab	15.32 ab	21.35 a-c	5.33 a-c	5.33 a-c	10.33 a-e	9.73 a-c	3.76 c-e	14.00 ef
BG-6523	58.00 ab	62.66 ab	13.11 b-f	19.28 b-d	4.00 c-e	4.00 c	11.20 ab	8.63 bc	4.36 a-c	25.33 b
BG-6527	58.66 a	62.66 ab	12.01 c-f	19.16 b-d	5.33 a-c	5.00 bc	10.73 a-d	10.86ab	3.53 c-f	25.33 b
BG-6307	57.33 a-d	61.33 a-e	10.94 f	19.64 b-d	4.66 b-d	5.00 bc	8.16 fg	10.06 a-c	3.33 c-f	14.33 ef
BG-6818	55.66 b-f	59.66 ef	11.78 d-f	18.54 b-d	4.33 c-e	4.66 bc	7.73 gh	7.96 c	3.33 c-f	30.66 a
BG-Arosh	54.66 ef	59.00 f	12.16 c-f	21.44 a-c	4.33 c-e	5.00 bc	10.46 a-e	10.92ab	5.10 ab	23.00 bc
BG-Nico	55.00 d-f	59.66 ef	12.16 c-f	24.62 a	4.66 b-d	5.66 ab	9.30 c-g	9.70 a-c	3.93 c-e	19.66 cd
LSD	2.55	2.55	2.03	2.84	4.48	1.54	1.45	1.89	2.56	1.13
SD	1.76	1.76	1.70	2.12	2.88	1.14	1.02	1.76	1.64	0.93
SE	0.25	0.25	0.24	0.30	0.40	0.16	0.14	0.25	0.23	0.13
Minimum	54.33	53.00	58.00	8.68	13.74	3.00	3.00	5.40	6.90	2.00
Maximum	58.67	60.00	65.00	17.36	28.46	7.00	7.00	12.65	15.00	6.20
Mean	56.53	56.53	61.12	13.44	20.55	4.67	5.25	9.47	9.53	3.69
CV (%)	2.71	2.71	1.99	12.70	13.12	19.89	16.61	11.99	16.12	18.45

Table 5. (contd.) Mean performance of 17 bottle gourd

Variety	Days to first fruit harvest	No of fruit per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (kg)	Seed length (cm)	Seed diameter (cm)	Seed thickness (cm)	100 seed weight (gm)	No of seed per fruit	Fruit yield per plant (kg)
BG-6309	80.33 a-c	3.66 bc	43.66 bc	33.66 c-e	1.76 bc	1.80 a-e	0.60 g	0.33 cd	8.00 gh	235.00 b-e	6.43 c-f
BG-Martina	81.66 ab	4.00 bc	47.66 ab	25.66 f	1.19 e	1.66 c-e	0.80 d-f	0.36 bc	6.33 h	185.67 d-h	4.70 fg
BG-7092	77.66 b-d	3.66 bc	51.66 a	32.10 c-f	2.26 a	1.70 b-e	0.60 g	0.30 c-e	9.00 e-g	300.33 ab	8.18 a-c
BG-6820	80.33 a-c	4.33 bc	46.33 ab	31.33 d-f	1.57 b-d	1.73 b-e	0.76 e-g	0.33 cd	8.66 f-h	162.33 f-h	6.79 b-e
BG-6813	77.66 b-d	4.33 bc	32.66 e-g	26.33 ef	1.85 b	2.06 a	1.06 ab	0.36 bc	12.33 cd	126.00 h	7.98a-d
BG-Barsha	79.66 a-d	6.66 a	21.63 h	39.00 a-c	0.79 f	1.83 a-d	0.93 a-e	0.30 c-e	7.33 gh	251.33 b-d	5.24 e-g
BG- 6829	81.66 ab	4.33 bc	26.00 gh	43.33 ab	1.57 b-d	1.80 a-e	0.83 c-f	0.33 cd	11.33c-e	191.00 d-h	6.88b-e
BG-Diana	75.66 d	6.66 a	26.46 f-h	41.33 ab	1.33 de	1.93 a-c	0.90 b-e	0.36 bc	16.33 a	183.67 e-h	8.86 a
BG- Tafsi	80.33 a-c	3.66 bc	35.33 de	25.00 f	1.22 e	1.93 a-c	1.03 ab	0.23 e	17.66 a	155.33 gh	4.57 fg
BG-6824	81.66 ab	3.33 c	42.00 b-d	26.33 ef	1.41 de	1.63 de	0.66 fg	0.43 ab	12.33cd	261.67 bc	4.72 fg
BG-6520	77.00 cd	4.33 bc	27.33 f-h	36.66 b-d	1.45 de	1.86 a-d	0.96 a-d	0.33 cd	11.33c-e	164.67 f-h	6.27 d-f
BG-6523	77.00 cd	3.33 c	35.33 de	28.16 ef	1.46 de	1.80 a-e	1.00 a-c	0.46 a	13.66 bc	144.33 gh	4.83 fg
BG-6527	82.33 a	4.00 bc	44.10 a-c	31.66 c-f	1.45 de	1.96 ab	1.10 a	0.26 de	11.66 cd	361.00 a	5.90 e-g
BG-6307	81.00 a-c	4.00 bc	33.76 ef	25.23 f	1.54 cd	1.83 a-d	1.03 ab	0.36 bc	16.33 a	155.00 gh	6.10 d-g
BG-6818	79.00 a-d	3.66 bc	25.70 gh	45.66 a	1.20 e	1.53 e	0.93 a-e	0.43 ab	11.00 d-f	209.67 c-g	4.37 g
BG-Arosh	80.33 a-c	4.00 bc	37.00 c-e	32.00 c-f	1.19 e	1.60 de	0.78 d-g	0.30 c-e	8.00 gh	227.33 c-f	4.67 fg
BG-Nico	75.66 d	4.66 b	47.00 ab	32.33 c-f	1.82 bc	1.83 a-d	1.00 a-c	0.43 ab	15.33 ab	200.67 c-g	8.37 ab
LSD	4.44	1.30	7.60	7.60	0.29	0.27	0.19	0.10	2.62	66.47	1.88
SD	3.09	1.15	9.75	7.38	0.36	0.19	0.18	0.08	3.60	72.10	1.75
SE	0.43	0.16	1.37	1.03	0.05	0.03	0.03	0.01	0.50	10.10	0.25
Minimum	75.00	3.00	20.40	21.00	0.65	1.40	0.50	0.20	5.00	111.00	3.05
Maximum	83.00	7.00	56.00	52.00	2.62	2.30	1.30	0.50	19.00	523.00	10.92
Mean	79.35	4.27	36.69	32.70	1.48	1.80	0.88	0.35	11.57	206.76	6.17
CV (%)	3.36	18.29	12.45	13.97	11.87	9.08	13.10	16.57	13.64	19.33	18.36

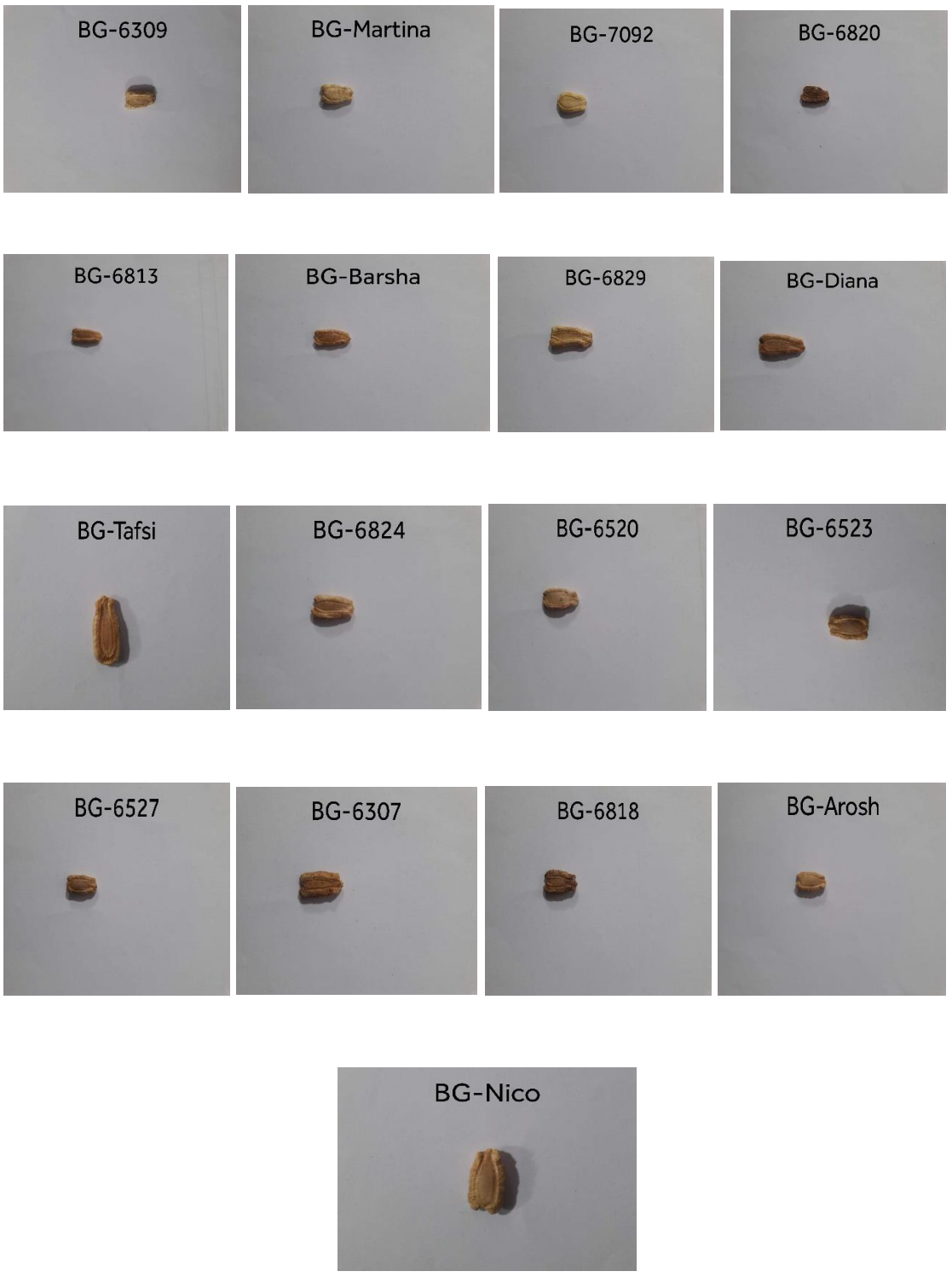

Plate 7. Showing seeds of different genotypes

4.2.2. Days to first female flowering

Highly significant variation showed in days to first female flowering among genotypes with mean sum of square (6.00) (Table 4). The maximum duration was observed 63.33 days in BG-6820 and the minimum duration was 59.00 in BG-Arosh with mean value 61.12 (Table 5)**.** The difference between phenotypic variance (2.99) and genotypic variance (1.50) was with large environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 2.01% and 2.85% respectively. Heritability showed moderate (50.37%) with low genetic advance (1.79) and low genetic advance in percent of mean (2.93) revealed that which indicated character was controlled by non-additive genes so that the selection based on this character would not be effective. Singh and Lal (2005) also found similar result in their study.

4.2.3. Internode length (cm)

Internode length (cm) showed highly significant difference among genotypes with mean sum of square (8.08) (Table 4). The maximum internode length was observed 16.30 cm in BG- Tafsi and the minimum internode length was 10.94 cm in BG- 6307 with mean value 13.44 (Table 5). The difference between phenotypic variance (4.63) and genotypic variance (1.72) was with large environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 9.76% and 16.01% respectively. Heritability moderate (37.14%) with low genetic advance (1.65) and moderate genetic advance in percent of mean (12.25) revealed that which indicated character was controlled by non-additive genes and the selection based on this character would not be effective.

4.2.4. Tendril length (cm)

Tendril length (cm) showed non-significant variation among genotype with mean sum of square (11.15) (Table 4). The maximum tendril length was observed 24.62 cm in BG-Nico and the minimum tendril length was 16.66 in BG- 6829 with mean value 20.55 (Table 5). The difference between phenotypic variance (8.56) and genotypic variance (1.30) was with large environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 5.54% and 14.24% respectively. Heritability showed low (15.14%) with low genetic advance (0.91) and low genetic advance in percent of mean (4.44) revealed that which indicated

character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.5. Sex ratio (male)

Highly significant variation was observed in sex ratio (male) among genotypes with mean sum of square (0.09) (Table 4). Gaffar (2008) found significant difference in sponge gourd. The maximum sex ratio was observed 6.66 in BG-Diana and the minimum sex ratio was 3 in BG- 6820 with mean value of 4.67 (Table 5). The difference between phenotypic variance (1.34) and genotypic variance (0.48) was slightly higher indicating less influence of environment on this character (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 14.80% and 24.79% respectively. Heritability showed moderate (35.62%) with low genetic advance (0.85) and moderate genetic advance in percent of mean (18.19) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.6. Sex ratio (female)

Sex ratio (female) showed highly significant variation among genotype mean sum of square (1.69) (Table 2). The maximum sex ratio was observed 6.66 days in BG-Diana and the minimum sex ratio was in BG- 6523, BG- 6824(4) with mean value 5.25 (Table 5). The difference between phenotypic variance (1.07) and genotypic variance (0.31) with slightly higher environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 10.58% and 19.69% respectively. Heritability showed low (28.83%) with low genetic advance (0.61) and moderate genetic advance in percent of mean (11.70) revealed that the character was governed by non-additive gene. Singh *et al*. (2002) also estimated high GCV and PCV for male flowers per plant in ridge gourd.

4.2.7. Male petiole length (cm)

Male petiole length (cm) flowering showed highly significant variation among genotype mean sum of square (7.13) (Table 4). The maximum male petiole length was observed 11.66 cm in BG-6813 and the minimum male petiole length was 6.13 in BG-Diana with mean value 9.47 cm (Table 5). The difference between phenotypic variance

(3.24) and genotypic variance (1.95) (Table 2). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 14.72% and 18.99% respectively. Heritability showed high (60.12%) with low genetic advance (2.23) and high genetic advance in percent of mean (23.52) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.8. Female petiole length (cm)

Female petiole length (cm) showed non-significant variation among genotype mean sum of square (3.38) (Table 4). The maximum female petiole length was observed 11.33 cm in BG- Tafsi and the minimum female petiole length was 7.86 in BG- 6309 with mean value 9.53 (Table 5). The difference between phenotypic variance (2.70) and genotypic variance (0.34) (Table 2). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 6.10% and 17.24% respectively indicating that high influence of environment on this character. Heritability showed low (12.54%) with low genetic advance (0.42) and low genetic advance in percent of mean (4.45) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.9. Female ovary diameter (cm)

Female ovary diameter (cm) showed highly significant variation among genotype mean sum of square (1.61) (Table 4). The maximum female ovary diameter was observed 5.23 cm in BG-Diana and the minimum female ovary diameter was 2.43 in BG- 6829 with mean value 3.69 (Table 5). The difference between phenotypic variance (0.85) and genotypic variance (0.38) was slightly higher indicating less influence of environment on this character (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 16.79% and 24.95% respectively. Heritability showed moderate (45.29%) with low genetic advance (0.86) and high genetic advance in percent of mean (23.27) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.10. Number of primary branches

Number of primary branches showed highly significant variation among genotype mean sum of square (82.68) (Table 4). The maximum number of primary branches was observed 30.66 in BG-6818 and the minimum number of primary branches was 11.00 in BG- 6309 with mean value 19.06 (Table 5). The difference between phenotypic variance (31.82) and genotypic variance (25.43) was with large environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 26.46% and 29.60% respectively were indicated presence of higher variability in this trait. Heritability showed high (79.93%) with low genetic advance (9.29) and high genetic advance in percent of mean (48.73) revealed that which indicated character was controlled by non-additive genes the selection based on this character would be ineffective.

4.2.11. Days to first fruit harvest

Days to first fruit harvest showed significant variation among genotype mean sum of square (14.19) (Table 4). The maximum duration was observed 82.33 days in BG-6527 and the minimum duration was 75.66 in BG-Nico with mean value 79.35 (Table 5). The difference between phenotypic variance (9.47) and genotypic variance (2.36) was slightly higher indicating less influence of environment on this character (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 1.94% and 3.88% respectively was indicated presence of low variability in this trait. Heritability showed low (24.90%) with low genetic advance (1.58) and low genetic advance in percent of mean (1.99) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.12. No of fruit per plant

No of fruit per plant showed highly significant variation among genotype mean sum of square (2.84) (Table 4). The maximum no of fruit per plant was observed 6.66 in BG-Barsha and the minimum no of fruit per plant was in BG- 6523 (3.33) with mean value 4.27 (Table 5). The difference between phenotypic variance (1.36) and genotypic variance (0.74) was with large environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 20.18% and 27.24% respectively. Heritability showed moderate (54.88%) with low genetic

advance (1.32) and high genetic advance in percent of mean (30.79) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective. 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.

4.2.13. Fruit length (cm)

Fruit length (cm) showed highly significant variation among genotype mean sum of square (254.66) (Table 2). The maximum fruit length was observed 51.66 cm in BG-7092 and the minimum fruit length was 21.63 in BG- Barsha with mean value 36.69 (Table 5). The difference between phenotypic variance (98.79) and genotypic variance (77.93) was with large environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 24.06% and 27.09% respectively were indicated presence of considerable variability in this trait. Heritability showed high (78.89%) with moderate genetic advance (16.15) and high genetic advance in percent of mean (44.03). Genetic advances in percent of mean were higher which is in accordance with the findings of Singh *et al*. (1973). Islam and Khan (1991) reported high heritability for this trait

4.2.14. Fruit diameter (cm)

Fruit diameter (cm) showed highly significant variation among genotype mean sum of square (127.90) (Table 4). The maximum fruit diameter was observed 45.66 cm in BG-6818 and the minimum fruit diameter was in BG- Tafsi (25.00 cm) with mean value 32.70 (Table 5). The difference between phenotypic variance (56.55) and genotypic variance (35.68) which indicated large environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 18.27% and 23.00% respectively. Heritability showed high (63.09%) with low genetic advance (9.77) and high genetic advance in percent of mean (29.89) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.15. Fruit weight (kg)

Fruit weight (kg) showed highly significant variation among genotype mean sum of square (0.33) (Table 4). The maximum fruit weight was observed 2.26 kg in BG-7092 and the minimum fruit weight was in BG- Barsha (0.79 kg) with mean value 1.48 kg (Table 5). The difference between phenotypic variance (0.13) and genotypic variance (0.10) indicating less influence of environment on this character (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 21.48% and 24.54% respectively were indicated presence of high variability in this trait. Heritability showed high (76.61%) with low genetic advance (0.57) and high genetic advance in percent of mean (38.72) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.16. Seed length (cm)

Seed length (cm) showed significant variation among genotype mean sum of square (0.06) (Table 4). The maximum seed length was observed 2.06 cm in BG-6813 and the minimum seed length was in BG- 6818 (1.53 cm) with mean value 1.80 (Table 5). The difference between phenotypic variance (0.04) and genotypic variance (0.01) was with less environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 5.76% and 10.75% respectively indicating less variability was found in this character. Heritability showed low (28.67%) with low genetic advance (0.11) and low genetic advance in percent of mean (6.35) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.17. Seed diameter (cm)

Seed diameter (cm) showed highly significant variation among genotype mean sum of square (0.08) (Table 4). The maximum seed diameter was observed 1.10 cm in BG-6527 and the minimum seed diameter was in BG-7092, BG-6309 (0.60 cm) with mean value 0.88 (Table 5). The difference between phenotypic variance (0.03) and genotypic variance (0.02) was with less environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 16.37% and 20.97% respectively. Heritability showed high (60.95%) with low genetic advance (0.23) and high genetic advance in percent of mean (26.33). Mathew and Khader (1999)

also reported high heritability in snake gourd. Genetic advances in percent of mean were higher which is in accordance with the findings of Singh *et al*. (1973). Islam and Khan (1991) reported high heritability for this trait.

4.2.18. Seed thickness (cm)

Seed thickness (cm) showed highly significant variation among genotype mean sum of square (0.01) (Table 4). The maximum seed thickness was observed 0.46 cm in BG-6523 and the minimum seed thickness was in BG- Tafsi (0.23 cm) with mean value 0.35 (Table 5). The difference between phenotypic variance (0.01) and genotypic variance (0.003) suggested less influence of environment on the expression of genes controlling this trait (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 15.39% and 22.61% respectively. Heritability showed moderate (46.32%) with low genetic advance (0.08) and high genetic advance in percent of mean (21.75) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.19. 100 seed weight (g)

Significant mean sum of square for 100 seed weight (gm) (35.37) indicated considerable difference for 100 seed weight (gm) among the genotypes studied. (Table 4). The maximum weight was observed 17.66 g in BG-Tafsi and the minimum weight was 6.33 g in BG- Martina with mean value 11.57 g (Table 5). The difference between phenotypic variance (13.45) and genotypic variance (10.96) was with large environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 28.61% and 31.70% respectively indicated presence of high variability in this trait. Heritability showed high (81.48%) with low genetic advance (6.16) and high genetic advance in percent of mean (53.21) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.2.20. No of seed per fruit

Number of seed per fruit showed highly significant variation among genotype mean sum of square (11161.70) (Table 4). The maximum no of seed per fruit was observed 361.00 in BG-6527 and the minimum no of seed per fruit was in BG- 6813 (126.00)

with mean value 206.76 (Table 5). The difference between phenotypic variance (4785.57) and genotypic variance (3188.07) was with large environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 27.31% and 33.46% respectively indicated presence of high variability in this trait. Heritability showed high (66.62%) with high genetic advance (94.94) and high genetic advance in percent of mean (45.92) revealed that which indicated character was controlled by additive genes the selection based on this character would be effective.

4.2.21. Fruit yield per plant (kg)

Fruit yield per plant (kg) showed highly significant variation among genotype mean sum of square (6.63) (Table 4). The maximum fruit yield per plant was observed 8.86 kg in BG-Diana and the minimum was 4.37 kg in BG- 6818 with mean value 6.17 (Table 5). The difference between phenotypic variance (3.06) and genotypic variance (1.78) with less environmental influence (Table 4). The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 21.62% and 28.36% respectively which indicating that considerable variation exists among different genotypes. Heritability showed moderate (58.12%) with low genetic advance (2.10) and high genetic advance in percent of mean (33.96) revealed that which indicated character was controlled by non-additive genes the selection based on this character would not be effective.

4.3. Correlation

Improvement of a particular character all the breeding programs can be achieved by indirect selection via different characters. This wants a good understanding of the association of various characters with the target character and among the different characters themselves. It's necessary to have the estimates of correlation of yield with different characters that the genotype might be assessed visually. The makeup and constitution correlation reveals the extent of association between completely different characters, thus, it helps to base choice procedure to a needed balance, once 2 opposite fascinating characters moving the principal characters are being selected. A positive correlation happens because of coupling section of linkage and correlation arises because of repulsion section of linkage of genes dominant completely different traits.

No correlation indicates that genes involved are situated so much apart on identical chromosome or they're situated on completely different bodies. Yield being a fancy character is governed by an outsized range of genes. The influence of every character on yield might be well-known through correlation studies with a view to see the extent and nature of relationships prevailing among yield and yield attributing characters. So, the constitution and phenotypic correlation co-efficient values for fourteen characters in bottle gourd genotypes studied are given in (Table 6).

4.3.1. Days to first male flowering

Days to first male flowering showed highly significant and positive correlation with days to first female flowering (G= 0.960, P= 0.354), days to first fruit harvest (G= 0.703), no of fruit per plant (G= 0.285) and no of seed per fruit (G= 0.453). It also observed that highly significant but negative correlation with 100 seed weight (g) (G= -0.327). Non-significant and positive correlation with number of primary branches (P= 0.053), days to first fruit harvest (P= 0.124), fruit length (cm) (P= 0.077), fruit diameter (cm) (P= 0.142), fruit weight (kg) (P= 0.013), seed length (cm) (G= 0.162, P= 0.041), seed diameter (cm) (G= 0.055), seed thickness (G= 0.147, P= 0.072) and no of seed per fruit (P= 0.227) and non-significant but negative correlation number of primary branches (G= -0.266), no of fruit per plant (P= -0.115), fruit length (cm) (G= -0.153), fruit diameter (cm) (G= -0.006), fruit weight (kg) (G= -0.228), seed diameter (cm) (P= -0.024), 100 seed weight (g) (P= -0.137) and fruit yield per plant (kg) (G= -0.053, P= -0.140).

4.3.2. Days to first female flowering

Days to first female flowering showed non-significant and positive correlation with number of primary branches (G= 0.023), days to first fruit harvest (G= 0.247, P= 0.160), fruit length (cm) (G= 0.243, P= 0.100), fruit weight (kg) (G= 0.210, P= 0.170), seed length (cm) (P= 0.071), seed thickness (G= 0.072), no of seed per fruit (G= 0.263, P= 0.208) and fruit yield per plant (kg) (G= 0.003, P= 0.021) and non-significant but negative correlation number of primary branches (P= -0.004), no of fruit per plant (G= -0.205, P= -0.084), fruit diameter (cm) (G= -0.032, P= -0.049), seed length (cm) (G= -0.129), seed diameter (cm) (G= -0.199, P= -0.101), 100 seed thickness (cm) (P= -0.012) and 100 seed weight (g) (G= -0.179, P= -0.212

Table 6. Coefficients of phenotypic and genotypic correlation among different yield components

Trait		Days to first male flowering	Days to first female flowering	Number of primary branches	Days to first fruit harvest	No of fruit per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (kg)	Seed length (cm)	Seed diameter (cm)	Seed thickness (cm)	100 seed weight (gm)	No of seed per fruit
Days to first female flowering	G	0.960**												
	P	0.354**												
Number of primary branches	G	-0.266^{NS}	0.023^{NS}											
	P	0.053^{NS}	-0.004^{NS}											
Days to first fruit harvest	G	0.703**	0.247^{NS}	-0.242^{NS}										
	P	0.124^{NS}	0.160^{NS}	-0.066^{NS}										
No of fruit per plant	G	0.285*	-0.205^{NS}	0.001^{NS}	-0.506**									
	P	-0.115^{NS}	-0.084^{NS}	-0.107^{NS}	-0.235^{NS}									
Fruit length (cm)	G	-0.153^{NS}	0.243^{NS}	-0.078^{NS}	0.326*	-0.521**								
	P	0.077^{NS}	0.100^{NS}	-0.055^{NS}	0.024^{NS}	-0.467**								
Fruit diameter (cm)	G	-0.006^{NS}	-0.032^{NS}	0.272*	-0.298*	0.583**	-0.693**							
	P	0.142^{NS}	-0.049^{NS}	0.302*	-0.172^{NS}	0.327*	-0.402**							
Fruit weight (kg)	G	-0.228^{NS}	0.210^{NS}	-0.167^{NS}	-0.466**	-0.373**	0.558**	-0.293*						
	P	0.013^{NS}	0.170^{NS}	-0.093^{NS}	-0.157^{NS}	-0.382**	0.562**	-0.079^{NS}						
Seed length (cm)	G	0.162^{NS}	-0.129^{NS}	-0.323*	-0.413**	0.462**	-0.229^{NS}	-0.273*	0.252^{NS}					
	P	0.041^{NS}	0.071^{NS}	-0.187^{NS}	-0.165^{NS}	0.269^{NS}	-0.161^{NS}	-0.116^{NS}	0.097^{NS}					
Seed diameter (cm)	G	0.055^{NS}	-0.199^{NS}	0.308*	-0.438**	0.281*	-0.438**	-0.058^{NS}	-0.323*	0.745**				
	P	-0.024^{NS}	-0.101^{NS}	0.267^{NS}	-0.010^{NS}	0.091^{NS}	-0.396**	-0.096^{NS}	-0.210^{NS}	0.496**				
Seed thickness (cm)	G	0.147^{NS}	0.072^{NS}	0.164^{NS}	-0.398**	-0.080^{NS}	-0.082^{NS}	0.090^{NS}	0.089^{NS}	-0.546**	-0.030^{NS}			
	P	0.072^{NS}	-0.012^{NS}	0.101^{NS}	-0.357**	-0.221^{NS}	0.031^{NS}	-0.008^{NS}	0.103^{NS}	-0.145^{NS}	0.049^{NS}			
100 seed weight (gm)	G	-0.327*	-0.179^{NS}	-0.151^{NS}	-0.507**	0.040^{NS}	-0.220^{NS}	-0.195^{NS}	0.103^{NS}	0.681**	0.626**	0.175^{NS}		
	P	-0.137^{NS}	-0.212^{NS}	-0.081^{NS}	-0.216^{NS}	0.006^{NS}	-0.204^{NS}	-0.116^{NS}	0.087^{NS}	0.316*	0.503**	0.155^{NS}		
No of seed per fruit	G	0.453**	0.263^{NS}	0.284*	0.581**	-0.107^{NS}	0.365**	0.156^{NS}	0.047^{NS}	-0.293*	-0.301*	-0.411**	-0.369**	
	P	0.227^{NS}	0.208^{NS}	0.118^{NS}	0.157^{NS}	0.066^{NS}	0.301*	0.167^{NS}	0.088^{NS}	-0.118^{NS}	-0.307*	-0.208^{NS}	-0.329*	
Fruit yield per plant (kg)	G	-0.053^{NS}	0.003^{NS}	-0.179^{NS}	-0.904**	0.322*	0.161^{NS}	0.179^{NS}	0.747**	0.668**	-0.018^{NS}	0.087^{NS}	0.258^{NS}	-0.155^{NS}
	P	-0.140^{NS}	0.021^{NS}	-0.200^{NS}	-0.336*	0.509**	0.091^{NS}	0.179^{NS}	0.564**	0.343*	-0.047^{NS}	-0.079^{NS}	0.181^{NS}	0.088^{NS}

4.3.3. Number of primary branches

Number of primary branches showed highly significant and positive correlation with fruit diameter (cm) (G= 0.272, P= 0.302), seed diameter (cm) (G= 0.308) and no of seed per fruit (G= 0.284) It also observed that highly significant but negative correlation with seed length (cm) (G= -0.323). Non-significant and positive correlation with no of fruit per plant (G= 0.001), seed diameter (cm) (P= 0.267), seed thickness (cm) (G= 0.164, P= 0.101) and no of seed per fruit (P= 0.118) and non-significant but negative correlation days to first fruit harvest (G= -0.242, P= -0.066), no of fruit per plant (P=-0.107), fruit length (cm) (G= -0.078, P= -0.055), fruit weight (kg) (G= -0.167, P= -0.093), seed length (cm) (P= -0.187), 100 seed weight (gm) (G= -0.151, P= -0.081) and fruit yield per plant (kg) (G= -0.179, P= -0.200).

4.3.4. Days to first fruit harvest

Days to first fruit harvest showed highly significant and positive correlation with fruit length (cm) (G= 0.326) and no of seed per fruit (G= 0.581). It also observed that highly significant but negative correlation with no of fruit per plant (G= -0.506), fruit diameter (cm) (G= -0.298), fruit weight (kg) (G= -0.466), seed length (cm) (G= -0.413), seed diameter (cm) (G= -0.438), seed thickness (cm) (G= -0.398, P= -0.357), 100 seed weight (g) (G= -0.507) and fruit yield per plant (kg) (G= -0.904, P= -0.336). Non-significant and positive correlation with fruit length (cm) (P= 0.024) and no of seed per fruit (P= 0.157) and non-significant but negative correlation no of fruit per plant (P= -0.235), fruit diameter (cm) (P= -0.172), fruit weight (kg) (P= -0.157), seed length (cm) (P= -0.165), seed diameter (cm) (P= -0.010) and 100 seed weight (gm) (P= -0.216).

4.3.5. No of fruit per plant

No of fruit per plant showed highly significant and positive correlation with fruit diameter (cm) (G= 0.583, P= 0.327), seed length (cm) (G= 0.462), seed diameter (cm) (G= 0.281) and fruit yield per plant (kg) (G= 0.322, P= 0.509). It also observed that highly significant but negative correlation with fruit length (cm) (G= -0.521, P= -0.467) and fruit weight (kg) (G= -0.373, P= -0.382). Non-significant and positive correlation with seed length (cm) (P= 0.269), seed diameter (cm) (P= 0.091), 100 seed weight (g) (G= 0.040, P= 0.006) and no of seed per fruit (P= 0.066) and non-significant but negative correlation seed thickness (cm) (G= -0.080, P= -0.221) and no of seed per fruit (G= -0.107).

4.3.6. Fruit length (cm)

Fruit length (cm) showed highly significant and positive correlation with fruit weight (kg) (G= 0.558, P= 0.562) and no of seed per fruit (G= 0.365, P= 0.301). It also observed that highly significant but negative correlation with fruit diameter (cm) (G= -0.693, P= -0.402) and seed diameter (cm) (G= -0.438, P= -0.396). Non-significant and positive correlation with seed thickness (cm) (P= 0.031) and fruit yield per plant (kg) (G= 0.161, P= 0.091) and non-significant but negative correlation seed length (cm) (G= -0.229, P= -0.161), seed thickness (cm) (G= -0.082) and 100 seed weight (g) (G= -0.220, P= -0.204).

4.3.7. Fruit diameter (cm)

Fruit diameter (cm) showed significant but negative correlation with fruit weight (kg) (G= -0.293) and seed length (cm) (G= -0.273). Non-significant and positive correlation with seed thickness (cm) (G= 0.090), no of seed per fruit (G= 0.156, P= 0.167) and fruit yield per plant (kg) (G= 0.179, P= 0.179) and non-significant but negative correlation fruit weight (kg) (P= -0.079), seed length (cm) (P= -0.116), seed diameter (cm) (G= - 0.058, P=- 0.096), seed thickness (cm) (P= -0.008) and 100 seed weight (g) (G= -0.195, P= -0.116).

4.3.8. Fruit weight (kg)

Fruit weight (kg) showed highly significant and positive correlation with fruit yield per plant (kg) (G= 0.747, P= 0.564). It also observed that highly significant but negative correlation with fruit diameter (cm) (G= -0.323). Non-significant and positive correlation with seed length (cm) (G= 0.252, P= 0.097), seed thickness (cm) (G= 0.089, P= 0.103), 100 seed weight (gm) (G= 0.103, P= 0.087) and no of seed per fruit (G= 0.047, P= 0.088) and non-significant but negative correlation seed diameter (cm) (P= -0.210).

4.3.9. Seed length (cm)

Seed length (cm) showed highly significant and positive correlation with seed diameter (cm) (G= 0.745, P= 0.496), 100 seed weight (g) (G= 0.681, P= 0.316) and fruit yield per plant (kg) (G= 0.668, P= 0.343). It also observed that highly significant but negative correlation with seed thickness (cm) (G= -0.546) and no of seed per fruit (G= -0.293). Non-significant and negative correlation with seed thickness (cm) (P= -0.145) and no

of seed per fruit (P= -0.118).

4.3.10. Seed diameter (cm)

Seed diameter (cm) showed highly significant and positive correlation with 100 seed weight (gm) (G= 0.626, P= 0.503). It also observed that highly significant but negative correlation with no of seed per fruit (G= -0.301, P= -0.307). Non-significant and positive correlation with seed thickness (cm) (P= 0.049). Non-significant and negative correlation with seed thickness (cm) (G= -0.030) and fruit yield per plant (kg) (G= -0.018, P= -0.047).

4.3.11. Seed thickness (cm)

Seed thickness (cm) not showed highly significant and positive correlation. It also observed that highly significant but negative correlation with no of seed per fruit (G= -0.411). Non-significant but positive correlation 100 seed weight (gm) (G= 0.175, P= 0.155) and fruit yield per plant (kg) (G= 0.087) and non-significant but negative correlation no of seed per fruit (P= -0.208) and fruit yield per plant (kg) (P= -0.079).

4.3.12. 100 seed weight (g)

100 seed weight (g) not showed highly significant and positive correlation. It also observed that highly significant but negative correlation with no of seed per fruit (G= -0.369, P= -0.329) and non-significant but positive correlation fruit yield per plant (kg) (G= 0.258, P= 0.181).

4.3.13. No of seed per fruit

No of seed per fruit showed highly significant and positive and negative correlation. Non-significant and positive correlation with no of seed per fruit (P= 0.088) and non-significant but negative correlation no of seed per fruit (G= -0.155).

4.4. Path Coefficient Analysis

Association of character determined by correlation co-efficient may not provide an exact picture of the relative importance of direct and indirect influence of each of yield components on seed yield per plant. In order to find out a clear picture of the inter-relationship between seed yield per plant and other yield attributes, direct and indirect

effects were worked out using path analysis at phenotypic level which also measured the relative importance of each component. Though correlation analysis denotes the association pattern of components traits with yield, they basically represent the overall effect of a particular trait on yield rather than providing cause and effect relationship. The technique of path coefficient analysis developed by Wright (1921) and demonstrated by Dewey and Lu (1959) facilitates the portioning of correlation coefficients into direct and indirect contribution of various characters on yield. It is standardized partial regression coefficient analysis. As such, it measures the direct effect of one variable upon other. Such information would be of great value in enabling the breeder to exclusively identify the important component traits of yield and use the genetic resources for improvement in a planned way. In path coefficient analysis the direct effect of a trait on seed yield per plant and its indirect effect through other characters were calculated and the results are presented in Table 7 and Table 8.

4.4.1. Days to first male flowering

Path co-efficient analysis revealed that days to first male flowering had a negative direct effect (**-0.190**) on fruit yield per plant (kg). Days to first male flowering had positive indirect effect on days to first female flowering (0.152), number of primary branches (0.220), no of fruit per plant (0.117), seed diameter (cm) (0.058), 100 seed weight (g) (0.107) and no of seed per fruit (0.079) while negative indirect effect on days to first fruit harvest (-0.260), fruit length (cm) (-0.071), fruit diameter (cm) (-0.003), fruit weight (kg) (-0.198), seed length (cm) (-0.063) and seed thickness (cm) (-0.0019). It showed non-significant negative phenotypic correlation (**-0.140**) with fruit yield per plant (kg). (Table 7)

4.4.2. Days to first female flowering

Path co-efficient analysis revealed that days to first female flowering had a positive direct effect (0.159) on fruit yield per plant (kg). Days to first male flowering had positive indirect effect on fruit length (cm) (0.112), fruit weight (kg) (0.180), seed length (cm) (0.051), 100 seed weight (g) (0.059) and no of seed per fruit (0.046) while negative indirect effect on days to first male flowering (-0.182), number of primary branches (-0.019), days to first fruit harvest (-0.091), no of fruit per plant (-0.084), fruit diameter (cm) (-0.016), seed diameter (cm) (-0.211) and seed thickness (cm) (-0.0009). It showed non-significant positive phenotypic correlation (0.021) with fruit yield/plant

Table 7. Partitioning of phenotypic into direct and indirect effects of morphological characters of 17 bottle gourd genotypes by path coefficient analysis

Trait	Days to first male flowering	Days to first female flowering	Number of primary branches	Days to first fruit harvest	No of fruit per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (kg)	Seed length (cm)	Seed diameter (cm)	Seed thickness (cm)	100 seed weight (gm)	No of seed per fruit	Fruit yield per plant (kg)
Days to first male flowering	**-0.041**	-0.010	-0.002	0.005	-0.099	0.003	0.003	0.012	-0.0001	-0.0010	0.0018	-0.010	-0.001	**-0.140^{NS}**
Days to first female flowering	-0.014	**-0.029**	0.0001	0.007	-0.072	0.005	-0.001	0.150	-0.0002	-0.004	-0.0003	-0.016	-0.001	**0.021^{NS}**
Number of primary branches	-0.002	0.00012	**-0.032**	-0.003	-0.092	-0.002	0.006	-0.081	0.0005	0.011	0.002	-0.006	-0.0009	**-0.200^{NS}**
Days to first fruit harvest	-0.005	-0.005	0.002	**0.042**	-0.203	0.001	-0.004	-0.138	0.0004	-0.0004	-0.009	-0.017	-0.001	**-0.336***
No of fruit per plant	0.005	0.002	0.003	-0.010	**0.861**	-0.021	0.007	-0.336	-0.0007	0.003	-0.005	0.0005	-0.0005	**0.509****
Fruit length (cm)	-0.003	-0.003	0.002	0.001	-0.402	**0.045**	-0.008	0.494	0.0004	-0.016	0.0008	-0.016	-0.002	**0.091^{NS}**
Fruit diameter (cm)	-0.006	0.001	-0.010	-0.007	0.281	-0.018	**0.021**	-0.069	0.0003	-0.004	-0.0002	-0.009	-0.001	**0.179^{NS}**
Fruit weight (kg)	-0.001	-0.005	0.003	-0.007	-0.329	0.025	-0.002	**0.879**	-0.0003	-0.0089	0.002	0.006	-0.0006	**0.564****
Seed length (cm)	-0.002	-0.002	0.006	-0.007	0.232	-0.007	-0.002	0.085	**-0.0026**	0.0209	-0.003	0.024	0.0008	**0.343***
Seed diameter (cm)	0.001	0.003	-0.009	-0.0004	0.079	-0.018	-0.002	-0.185	-0.0013	**0.042**	0.001	0.039	0.002	**-0.047^{NS}**
Seed thickness (cm)	-0.003	0.0003	-0.003	-0.015	-0.191	0.001	-0.0001	0.090	0.0004	0.0021	**0.025**	0.012	0.001	**-0.079^{NS}**
100 seed weight (gm)	0.006	0.006	0.003	-0.009	0.005	-0.009	-0.002	0.076	-0.0008	0.0212	0.003	**0.078**	0.002	**0.181^{NS}**
No of seed per fruit	-0.009	-0.006	-0.004	0.007	0.057	0.014	0.003	0.077	0.0003	-0.0129	-0.005	-0.0259	**-0.007**	**0.088^{NS}**
Residual effect = 0.05														

Table 8. Partitioning of genotypic into direct and indirect effects of morphological characters of 17 bottle gourd genotypes by path coefficient analysis

Trait	Days to first male flowering	Days to first female flowering	Number of primary branches	Days to first fruit harvest	No of fruit per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (kg)	Seed length (cm)	Seed diameter (cm)	Seed thickness (cm)	100 seed weight (gm)	No of seed per fruit	Fruit yield per plant (kg)
Days to first male flowering	**-0.190**	0.152	0.220	-0.260	0.117	-0.071	-0.003	-0.198	-0.063	0.058	-0.0019	0.107	0.079	-0.053^{NS}
Days to first female flowering	-0.182	**0.159**	-0.019	-0.091	-0.084	0.112	-0.016	0.182	0.051	-0.211	-0.0009	0.059	0.046	0.003^{NS}
Number of primary branches	0.051	0.004	**-0.828**	0.090	0.0003	-0.036	0.135	-0.145	0.127	0.327	-0.0021	0.050	0.050	-0.179^{NS}
Days to first fruit harvest	-0.134	0.039	0.201	**-0.369**	-0.208	0.151	-0.148	-0.405	0.162	-0.465	0.0051	0.166	0.102	-0.904**
No of fruit per plant	-0.054	-0.033	-0.00058	0.187	**0.411**	-0.241	0.290	-0.324	-0.181	0.298	0.0010	-0.013	-0.019	0.322*
Fruit length (cm)	0.029	0.038	0.065	-0.120	-0.214	**0.463**	-0.345	0.485	0.090	-0.465	0.0011	0.072	0.064	0.161^{NS}
Fruit diameter (cm)	0.001	-0.005	-0.225	0.110	0.240	-0.321	**0.497**	-0.254	0.107	-0.061	-0.0012	0.064	0.027	0.179^{NS}
Fruit weight (kg)	0.043	0.033	0.139	0.172	-0.153	0.258	-0.146	**0.869**	-0.099	-0.343	-0.0011	-0.034	0.008	0.747**
Seed length (cm)	-0.031	-0.020	0.267	0.152	0.190	-0.106	-0.136	0.219	**-0.392**	0.791	0.0070	-0.223	-0.051	0.668**
Seed diameter (cm)	-0.010	-0.032	-0.255	0.162	0.115	-0.203	-0.029	-0.280	-0.292	**1.063**	0.0004	-0.205	-0.053	-0.018^{NS}
Seed thickness (cm)	-0.028	0.011	-0.135	0.147	-0.033	-0.038	0.045	0.077	0.214	-0.032	**-0.0128**	-0.057	-0.072	0.087^{NS}
100 seed weight (gm)	0.062	-0.028	0.125	0.187	0.016	-0.102	-0.097	0.089	-0.267	0.666	-0.0022	**-0.327**	-0.065	0.258^{NS}
No of seed per fruit	-0.086	0.042	-0.235	-0.214	-0.044	0.169	0.077	0.041	0.115	-0.319	0.0053	0.121	**0.175**	-0.155^{NS}
Residual effect = 0.044														

4.4.3. Number of primary branches

Path co-efficient analysis revealed that number of primary branches had a negative direct effect (-0.828) on fruit yield per plant (kg). Number of primary branches had positive indirect effect on days to first male flowering (0.151), days to first female flowering (0.004), days to first fruit harvest (0.090), no of fruit per plant (0.0003), fruit diameter (cm) (0.135), seed length (cm) (0.127), seed diameter (cm) (0.327), 100 seed weight (g) (0.050) and no of seed per fruit (0.050) while negative indirect effect on fruit length (cm) (-0.036), fruit weight (kg) (-0.145) and seed thickness (cm) (-0.0021). It showed non-significant negative phenotypic correlation (-0.200) with fruit yield per plant (kg). (Table 7).

4.4.4. Days to first fruit harvest

Path co-efficient analysis revealed that days to first fruit harvest had a negative direct effect (-0.369) on fruit yield per plant (kg). Days to first fruit harvest had positive indirect effect on days to first female flowering (0.039), number of primary branches (0.201), fruit length (cm) (0.151), seed length (cm) (0.162), seed thickness (cm) (0.0051), 100 seed weight (g) (0.166) and no of seed per fruit (0.102) while negative indirect effect on days to first male flowering (-0.134), no of fruit per plant (-0.208), fruit diameter (cm) (-0.148), fruit weight (kg) (-0.405) and seed diameter (cm) (-0.465). It showed highly significant negative phenotypic correlation (-0.336) with fruit yield per plant (kg). (Table 7).

4.4.5. No of fruit per plant

Path co-efficient analysis revealed that no of fruit per plant had a positive direct effect (0.411) on fruit yield per plant (kg). No of fruit per plant had positive indirect effect via number of primary branches (0.00058), days to first fruit harvest (0.187), fruit diameter (cm) (0.290), seed diameter (cm) (0.298) and seed thickness (cm) (0.0010) while negative indirect effect via days to first male flowering (-0.054), days to first female flowering (-0.033), fruit length (cm) (-0.241), fruit weight (kg) (-0.324), seed length (cm) (-0.181), 100 seed weight (g) (-0.013) and no of seed per fruit (-0.019). It showed significant positive phenotypic correlation (0.509) with fruit yield per plant (kg). (Table 7)

4.4.6. Fruit length (cm)

Path co-efficient analysis revealed that fruit length (cm) had a positive direct effect (**0.463**) on fruit yield per plant (kg). Fruit yield per plant (kg) positive indirect effect on days to first male flowering (0.029), days to first female flowering (0.038), number of primary branches (0.065), fruit weight (kg) (0.485), seed length (cm) (0.090), seed thickness (cm) (0.0011), 100 seed weight (g) (0.072) and no of seed per fruit (0.064) while negative indirect effect on days to first fruit harvest (-0.120), no of fruit per plant (-0.214), fruit diameter (cm) (-0.345) and seed diameter (cm) (-0.465).It showed non-significant positive phenotypic correlation (0.091) with fruit yield per plant (kg). (Table 7).

4.4.7. Fruit diameter (cm)

Path co-efficient analysis revealed that fruit diameter (cm) had a positive direct effect (0.497) on fruit yield per plant (kg). Fruit diameter (cm) had positive indirect effect on days to first male flowering (0.001), days to first fruit harvest (0.110), no of fruit per plant (0.240), seed length (cm) (0.107), 100 seed weight (g) (0.064) and no of seed per fruit (0.027) while negative indirect effect on days to first female flowering (-0.005), number of primary branches (-0.225), fruit length (cm) (-0.321), fruit weight (kg) (-0.254), seed diameter (cm) (-0.061) and seed thickness (cm) (-0.0012). It showed non-significant positive phenotypic correlation (0.179) with fruit yield per plant (kg). (Table 5)

4.4.8. Fruit weight (kg)

Path co-efficient analysis revealed that fruit weight (kg) had a positive direct effect (0.869) on fruit yield per plant (kg). Fruit weight (kg) had positive indirect effect via days to first male flowering (0.043), days to first female flowering (0.033), number of primary branches (0.139), days to first fruit harvest (0.172), fruit length (cm) (0.258) and no of seed per fruit (0.008). while negative indirect effect via no of fruit per plant (-0.153), fruit diameter (cm) (-0.146), seed length (cm) (-0.099), seed diameter (cm) (-0.343), seed thickness (cm) (-0.0011) and 100 seed weight (g) (-0.034). It showed highly significant positive phenotypic correlation (0.564) with fruit yield per plant (kg). (Table 7)

4.4.9. Seed length (cm)

Path co-efficient analysis revealed that seed length (cm) had a negative direct effect (-0.392) on fruit yield per plant (kg). Seed length (cm) had positive indirect effect on number of primary branches (0.267), days to first fruit harvest (0.152), no of fruit per plant (0.190), fruit weight (kg) (0.219), seed diameter (cm) (0.791) and seed thickness (cm) (0.0070). While negative indirect effect on days to first male flowering (-0.031), days to first female flowering (-0.020), fruit length (cm) (-0.106), fruit diameter (cm) (-0.136), 100 seed weight (g) (-0.223) and no of seed per fruit (-0.051). It showed highly significant positive phenotypic correlation (0.343) with fruit yield per plant (kg). (Table 7)

4.4.10. Seed diameter (cm)

Path co-efficient analysis revealed that seed diameter (cm) had a positive direct effect (1.063) on fruit yield per plant (kg). Seed diameter (cm) had positive indirect effect on days to first fruit harvest (0.162), no of fruit per plant (0.115) and seed thickness (cm) (0.0004). While negative indirect effect on days to first male flowering (-0.010), days to first female flowering (-0.032), number of primary branches (-0.255), fruit length (cm) (-0.230), fruit diameter (cm) (-0.029), fruit weight (kg) (-0.280), seed length (-0.292), 100 seed weight (g) (-0.205) and no of seed per fruit (-0.053). It showed non-significant negative phenotypic correlation (-0.047) with fruit yield per plant (kg). (Table 7)

4.4.11. Seed thickness (cm)

Path co-efficient analysis revealed that seed thickness (cm) had a negative direct effect (-0.0128) on fruit yield per plant (kg). Seed thickness (cm) had positive indirect effect on days to first female flowering (0.011), days to first fruit harvest (0.147), fruit diameter (cm) (0.045), fruit weight (kg) (0.077) and seed length (cm) (0.214). While negative indirect effect on days to first male flowering (-0.028), number of primary branches (-0.135), no of fruit per plant (-0.033), fruit length (cm) (-0.038), seed diameter (cm) (-0.032), 100 seed weight (g) (-0.057) and no of seed per fruit (-0.072). It showed non-significant negative phenotypic correlation (-0.079) with fruit yield per plant (kg). (Table 7)

4.4.12. 100 seed weight (g)

Path co-efficient analysis revealed that 100 seed weight (gm) had a negative direct effect (-0.327) on fruit yield per plant (kg). 100 seed weight (gm) had positive indirect effect on days to first male flowering (0.062), number of primary branches (0.125), days to first fruit harvest (0.187), no of fruit per plant (0.016), fruit weight (kg) (0.089) and seed diameter (cm) (0.666). While negative indirect effect on days to first female flowering (-0.028), fruit length (cm) (-0.102), seed length (cm) (-0.267), seed thickness (cm) (-0.0022) and no of seed per fruit (-0.065. It showed non-significant positive phenotypic correlation (0.181) with fruit yield per plant (kg). (Table 7)

4.4.13. No of seed per fruit

Path co-efficient analysis revealed that no of seed per fruit had a positive direct effect (0.175) on fruit yield per plant (kg). No of seed per fruit had positive indirect effect on days to first female flowering (0.042), fruit length (cm) (0.169), fruit diameter (cm) (0.077), fruit weight (kg) (0.041), seed length (cm) (0.115), seed thickness (cm) (0.0053) and 100 seed weight (g) (0.121). While negative indirect effect on days to first male flowering (-0.086), number of primary branches (-0.235), days to first fruit harvest (-0.214), no of fruit per plant (-0.044) and seed diameter (cm) (-0.319). It showed non-significant positive phenotypic correlation (0.088) with fruit yield per plant (kg). (Table 7)

4.5. Genetic diversity analysis of the bottle gourd genotypes

Genetic divergence in bottle gourd was analyzed by using GENSTAT software programme. Genetic diversity analysis involved several steps i.e., estimation of distance between the genotypes, clusters and analysis of inter-cluster distance. Therefore, more than one multivariate technique was required to represent the results more clearly and it was obvious from the results of many researchers (Bashar. 2002; Uddin, 2001; Juned et al., 1988 and Ario, 1987). In the analysis of genetic diversity in bottle gourd multivariate techniques were used.

4.5.1. Construction of scatter diagram

In multivariate analysis, cluster analysis refers to methods used to divide up objects into similar groups, or more precisely, groups whose members are all close to one another on various dimensions being measured. Depending on the values of principal

component scores 2 and 1 obtained from the principal component analysis, a two-dimensional scatter diagram (Z1-Z2) using component score 2 as X-axis and component score 1 as Y-axis was constructed, which has been presented in Figure 1. The position of the genotypes in the scatter diagram was apparently distributed into five groups, which indicated that there existed considerable diversity among the genotypes.

4.5.2. Principal component analysis (PCA)

Genetic divergence analysis quantifies the genetic distance among the selected genotypes and reflects the relative contribution of specific traits towards the total divergence and is an important tool for breeding program. The diversity analysis is useful to determine the magnitude of divergence among population (Murthy and Quadri, 1966). The Principal component analysis was studied with seventeen genotypes of bottle gourd. Eigen values and latent vectors of corresponding 14 principal component axes and percentage of total variation accounting for them obtained from the principal component analysis are presented in (Table 7). It represents that the cumulative Eigen values of first five principal components accounted for 77.23% of the total variation; the first principal component accounted for 22.86% of the total variation; the second, third, fourth and fifth components accounted for 17.72%, 13.59%, 12.64% and 10.42% of the total variation, respectively. The rest of the components accounted for only 22.77% of the total variation.

4.5.3. Cluster analysis

The experiment was conducted to investigate the genetic diversity of seventeen genotypes of bottle gourd. The genotypes were divided into five cluster according to D^2 analysis (Table 10). Cluster I consist of three genotypes. These genotypes produced the highest mean for number of seed per fruit (249.33) and the lowest mean value (0.35) was the seed thickness (cm). (Table 10 & 11). Cluster II composed of two genotypes. These genotypes produced the highest mean for number of seed per fruit (330.66) and the lowest mean value (0.29) was the seed thickness (cm) (Table 10 & 11). Among the five clusters, cluster III composed of six genotypes. In cluster-III the highest mean for number of seed per fruit (151.28) and the lowest mean value for cluster- III (0.35) was the seed thickness (cm) (Table 10 & 11). Cluster IV consists of four genotypes. From the clustering mean values, it was observed that cluster IV produced the highest mean

Table 9. Eigen value, % variance and cumulative (%) total variance of the principal components

Principal component axes	Eigen value	% Variance	Cumulative (%) total variance
I	3.201	22.86	22.86
II	2.481	17.72	40.58
III	1.902	13.59	54.17
IV	1.769	12.64	66.81
V	1.459	10.42	77.23
VI	1.161	8.29	85.52
VII	0.577	4.12	89.64
VIII	0.556	3.97	93.61
IX	0.375	2.68	96.29
X	0.229	1.64	97.93
XI	0.127	0.91	98.84
XII	0.096	0.69	99.53
XIII	0.061	0.43	99.96
XIV	0.006	0.04	100

Table 10. Number, percent and name of genotypes in different cluster

Cluster number	Number of genotypes	Percent (%)	Name of genotypes
I	3	17.65	BG-6309, BG-Barsha, BG-6824
II	2	11.76	BG-7092, BG-6527
III	6	35.29	BG-6820, BG-6813, BG- Tafsi, BG-6520, BG-6523, BG-6307
IV	4	23.53	BG-Martina, BG- 6829, BG-Diana, BG-Nico
V	2	11.76	BG-6818, BG-Arosh

Table 11. Cluster mean for twelve yield and yield characters of 17 bottle gourd genotypes

Characters	I	II	III	IV	V
Days to first male flowering	57	57.5	56.22	56.84	55.17
Days to first female flowering	61.33	62.5	61.5	60.59	59.34
Number of primary branches	15.22	23.33	18.55	16.67	26.83
Days to first fruit harvest	80.56	80	78.89	78.67	79.66
No of fruit per plant	4.56	3.83	4	4.92	3.83
Fruit length (cm)	35.77	47.89	35.13	36.78	31.35
Fruit diameter (cm)	33	31.89	28.79	35.67	38.84
Fruit weight (kg)	1.33	1.86	1.52	1.48	1.19
Seed length (cm)	1.75	1.83	1.87	1.81	1.56
Seed diameter (cm)	0.73	0.85	0.98	0.88	0.85
Seed thickness (cm)	0.35	0.29	0.35	0.37	0.36
100 seed weight (gm)	9.22	10.34	13.33	12.33	9.5
No of seed per fruit	249.33	330.66	151.28	190.25	218.5
Fruit yield per plant (kg)	5.47	7.04	6.09	7.2	4.53

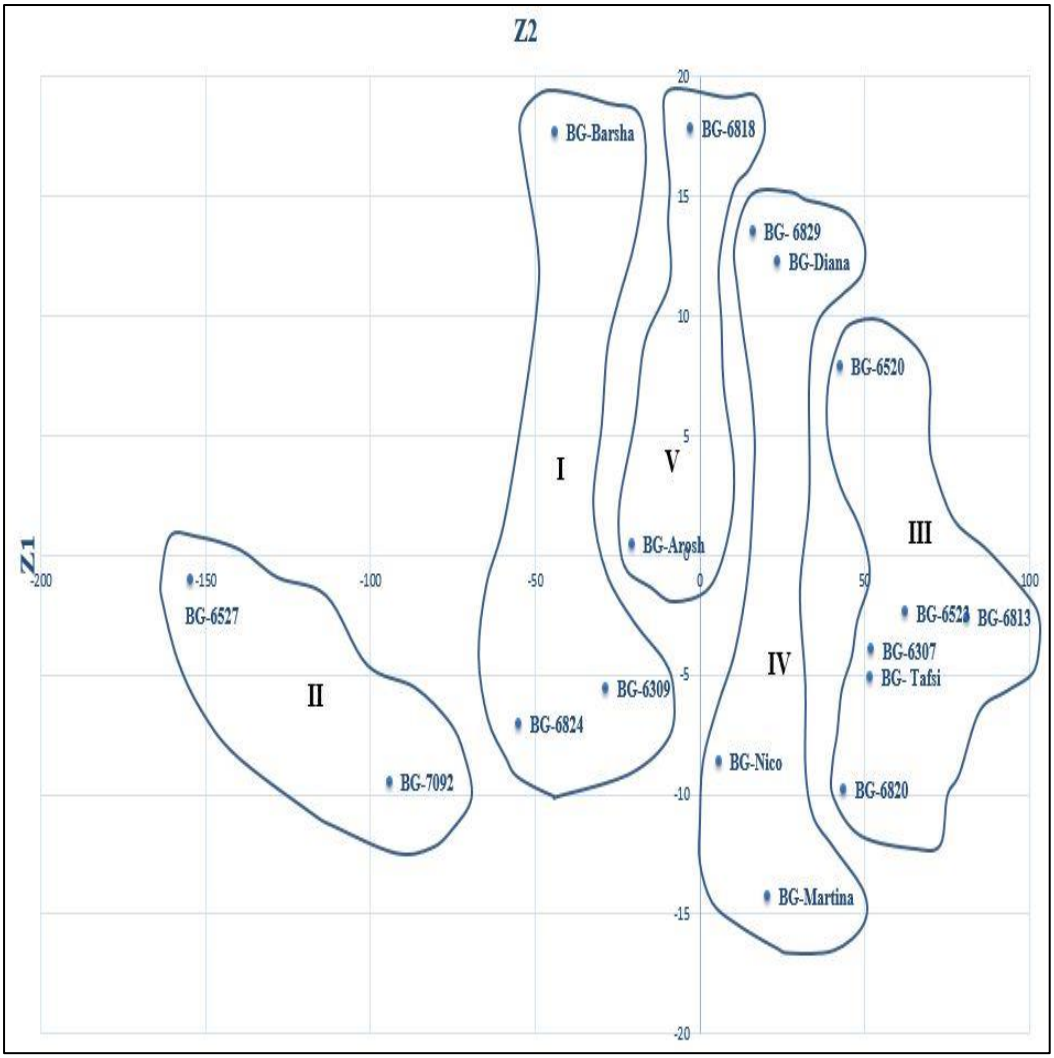

Figure 1. Scatter diagram of 17 bottle gourd genotypes of based on their principal component scores

values for number of seed per fruit (190.25) and the lowest mean value for cluster-IV (0.37) was the seed thickness (cm) (Table 10 & 11). Similar findings were mentioned by Rahman (2005). Cluster V constituted with two genotypes (Table 10). In cluster-V the highest mean for number of seed per fruit (218.5) and the lowest mean value for cluster-V (0.36) was the seed thickness. (cm) (Table 9). Desai *et al.* (1997) evaluated thirty-six genotypes of potato for genetic divergence by Mahalanobis's D^2 statistic. Nine clusters were identified; I being the largest, accommodating 7 genotypes. Cluster I, III, V, VI and VII showed larger genetic divergence. Joshi *et al*. (2003) assessed the nature and magnitude of genetic divergence using nonhierarchical Euclidean cluster analysis in 73 tomato genotypes of diverse origin for different quantitative and qualitative traits. Maximum value of (53.208) was recorded for shelf life of fruits while minimum value was 69.208 for days to first picking. The grouping of genotype into 15 clusters indicated the presence of wide range of genetic diversity among the genotypes.

4.5.4. Principal coordinate analysis

Principal coordinate analysis (PCO) was estimated on auxiliary principal component analysis. This analysis helps in estimating distances. By using these inter-genotypic distances intra-cluster genotypic distances were calculated (Table 12 & Figure 2) as suggested by Singh *et al.* (1977). Cluster I which (**0.992**) composed of three genotypes showed the maximum intra cluster distances and cluster **II** showed the lowest intra-cluster distance (**0.628**) which composed of two genotypes. The coordinates obtained from the Principal Component analysis (PCA) were used as input at Principal Coordinate Analysis (PCO) to calculate distances among the points reported by Digby *et al.* (1989). PCA was used for the graphical representation of the points while PCO was used to calculate the minimum distance straight line between each pair of points.

4.5.5. Canonical variate analysis

Conical variate analysis (CVA) was done to identify the inter-cluster distance. (Table 12) were presented intra and inter-cluster distance (D^2) values. In this experiment the inter-cluster distances were higher from intra-cluster distances. It showed that the wide range of genetic variability among genotypes of bottle gourd. Based on the result it indicated that the highest inter cluster distance was observed between II and V (16.083), followed by II and IV (15.568),

Table 12. Intra-inter cluster distance

Characters	I	II	III	IV	V
I	**0.992**				
II	13.504	**0.628**			
III	5.767	15.425	**0.656**		
IV	2.084	15.568	5.534	**0.915**	
V	2.798	16.083	7.102	1.573	**0.66**

II and III (15.425), I and II (13.504) and III and V (7.102). The lowest inter-cluster distance was observed between IV and V (1.573) followed by I and IV (2.084) and I and V (2.798). With the help of D^2 values within and between clusters, an arbitrary cluster diagram was constructed, which showed the relationship between different genotypes. Diagram also showed the intra and inter cluster distance of seventeen genotype of bottle gourd. However, the maximum inter-cluster distance was recorded between clusters II and V followed by between II and IV. Genotypes from these clusters can be used in hybridization programme. The intra-cluster divergence varied from 0.628 to 0.992 maximum for cluster I, which was comprised of three genotypes of diverse origin, while the minimum distance was observed in cluster II that comprised two genotypes. Islam *et al*., (1995) was carried out an experiment on groundnut (*Arachis Hypogaea* L.) and obtained larger inter-cluster distances than the intra-cluster distances in a multivariate analysis. Results obtained from different multivariate techniques were superimposed in Table 10 from which it might be concluded that all the techniques gave more or less similar results and one technique supplemented and confirmed the results of another one. The clustering revealed that varieties/genotype originating from the same places did not form a single cluster because of direct selection hat geographic diversity is not always related pressure. It has been observed to genetic diversity and therefore it is not adequate as an index of genetic diversity. Murty and Arunachalam (1966) studied that genetic drift and selection in different environment could cause greater diversity than geographic distance.

4.5.6. Non-hierarchical clustering

By using covariance matrix with the application of Non-hierarchical clustering, the 17 bottle gourd genotypes were grouped into 5 (five) clusters. These results confined the clustering pattern of the genotype according to the principal component analysis. Khan (2009) reported five clustering in different gourd. Compositions of different clusters with their corresponding genotypes in each cluster were presented in Table 11. These results confirmed the clustering pattern of the genotypes according to the principal component analysis. So, the results obtained through PCA were confirmed by non-hierarchical clustering.

4.5.6.1. Cluster I

Cluster I had three genotypes namely BG-6309, BG-Barsha and BG-6824 (Table 8). From the clustering mean values (Table 9), it was observed that Cluster-I produced the highest mean for no of seed per fruit (249.33) followed by days to first fruit harvest (80.56), days to first female flowering (61.33), days to first male flowering (57), fruit length (cm) (35.77), fruit diameter (cm) (33), number of primary branches (15.22), 100 seed weight (g) (9.22), no of fruit per plant (4.56), fruit yield per plant (kg) (5.47). The lowest mean value for cluster I (0.35) was seed thickness (cm).

4.5.6.2. Cluster II

Cluster II was composed of two genotypes namely BG-7092 and BG-6527 (Table 8). These genotypes produced the highest mean for no of seed per fruit (330.66) followed by days to first fruit harvest (80), days to first female flowering (62.5), days to first male flowering (57.5), fruit length (cm) (47.89), fruit diameter (cm) (31.89), number of primary branches (23.33), 100 seed weight (g) (10.34), no of fruit per plant (3.83), fruit yield per plant (kg) (7.04). The lowest mean value for cluster II (0.29) was seed thickness (cm). (Table 11).

4.5.6.3. Cluster III

From the clustering mean value, it was observed that Cluster III was composed of six genotypes namely BG-6820, BG-6813, BG- Tafsi, BG-6520, BG-6523 and BG-6307 (Table 8). These genotypes produced the highest mean for no of seed per fruit (151.28) followed by days to first fruit harvest (78.89), days to first female flowering (61.5), days to first male flowering (56.22), fruit length (cm) (35.13), fruit diameter (cm) (28.79), number of primary branches (18.55), 100 seed weight (g) (13.33), no of fruit per plant (4), fruit yield per plant (kg) (6.09). The lowest mean value for cluster III (0.35) was seed thickness (cm). (Table 11).

4.5.6.4. Cluster IV

From the clustering mean value (Table 9) it was observed that Cluster IV was consists of four genotypes BG-Martina, BG- 6829, BG-Diana and BG-Nico (Table 10). From the clustering mean values (Table 10), it was observed that cluster IV produced the highest mean values for no of seed per fruit (190.25) followed by days to first fruit harvest (78.67), days to first female flowering (59.34), days to first male flowering

(56.84), fruit length (cm) (36.78), fruit diameter (cm) (35.67), number of primary branches (16.67), 100 seed weight (g) (12.33), no of fruit per plant (4.92), fruit yield per plant (kg) (7.2). The lowest mean value for cluster IV (0.37) was seed thickness (cm). (Table 11).

4.5.6.5. Cluster V

Cluster V was constituted with two genotypes BG-6818 and BG-Arosh (Table 10). In Cluster-V the highest mean for no of seed per fruit (218.5) followed by days to first fruit harvest (79.66), days to first female flowering (61.33), days to first male flowering (55.17), fruit length (cm) (31.35), fruit diameter (cm) (38.84), number of primary branches (26.83), 100 seed weight (g) (9.5), no of fruit per plant (3.83), fruit yield per plant (kg) (4.53). The lowest mean value for cluster V (0.36) was seed thickness (cm). (Table 11).

4.6. Comparison of different multivariate techniques

The cluster pattern of D^2 analysis though non-hierarchical clustering has taken care of simultaneous variation in all the character under study. However, the distribution of genotypes in different cluster of the D^2 analysis has followed more or less similar trend of principal component analysis were found to be alternative methods in giving the information regarding the clustering pattern of genotypes. However, the principal component analysis provides the information regarding the contribution of characters towards divergence of bottle gourd.

4.7. Selection of genotypes for further hybridization

Identification and utilization of diverse germplasm is the main issue in plant breeding. Three factors (choice of particular cluster, selection of specific variety from a cluster and relative contribution of the character to the total divergence) should be considered for selecting parents for a breeding program (Chaudhary *et al*. 1977). Through knowledge of genetic diversity of the crop is necessary for parental selection that maximizes genetic improvement (Rahman *et al.* 2011). More accurate and complete description of genotypes and patterns of genetic diversity could help determinate future breeding strategies and facilitate introgression of diverse germplasm into the current commercial soybean genetic base (Baranek *et al*. 2002). Principal component analysis is useful as it gives information about the groups where certain traits are more important

allowing the breeders to conduct specific breeding program (Salimi *et al*. 2012). Genetically distant parents are usually able to produce highest heterosis. Based on cluster mean and agronomic performance the variety BG-Diana maximum sex ratio (male), maximum sex ratio (female), maximum female ovary diameter (cm) and maximum fruit yield per plant (kg) from cluster IV. BG- Tafsi minimum days to first male flowering, maximum female petiole length (cm) and maximum 100 seed weight (gm) from cluster III. BG-6818 maximum number of primary branches and maximum fruit diameter (cm) from cluster V. BG-7092 maximum fruit length (cm) and maximum fruit weight (kg) from cluster II. Therefore, considering group distance and other agronomic performance the inter genotypic crosses between and other improved variety and might be suggested for future hybridization program.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out at the Sher-e-Bangla Agricultural University farm, Bangladesh during March, 2019 to September, 2019 in kharif season for study on Genetic Variability and Characters Association in Bottle Gourd. The field experiment was laid out in the main field in Randomized Complete Block Design (RCBD) with three replications. In this experiment 17 bottle gourd genotypes were used as experimental materials. It was observed that significant variation exists among all the genotypes used for most of the characters studied. The longer duration was observed 61.66 days in BG-6527 and the early duration was in BG- Nico (54.66). The maximum internode length was observed 16.30 cm in BG- Tafsi and the minimum internode length was 10.94 cm in BG- 6307.The highest tendril length was observed 24.62 cm in BG-Nico and the lowest tendril length was in BG- 6829 (16.66).The maximum sex ratio (male) was observed (6.66) in BG-Diana and the minimum sex ratio was in BG- 6820 (3).The highest sex ratio (female) was observed 6.66 days in BG-Diana and the lowest sex ratio was in BG- 6523, BG- 6824(4).The maximum male petiole length was observed 11.66 cm in BG-6813 and the minimum male petiole length was in BG-Diana (6.13).The highest female petiole length was observed 11.33 cm in BG- Tafsi and the lowest female petiole length was in BG- 6309 (7.86). The maximum female ovary diameter was observed 5.23 cm in BG-Diana and the minimum female ovary diameter was in BG- 6829 (2.43). The highest number of primary branches was observed 30.66 in BG-6818 and the lowest number of primary branches was in BG- 6309 (11.00). The maximum duration was observed 82.33 days in BG-6527 and the minimum duration was in BG-Nico (75.66). The highest no of fruit per plant was observed 6.66 in BG-Barsha and the lowest no of fruit per plant was in BG- 6523 (3.33). The maximum fruit length was observed 51.66 cm in BG-7092 and the minimum fruit length was in BG-Barsha (21.63). The highest fruit diameter was observed 45.66 cm in BG-6818 and the lowest fruit diameter was in BG- Tafsi (25.00). The maximum fruit weight was observed 2.26 kg in BG-7092 and the minimum fruit weight was in BG- Barsha (0.79). The highest seed length was observed 2.06 cm in BG-6813 and the lowest seed length was in BG- 6818 (1.53). The maximum seed diameter was observed 1.10 cm in BG-

6527 and the minimum seed diameter was in BG-7092, BG-6309 (0.60). The highest seed thickness was observed 0.46 cm in BG-6523 and the lowest seed thickness was in BG- Tafsi (0.23). The maximum weight was observed 17.66 gm in BG-Tafsi and the minimum weight was in BG- Martina (6.33). The highest no of seed per fruit was observed 361.00 in BG-6527 and the lowest no of seed per fruit was in BG- 6813 (126.00). The maximum fruit yield per plant was observed 8.86 kg in BG-Diana and the minimum was found in BG- 6818 (4.37 kg).

The phenotypic variance was higher than the corresponding genotypic variance in all the characters observed under close supervision, indicating greater influence of environment on the expression of these characters. The maximum difference between phenotypic and genotypic co efficient of variation were 28.61% and 31.70% which indicated that 100 seed weight (gm) mostly dependent on environmental effect. The highest heritability estimates among fourteen yield contributing characters were male petiole length (cm), number of primary branches, fruit length (cm), fruit diameter (cm), fruit weight (kg), seed diameter (cm), 100 seed weight (gm) and no of seed per fruit. The lowest heritability was found in days to first male flowering, internode length (cm), tendril length (cm), sex ratio (female), female petiole length (cm), days to first fruit harvest and seed length (cm). The maximum genetic advance was observed in male petiole length (cm), female ovary diameter (cm), number of primary branches, no of fruit per plant, fruit length (cm), fruit diameter (cm), fruit weight (kg), seed diameter (cm), seed thickness (cm), 100 seed weight (gm), no of seed per fruit and fruit yield per plant (kg). The maximum genetic advance in percent of mean was observed for male petiole length (cm), female ovary diameter (cm), number of primary branches, no of fruit per plant, fruit length (cm), fruit diameter (cm), fruit weight (kg), seed diameter (cm), seed thickness (cm), 100 seed weight (gm), no of seed per fruit and fruit yield per plant (kg). Correlation coefficients among the characters were studied to determine the association between yield and yield components. Correlation revealed that fruit yield per plant had positive association with no of fruit per plant, fruit weight (kg) and seed length (cm). Path co-efficient analysis revealed that positive and direct effect on days to first female flowering, no of fruit per plant, fruit length (cm), fruit diameter (cm), fruit weight (kg), seed diameter (cm) and no of seed per fruit. The direct effect of number of fruits per plant and fruit weight on fruit yield per plant is very high in both phenotypic and genotypic level. Selection through these traits may be effective for yield

improvement. Multivariate analysis, cluster analysis and Canonical variate analysis revealed significant difference among the cluster. Genetic diversity among bottle gourd genotypes was performed through Principal Component Analysis (PCA), Cluster Analysis, Canonical Variate Analysis (CVA) using GENSTAT According to PCA, PCO and Cluster analysis, the genotypes were grouped into five different clusters. The cluster III comprised the maximum number 6 of genotypes, followed by cluster IV comprised of 4 genotypes. The cluster I, II and V comprised 3, 2 and 2 genotypes, respectively. The highest inter-cluster distance was observed between II and V and the lowest inter-cluster distance was observed between IV and V. The highest and lowest intra-cluster distances were observed in cluster I and II respectively. Considering diversity pattern, genetic status and other agronomic performances, Considering the magnitude of genetic distance, contribution of character towards divergence, magnitude of cluster means and agronomic performance the genotype BG-Martina from cluster IV, BG-Diana maximum sex ratio (male), maximum sex ratio (female), maximum female ovary diameter (cm) and maximum fruit yield per plant (kg) from cluster IV. BG- Tafsi minimum days to first male flowering, maximum female petiole length (cm) and maximum 100 seed weight (gm) from cluster III. BG-6818 maximum number of primary branches and maximum fruit diameter (cm) from cluster V. BG-7092 maximum fruit length (cm) and maximum fruit weight (kg) from cluster II. Diverse genotypes in crossing programme may produce desirable segregants. So, divergent genotypes (BG- Diana, BG- 7092 BG- 6818) are recommended to use as parent in hybridization programme in future.

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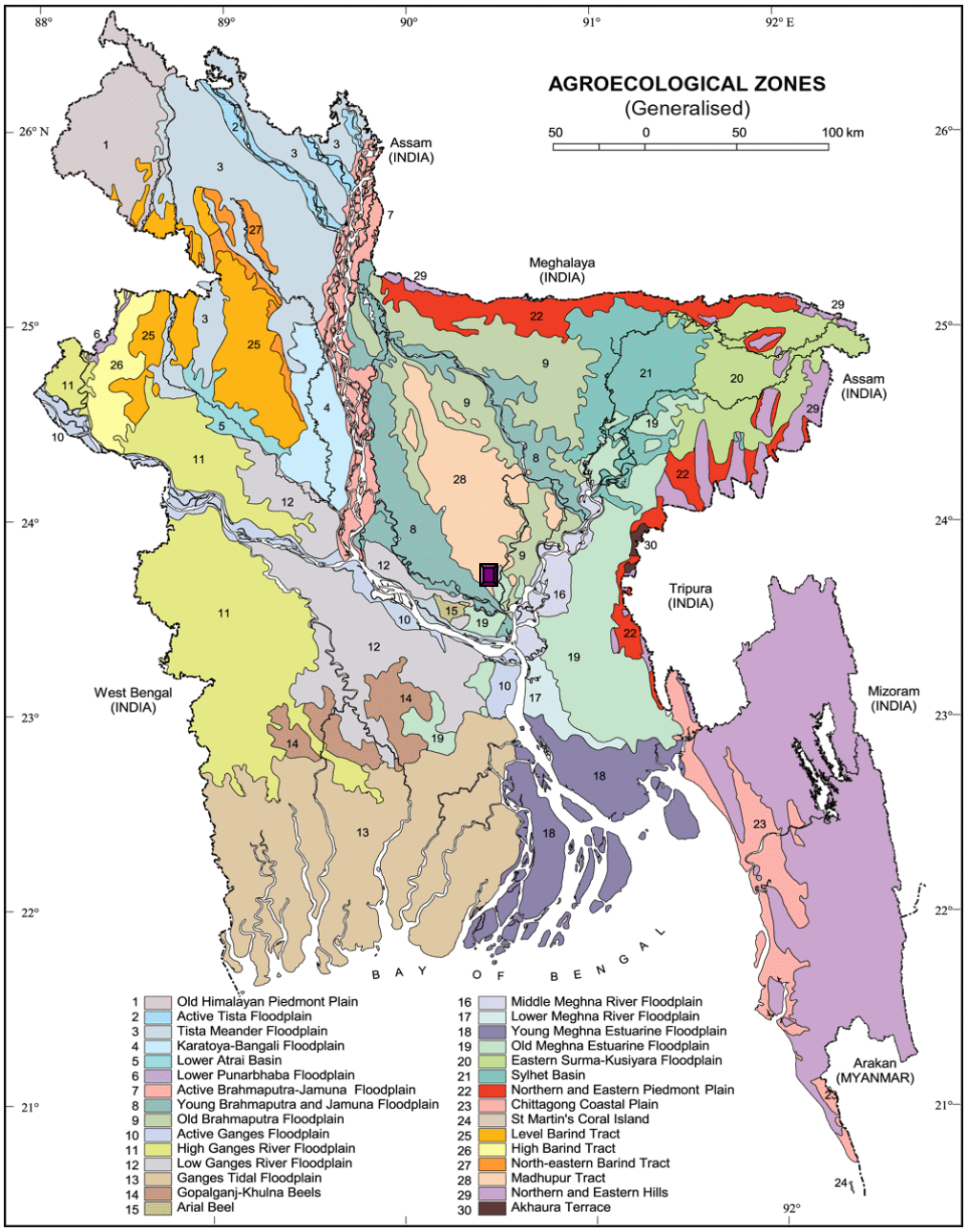

Appendix I. Map showing the experimental site under study

Appendix II. Monthly average Temperature, Relative Humidity and Total Rainfall of the experimental site during the period from March, 2019 to September, 2019

Month	Air temperature		Relative Humidity (%)	Rainfall (mm) (total)	Sunshine (hr.)
	Maximum	Minimum			
March, 2019	31.50	21.10	69	72	5.4
April, 2019	33.70	23.60	65	173	7.8
May, 2019	34.90	26.40	63	195	3.8
June, 2019	33.60	26.60	59	260	5.7
July, 2019	33.10	26.90	55	368	8.1
August, 2019	33.80	27.20	61	216	7.5
September, 2019	33.30	26.50	66	162	9.5

Source: Bangladesh Bureau of Statistics (BBS), May 2020., Agargaon, Dhaka-1212

Appendix III. Morphological, physical and chemical characteristics of initial soil (0-15cm 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
01.	Organic carbon (%)	0.82	Walkley and Black, 1947
02	Total N (kg/ha)	1790.00	Bremmer and Mulvaney,1965
03	Total S (ppm)	225.00	Bardsley and Lanester,1965
04	Total P (ppm)	840.00	Olsen and Sommers, 1982
05	Available N (kg/ha)	54.00	Bremner, 1965
06	Available P (kg/ha)	69.00	Olsen and Dean ,1965
07	Exchangeable K (kg/ha)	89.00	Pratt, 1965
08	Available S (ppm)	16.00	Hunter,1984
09	PH (1:2.5 soil to water)	5.55	Jackson,1958
10	CEC	11.23	Chapman, 1965

Source: Central library, Sher-e-Bangla Agricultural University, Dhaka-1207.

Appendix iv. Analysis of variance

Source of variation	d.f.	Days to first male flowering	Days to first female flowering	Internode length (cm)	Tendril length (cm)	Sex ratio (male)	Sex ratio (female)	Male petiole length (cm)	Female petiole length (cm)	Female ovary diameter (cm)	Number of primary branches
Replication	2	1.82	0.94	1.36	1.28	0.55	0.14	0.11	2.31	1.23	1.82
Genotypes	16	4.75*	6.00**	8.08**	11.15^{ns}	2.29**	1.69**	7.13**	3.38^{ns}	1.61**	82.68**
Error	32	2.34	1.48	2.91	7.26	0.86	0.76	1.29	2.36	0.46	6.39

**

Appendix iv. (contd.) Analysis of variance

Source of variation	d. f.	Days to first fruit harvest	No of fruit per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (kg)	Seed length (cm)	Seed diameter (cm)	Seed thickness (cm)	100 seed weight (gm)	No of seed per fruit	Fruit yield per plant (kg)
Replication	2	11.53	0.55	6.15	5.00	0.09	0.02	0.01	0.003	1.49	15111.80	3.38
Genotypes	16	14.19*	2.84**	254.66**	127.90**	0.33**	0.06*	0.08**	0.01**	35.37**	11161.70**	6.63**
Error	32	7.11	0.61	20.86	20.87	0.03	0.03	0.01	0.003	2.49	1597.50	1.28