EVALUATION OF SOME BOTTLE GOURD GENOTYPES IN RELATION TO YIELD AND ITS CONTRIBUTING TRAITS

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CERTIFICATE

This is to certify that thesis entitled, ***"Evaluation of Some Bottle Gourd Genotypes in Relation to Yield and Its Contributing Traits"*** *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. Fozle Rabbi****, Registration No.:* ***18-09102*** *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 been duly been acknowledged by her.

Dated: December, 2020
Place: Dhaka, Bangladesh

(Dr. Firoz Mahmud)
Professor
Supervisor

Dedicated to
My Beloved
Parents

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ABSTRACT

The present investigation with seventeen genotypes of bottle gourd was conducted during Kharif season (March to September) in 2019 at the experimental field of Sher-e-Bangla Agricultural University. The experiment laid out in Randomized Complete Block Design (RCBD) with three replications. The main objective of the experiment was to evaluate the genotypes of bottle gourd in relation to yield and yield contributing characters. This helped to screen out the suitable bottle gourd genotypes for future breeding programme. Analysis of variance showed that mean sum of squares among genotypes was significant for all the traits. PCV were higher than the GCV for all the characters studied. Number of seed per fruit (98.06), number of primary branches (90.09), fruit length (87.57) and fruit weight (86.84) showed high heritability with high genetic advance. Correlation analysis revealed that fruit yield per plant showed the high positive and significant correlation with number of fruit per plant (g= 0.792, p= 0.797), fruit weight (g= 0.808, p= 0.713) and seed thickness (g= 0.655, p= 0.388) at both genotypic and phenotypic level. The path coefficient analysis revealed that positive and direct effect of fruit yield on days to first male flowering (0.006), days to first fruit harvest (0.067), number of fruit per plant (0.680), fruit length (0.043), fruit diameter (0.009) and fruit weight (0.602). The highest intra cluster distance was found in cluster-II (1.547). Among five clusters the highest inter cluster distance was observed between cluster-II and cluster-III (14.771) and the lowest between cluster-III and cluster-IV (4.919).Considering diversity pattern, genetic status and other agronomic performance, genotype from cluster I, II and V might be considered better parents for crop improvement programme. Genotypes BG- Diana, BG- 6818, BG- Arosh, BG- 6309, BG- Tafsi and BG-6527 are recommended to use as parent in hybridization programme as they have variation in characters like days to first fruit harvest, number of fruits per plant, fruit weight, number of seed per fruit and fruit yield per plant.

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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 (Cont'd)

FULL WORD	ABBREVIATION
Journal	*J.*
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

CHAPTER I

INTRODUCTION

Bottle gourd (*Lagenaria siceraria* L.) belongs to the family Cucurbitaceae having chromosome number 2n = 22, originated in Southern Africa. The names "lagenaria" and "siceraria" are derived from Latin words "lagena" for bottle and "sicera" for drinking utensil (Deepti, 2013). In Bangladesh Bottle gourd is locally known as lau. The cultivated species is commonly known as bottle gourd, water gourd, birdhouse gourd, trumpet gourd, calabash gourd, white flowered gourd etc. It is an important and popular vegetable in Bangladesh.

It is a monoecious, diploid, climbing or prostrate plant, solitary flowers and strictly cross pollinated due to its monoecious nature, bear more male flowers and less female flowers separately on the same plant (Sahu, 2016). The amount of cross pollination ranges from 60 to 80% (Chowdhury, 1979). Bees are the major pollinators.

Bottle gourd is the largest produced cucurbitaceous vegetables in the world, preferred in both urban and rural population. The bottle gourd probably originated in Africa and from there was widely distributed in pre-Columbian times, perhaps by floating on the seas. It traveled to India, where it has evolved into numerous local varieties, and from India to China, Indonesia, and as far as New Zealand. Archaeological remains show that the bottle gourd was used in Egypt about 3500 to 3300 B.C. It is grown in both rainy and summer seasons, and its fruits are available in the market, throughout the year. It is widely cultivated in tropics and subtropics, mostly grown for its fruit, which are very in size and shape viz; globular, cylindrical, bottle-shaped or club-shaped. The fruits are fleshy and multi seeded. Fruits are either sweet or bitter in taste. The sweet fruits are edible and also useful for medicinal purposes.

Bottle gourd is a rich source of minerals and vitamins. Edible portion bottle gourd is 86%. Among all cucurbits vegetables bottle gourd contains the maximum amount of minerals due to high keeping quality (Rashid, 1993). It contains many healing and medicinal properties. It has iron, Vitamin C and B complex. Regular consumption of this vegetable provides relief to people suffering with digestive problems, diabetics and convalescents. Numerous health benefits are reported in bottle gourd including it

is used to cure pain, ulcers and fever and is used for pectoral cough, asthma and other bronchial disorders using prepared syrup from the tender fruits (Upaganlawar and Balaraman, 2010). It is good for people suffering from biliousness and indigestion (Thamburaj and Singh, 2003). The fruit make delicious supplement to the human diet and 100 g of fruits contain nearly 96g water, 0.2g protein, 0.1g fat, 2.5g carbohydrate, 0.6g fiber, 0.5g minerals, 20mg calcium, 10mg phosphorus, 0.7mg iron, 0.3mg thiamine, 0.01mg riboflavin and 0.2 mg niacin and energy 1.2 cal. Their seeds are good sources of lipids and proteins and it contains 45 percent oil and 35 percent protein (Achu *et al.,* 2005).

It is an economically important crop cultivated worldwide for vegetable purpose. The fruits are used for variety of purposes, tender fruits used as vegetable and for preparing sweet dishes, rayta and pickle. In Bangladesh, it occupies about 18,892 ha with a total production of 226084 M. tons (BBS, 2018). The average yield is only 11.96 M. tons per hectare which is very low as compared to that in other tropical countries. On the other hand, high population growth rate is also putting increased pressure on the area of vegetable production. Bottle gourd can be grown with less cost and additional land is not required, can be grown in homestead area.

Collection and evaluation of germplasm is a pre-requisite for their utilization and detailed evaluation determines the potential of an accession in specific crop improvement programme. Therefore, a trial for characterization and evaluation of presently available bottle gourd germplasm is carried out in order to identify the potential cultivar for different characters. Path coefficient analysis provides an effective means of finding out direct and indirect causes of association among casual variables. Yield is a complex character controlled by a large number of contributing characters and their interactions. A study of correlation between different quantitative characters provides an idea of association that could be effectively exploited to formulate selection strategies for improving yield components. For any effective selection program, it would be desirable to consider the relative magnitude of association of various characters with yield. On the basis of these studies the quantum importance of individual character is marked to facilitate the selection program for better quality and yield.

Genetic improvement through conventional breeding approaches depends mainly on the availability of diverse germplasm and presence of enormous genetic variability. Genetic diversity analysis, among elite germplasm is the prerequisite for selecting, promising genetic diverse lines for desirable traits and to expose genetic distinctness among the genotypes (Ali *et al.,* 2008). High genotypic coefficient of variation values for yield/plant, number of fruits/plants, fruit length and fruit breadth and wider range of variation indicate more opportunity for selection of better genotypes (Rajesh *et al.,* 1999; Ram *et al.,* 2005). In nature, bottle gourd exhibits great morphological and genetic variability and could wide environmental adaptation (Koffi, 2009). Bangladeshi farmers used different local cultivars and released (from different organization) bottle gourd variety. But their yield is not in satisfactory level. Varietal performance might be helpful to overcome this problem. Considering these circumstances, the present study was undertaken with a view to evaluate the growth and yield performance of seventeen bottle gourd genotypes.

In spite of being in cultivation since ancient times and the presence of the wide germplasm, conscious evaluation and exploitation of germplasm has not been attended to until recently. At present, urgent need of the farmers is to develop early maturing and high yielding variety/ hybrid. Preliminary identification of early maturing genotypes can be done based on characters like days to opening of female flowers, node number to first female flowering and days to fruit picking.

Now a day's farmers are demanding for early maturing and high yielding variety of bottle gourd. To meet out the need of farmers, preliminary work should be initiated from identification of high yielding genotypes which can be utilized as variety or for further varietal development programme.

Therefore, the present study was undertaken with the following objectives:

- To know the yield potentiality of different bottle gourd genotypes,
- To know the nature of association of traits, direct and indirect relation between yield and yield contributing traits of bottle gourd genotypes and
- To screen out the suitable bottle gourd genotypes for future breeding programme.

CHAPTER II
RIVEW OF LITERATURE

The review of literatures contain report on the crop under study and other related crops studied by several investigators, which appears pertinent in understanding the problem which may help in the explanation and the interpretation of results of the present study. In this section, an attempt has been made to review the available information at home and aboard on direct and indirect genetic effects on the yield performance of different bottle gourd genotypes.

2.1 Evaluation of genotypes

Vaishali (2016), evaluated 10 genotypes of bottle gourd. Results revealed that the highest fruit yield per hectare was recorded in V3 (2013/ BOG VAR- 3). The maximum vine length was observed in V1 (2013/BOG VAR-1) and the minimum in (BBOG 15-3). The genotype V4 (2013/ BOG VAR-4) was the earliest in respect of node at which first female flower appeared and BBOG-15-3 produced the highest average fruit weight.

Sahu (2016), evaluated an experiment with 69 diverse genotypes of bottle gourd. The analysis of variance revealed that mean sum of squares due to genotypes were highly significant for all the characters. Which indicated that the presence of variability in the genotype. The genotype IBG-61 was found highest yield and earliest flowering was noticed in IBG-69.

Shinde *et al.* (2014), experimented that the maximum number of female flower (36.63), number of fruit (10.80), yield per plant 6.85 kg) and yield per hectare (342.54 quintal) were recorded in variety Pusa Samridhi, while variety Local (v5) was observed maximum average weight of fruit (734.72 g).

Visen *et al.* (2014), evaluated genetic parameters between yield and yield contributing characters of different bottle gourd genotypes. Analysis of variance revealed significant variation among the genotypes for all tested characters. The highest fruit yield was

found in genotype IBG-11 (536.66 q/ha) followed by IBG 25 (226.66 q/ha) and IBG 14 (223.26 q/ha).

Sahu *et al.* (2014), studied 8 varieties of bottle gourd and observed maximum fruit yield with variety Anokhi (592.90 q/ha) followed by variety Varad (579.84 q/h) and minimum yield (351.08 q/ha) in variety BGPL-4.

Uddin *et al.* (2014), experimented growth and yield performance of 11 bottle gourd lines. Maximum vine length (6.8 m), leaf area (975.4 cm2), number of fruit (14.3), fruit length (54.9 cm), single fruit weight (1.43 kg), yield/plant (20.6 kg), yield/plot (82.0 kg) and yield/ha (50.1 ton) was found in L11, followed by L10. On the other hand, minimum sex ratio (male to female) (0.21), days to first male flower appearance (37.3) and female flower appearance (41.0) was observed from L11.

Bhardwaj *et al.* (2013), studied 20 genotypes of bottle gourd and result revealed that the mean sum of squares due to replication was highly significant for all traits except fruit diameter, whereas the mean sum of squares due to genotype was highly significant for all the traits. GCV and PCV both were higher for vine length and number of primary branches. Number of primary branches, vine length and yield per plant indicated that these traits can be improved through simple selection.

Thakur *et al.* (2013), evaluated 22 genotypes of bottle gourd and found that the genotype 2012 BOG VAR 4 was early (25 DAT) for days to 50% flowering including early male and female flowering i.e. 16.26 and 25.66 DAT. The genotype 2010 BOG VAR 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, 2011 BOG VAR 3, 2010 BOG VAR 3 and NDBG 104 were observed to be promising for earliness and fruit yield.

Sharma and Sengupta (2013), studied 16 genotypes of bottle gourd and reported significant variation for all the characters among the genotypes. The significantly higher yield in Narendra Shivani (311.53 q/ha) might be due to higher values of yield attributes (fruit set percentage, fruit length, fruit width, number of fruits per vine and fruit weight followed by Narendra Sanker Lauki. Whereas, the lower yield was

observed in case of Narendra Jyoti (101.86 q/ha), respectively due to lower yield attributes. Among all the genotypes, Narendra Shivani, Narendra Sanker Lauki, and NS 421 gave promising results.

Kumar and Prasad (2011), experimented 5 hybrids and one open pollinated variety of bottle gourd. Among all the hybrids, Vikrant was found to be superior to the others in terms of fruit length, diameter, weight, yield, maximum net return per hectare and cost benefit ratio.

Kumar *et al.* (2011), studied 24 hybrids of bottle gourd obtained by crossing 11 parents and results revealed that the PCV was slightly higher than their corresponding GCV for all the characters studied. It was also observed that genotypic and phenotypic coefficient of variation was higher for fruit yield per plant.

Husna *et al.* (2011), experimented 31 bottle gourd genotypes for different quantitative characters. Among all the genotypes G4, G31, G26 and G28 observed superior for fruit yield and selected for future breeding programme.

Mahato *et al.* (2010), experimented 15 lines of bottle gourd for different morphological characters, yield components and fruit yield. The genotypes varied in fruit colour (whitish to deep green with or without patches), shape (globular to elongated) and size. A good amount of variation was found in fruit length (10.42- 42.33 cm). The inbreeds, BCBG-17, BCBG-15, BCBG-33, BCBG-3 and BCBG-6 have emerged as highly promising for developing good quality hybrids.

Ram *et al.* (2007), evaluated winter fruited bottle gourd and found a large genetic variation for characters like days to germination, flowering, edible maturity, number of branches per plant, fruit size (length x width), number of nodes on main vine, vine length, number of fruits per plant, individual fruit weight and yield per plant. Genotypes WVR-7, WVR-15, WVR-10 and WVR-19 were observed promising for earliness, fruit size, individual fruit weight and yield.

Sreevani (2004), experimented a study in bottle gourd *(Lagenaria siceraria* (Mol.) Stand I**.)** to investigate extent of heterosis for yield and its contributing characters with five parents and their 10 Fl hybrids. Maximum heterosis over the better parent was

expressed for fruit weight (108.3%) and fruit yield per vine (98.12%) in F_1 cross Pratik x TPT local while AB with TPT local and PSPL registered high heterobeltiosis for fruits per vine (22.95%) fruit girth (30.69%) and fruit flesh thickness (34.05%) respectively.

Sharma and Dhankar (1989), evaluated 18 accessions of bottle gourd for traits like fruit shape and colour, number of days to produce first female flower, male/female sex ratio, number of nodes per plant, internode length, number of fruits/plant and yield per plant and they concluded that the accessions HBG3 (round fruited), HBG2, HBG4 (both bell-shaped), HBG13, HBG14 and HBG18 (all long fruited) would be best to utilize in breeding programmes to produce the desired high yielding type.

Sharma and Dhankar (1990), experimented 35 genotypes of bottle gourd and reported that Hisar Local-3 (round-fruited type), was the earliest and highest yielder (4.71 kg/plant). Amongst the long-fruited types, Pusa Summer Prolific Long was most promising for earliness and yield.

2.1.1 Days to first flowering

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

Sharma and Dhankhar (1990), evaluated almost similar estimates of GCV and PCV (13.54 and 14.00) for days to first female flower opening in bottle gourd. They also observed high heritability (93.47%) along with considerably high Genetic advance (26.99) for days to flowering in bottle gourd. In bitter gourd, Mannan (1992) recorded considerable variability among eight lines for days to first male flower (66.7-81.6 days) and female flower (72.80-85.67 days) opening.

Rahman et al. (1991), also experimented that male flower was earlier than the female flower in several genotypes of bottle gourd, bitter gourd, ribbed gourd and sweet gourd. They reported significant variations for these characters among the genotypes of bitter gourd, bottle gourd, ribbed gourd and sweet gourd.

Bose and Som (1986), studied 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).

Harika *et al.* (2012), experimented that the minimum sex ratio (12.62) and it was significantly highest in Anand Bottle gourd-1 (24.40). In the present study, the high variation in sex ratio may be due to environmental conditions and variety.

Grubben (2004), studied that male flower open earlier and close later than female flowers, the ratio being approximately 9:1 in bottle gourd, although it is lower at low temperature. Rashid (1993) said that the male female flower ratio in cucurbits varied from 4:1 to 60:1 according to the variety and environment.

Bose and Som (1986), experimented that the sex ratio in cucurbits varied from 5:1 to 25-30:1, the ratio of male: female flower was changed by the climate and environmental factors.

2.1.2 Internodes distance (cm)

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

2.1.3 Tendril length (cm)

Wide variations for vine length were experimented in pumpkin (Rana *et al.,* 1986), musk melon (Swamy *et al.,* 1984) and sponge gourd (Prasad and Singh, 1990). However (Saha *et al.,* 1992) did not find significant differences among the pumpkin lines for vine length.

2.1.4 Number of primary branches

Number of branches per main vine could not show significant variations among the bottle gourd genotypes while some bitter gourd and ribbed gourd genotypes were observed to differ significantly among themselves (Rahman *et al.*, 1991).

Ramachandran (1978), found considerable variability for several vegetative and reproductive characters. The primary branches per plant in different bitter gourd genotypes ranged from 18.00 to 35.89 with a general mean of 27.12. The estimated phenotypic, genotypic and environmental variances (VP = 2.64, VG = 20.81, VE = 0.83) showed a predominant influence of genetic component in relation to the environmental effects on these traits.

2.1.5 Number of fruits per plant

Rahman *et al.* (1986), observed 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), (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), experimented 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.

2.1.6 Fruit length and breadth (cm)

Genus *Lagenaria* to which bottle gourd belongs is characterized by key characters-fruit fleshy and many seeded pepo, flowers solitary and chalky white opening at night. Botanical name is *Lagenaria siceraria* (Mol.) Standi (syn. *L. siceraria. L. leucantha* Rusby. *L. vulgaris* Ser) (Davis *et al.*, 1962).

Information on inheritance of characters is limited in bottle gourd. Fruit color is monogenically inherited through green dominant over white. Fruit shape is also monogenically inherited with long dominant over round. The time of maturity and seed size are polygenically inherited (Davis *et al.*, 1962).

Sirohi and Chowdhury (1986), experimented genetic analysis in long fruit bottle gourd. Narrow sense heritability was high for days to opening of first male flower, days to opening of first female flower, fruit length, diameter, weight and number of fruits per plant (Davis *et al.*, 1962).

Asmaul Husna (2009), experimented an experiment 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.

2.1.7 Fruit per plant

A wide range of variability for fruits per plant was found among the genotypes of bottle gourd (2.25 to 8.25) as indicated by (Rahman *et al.*, 1986) and (13.1 to 21.9) as indicated by Tyagi (1972) and (Arora *et al.*, 1983).

Significant variations of fruit length and diameter were experimented in bottle gourd and ribbed gourd (Rahman *et al.*, 1991) bitter gourd (Srivastava and Srivastava, 1976) and (Mangal *et al.*, 1981), sponge gourd (Arora *et al.*, 1983) and cucumber (Prasad and Singh, 1990). (Rahman *et al.*, 1990) also reported bitter gourd, ribbed gourd and sweet gourd genotypes differed significantly for fruits per plant.

2.1.8 Fruit weight (kg)

Saha *et al.* (1992), reported narrow difference between GCV and PCV for this trait in bitter gourd indicating less environmental influence on this character. High heritability coupled with genetic advance for average fruit weight was noticed in pumpkin (93.03 and 78.58).

2.1.9 Fruit yield per plant (kg)

Rahman *et al.* (1986) observed significant association between days to maturity and fruit yield per plant in bottle gourd (r = 0.662) while (Reddy and Rao, 1984) and (Swamy *et al.*, 1984) reported negative association between the traits in ribbed gourd (r = - 0.718) and muskmelon (r = - 0.025).

Swamy *et al.* (1984), studied interrelationship between yield and other quantitative characters in muskmelon and observed high variability in 100 seed weight of muskmelon. Whereas (Chhoknar, 1977) found narrow range of variability in 100 seed weight of watermelon and noted moderate GCV and PCV for seed weight in watermelon.

Positive and significant association between yield per plant and seeds per fruit both at phenotypic (r = 0.569) and genotypic (r_g = 0.621) level was reported by Tyagi (1972) in bottle gourd. Main vine length was positively and significantly correlated with branches per plant at phenotypic (r = 0.268) and genotypic (r_g = 0.594) level and seeds per fruit phenotypic (r = 0.394) and genotypic (r = 0.426) level whereas negative but significant only at genotypic level with hundred seed weight (r = - 0.291) were recorded by (Rahman *et al.*, 1986) in bottle gourd. They also found low genetic advance for days to maturity.

2.1.10 Seed length, breadth and weight

Seed length and breadth were 2.22, 1.19, 1.65 and 1.01, 0.71, 0.91 cm respectively for bottle gourd, white gourd and pumpkin as stated by (Haque, 1971).

(Tyagi, 1972) found moderate heritability (53.4) and considerable amount of genetic advance (20.81) as to the 100 seed weight in bottle gourd indicating that limited numbers of facts are involved for the control of seed weight.

2.2 Genetic variability, Heritability, Genetic advance

Narayan (2013), experimented an experiment on 10 diverse genotype of bottle gourd and reported variability for fruit and seed characters viz., days to 50% germination, days to first male flower anthesis, days to first female flower anthesis, node number of first male flower, node number of first female flower, days to first fruit harvest, number of branches per vine, vine length, fruit length, number of fruits per vine, fruit yield per vine, number of seeds per fruit and 100 seed mass.

Singh *et al.* (2008), conducted genetic variability in bottle gourd in both summer and rainy seasons and recorded the highest genotypic and phenotypic coefficients of variation for yield per vine.

Gayen and Hossain (2006), conducted genetic variability and heritability of bottle gourd and observed that magnitude of phenotypic coefficient of variation (PCV) was significantly higher than genotypic coefficient of variation (GCV) for all the characters, it reflected the effect of environment on expression of these traits. The estimation of heritability ranged from 60.60 to 95.45%. High genetic advance as percentage of mean was recorded for sex ratio, fruit length, fruit yield per plant and TSS. The sex ratio, fruit length, fruit yield per plant and TSS showed high heritability (above 80%) coupled with high genetic advance.

Singh and Kumar (2002), conducted genetic variability in bottle gourd and reported that the phenotypic coefficient of variation was higher than the genotypic coefficient of variation. High estimates of heritability were recorded for fruit yield per plant, vine length, number of days to first harvest, number of nodes to first male and female flowers, number of primary branches per plant, and fruit length, weight and diameter.

Hawlader *et al.* (1999), conducted genetic variability in thirteen cultivars of bottle gourd for eight quantitative characters. A wide range of variability was recorded for most of the characters. Heritability was very high for all the eight characters. Number of male flowers, number of female flowers and fruit yield per plant exhibited high heritability coupled with high genetic advance.

2.3 Correlation Co-efficient

Sahu *et al.* (2016), investigated an experiment with 69 diverse genotypes of bottle gourd. The results of correlation coefficient analysis revealed that fruit yield per plant was significantly and positive correlated with number of branches per plant at both genotypic and phenotypic levels.

Janaranjani *et al.* (2015), investigated correlation studies with 18 different characters comprising of 36 hybrids of bottle gourd. The analysis revealed that fruit yield was

positively and significantly correlated with fruit flesh thickness, number of fruits per vine (0.92) and number of fruit pickings.

Ara *et al.* (2014), investigated correlation studies on bottle gourd genotypes and reported correlation coefficient was highest for nodal position of first female flower opening followed by yield per plant, sex ratio among the genotypes. Total yield positively correlated with first male flowering and female flowering, first harvest, sex ratio, single fruit weight and fruit diameter. However, total yield was negatively correlated with edible maturity and fruit yield per plant in bottle gourd.

Sharma *et al.* (2013), conducted performance of 16 genotypes of bottle gourd for evaluating their performance for various horticultural characters. The significantly higher yield in Narendra Shivani (311.53 q/ha) might be due to higher values of yield attributes (fruit set percentage, fruit length, number of fruits per vine, fruit weight and fruit width) followed by Narendra Sanker Lauki. High genotypic coefficient of variation (GCV) was observed for fruit weight (39.48%). Among all the genotypes, Narendra Shivani, Narendra Sanker Lauki, and NS 421 gave promising results.

Emina *et al.* (2012), experimented 40 diverse genotypes of bottle gourd for correlation reported positive correlation of plant height with fruit length, seeds per plant and 100 seed moss but negative correlation with fruit weight.

Yadav *et al.* (2012) conducted that positive correlation was seen between length of fruit, weight per fruit, and number of fruits per plant to the fruit yield per plant in bottle gourd.

Kamal *et al.* (2012) conducted that fruit yield per vine showed positive and significant correlation with no. of branches per vine, vine length, node number of I st male flower, node number of I st female flower, length of edible fruits, number of fruits per vine, number of seeds per fruit and 100 seed weight at genotypic and phenotypic levels in 10 diverse bottle gourd entries.

Pandit *et al.* (2009) evaluated 15 genotypes of bottle gourd revealed that the correlation between both genotypes and phenotypes indicated the overriding importance of fruit length and fruit width in determining the average fruit weight, which in turn adequately described the increase in fruit yield per plant.

Ahmed *et al*. (2005) conducted correlation in 23 genotypes of bottle gourd and reported that fruit yield exhibited strong positive and significant correlation both at genotypic and phenotypic levels with number of fruits per plant, average fruit weight and fruit length. The negative significant association with days to first fruit picking and fruit diameter indicated that selection for earliness and increased fruit diameter would not have positive bearing on fruit yield.

Parvathi *et al.* (2006) conducted correlation in bottle gourd and reported that fruit yield per vine showed significant positive correlation with fruit weight, fruit girth, fruit flesh thickness, fruits per vine and 100 seed weight, indicating that selection for these characters may improve fruit yield in bottle gourd.

Tyagi (1972), conducted that the yield was positively and significantly correlated as both phenotypically and genotypically with the number of fruits per plant, girth of fruit, length of fruit, and number of seeds per fruit. Number of fruits per plant was significantly correlated with number of seeds per fruit and girth of fruit. Length of fruit was significantly associated with number of seeds per fruit at both phenotypic and genotypic levels. Girth of fruit was negatively associated with number of branches and number of seeds per fruit. Number of branches was significantly associated with number of seeds per fruit.

2.4 Path Co-efficient

Sahu *et al.* (2016), evaluated an experiment with 69 diverse genotypes of bottle gourd. The path coefficient analysis revealed that no. of fruits per plant showed the highest positive direct effect on fruit yield followed by duration of crop, days to first female flower appears, number of branches per plant, node number of first female flower appears, 100 seed weight, node number of first male flower appears, days to first female flower appears, whereas, average fruit weight, fruit girth, days to first fruit harvest, days to 50% flowering, fruit length and days to fruit set showed negative direct effects on fruit yield per plot.

Janaranjani *et al.* (2015), evaluated path analysis with 18 different characters comprising of 36 hybrids of bottle gourd. The path analysis indicated that number of fruits per vine, days to first female flower opening (0.800), fruit cavity (0.380) and fruit

weight (0.373) had positive direct effect on fruit yield, however fruit length (-0.370) recorded high negative direct effect on fruit yield per vine. Number of primary branches (-0.189), days to first male flower opening (1.103), sex ratio (0.141) and number of pickings (-0.122) recorded negative low direct effect on fruit yield per vine.

Husna *et al.* (2011), conducted that the results of path coefficient analysis revealed the maximum direct contribution towards yield per plant with number of fruits per plant (0.680) followed by fruit weight (0.453) in 31 bottle gourd genotypes.

Yadav *et al.* (2007), studied on path coefficient analysis in 18 bottle gourd strains and reported that all the characters except days to first female flowering, number of nodes of first male flowering and fruit length had direct effect on yield. For indirect effects, the number of fruits per plant showed highly significant and positive association with yield per plant due to days to first male flowering, number of nodes of first female flowering, days to edible fruit, fruit width and number of fruits per plant.

Narayan *et al.* (1996), conducted that maximum weightage should be given primarily to days to the first harvest followed by average weight of edible fruit, fruit number per plant and days to anthesis of first female flower while formulating selection indices for improvement of yield in 25 genotypes of bottle gourd.

Kumar *et al.* (1998), conducted path coefficient analysis in 16 parents of bottle gourd. Path coefficient analysis revealed that maximum weight should be given to average weight of edible fruit and number of fruits per plant, while formulating selection indices for improvement of yield per plant in bottle gourd.

Rahaman *et al.* (1986), estimated four lines of bottle gourd for path coefficient analysis and 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.

2.5 Genetic Diversity

Quamruzzaman *et al.* (2008), conducted the genetic divergence among thirty genotypes of ridge gourd (Luffa acutangula) using D^2 and principal component analysis. The genotypes were grouped into six clusters. The highest intra cluster distance was noticed

for the cluster II (0.882) and the lowest for the cluster III (0.220). The highest inter-cluster distance was found between cluster I and II (15.045) whereas the lowest was observed between cluster IV and V (3.402).

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

Khan *et al.* (2008), experimented the genetic diversity among 64 pointed gourd genotypes through multivariate analysis from an experiment conducted in Regional Agricultural Research Station, Ishurdi, Pabna during the growing season 2002-2003. The genotypes were grouped into twelve clusters. The cluster V consisted of highest number of genotypes and it was nine, the cluster VI and cluster VIII contained the lowest number of genotypes and it was two in each. The highest inter genotype distance as 366.3 observed between the genotypes P0022 and P0007 and the lowest 2.6 as observed between the genotypes P0043 and P0044. Cluster V had the highest cluster mean value for internodes length, fruit weight per plant and yield the highest inter-cluster distance was noticed between cluster III and II (45.71) and the lowest between cluster VII and VI (3.33).

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 D2 value. Considerable diversity within and between clusters was noted and it was observed for the characters viz. vine length, number of branches, fruit per vine, length and diameter of fruit and yield per vine.

CHAPTER III

MATERIALS AND METHODS

The present investigation "**Evaluation of Some Bottle Gourd Genotypes in Relation to Yield and Its Contributing Traits**" was carried out during Kharif season 2019 in the field of genetics and plant breeding at Sher-e-Bangla Agricultural University, Dhaka-1207. This chapter deals with a concise description of the materials adopted and methodology used during the course of investigation. A brief description about the locations of the experimental site, characteristics of soil, climate, materials, layout and design of the experiment are given. Land preparation, manuring and fertilizing, transplanting of seedlings, intercultural operations, harvesting, data recording procedure, economic and statistical analysis etc.

3.1 Experimental site

The study was conducted in the field of genetics and plant breeding at Sher-e-bangla agricultural university, Sher-e-bangla Nagar, Dhaka Bangladesh during the period of 30 March to September 2019.

3.2 Geographical location

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

3.3 Characteristics of soil

The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Soil pH ranges from 5.4–5.6. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0–15 cm depths were collected from the experimental field.

The soil analyses were done at Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in (Appendix III).

3.4 Climatic condition of the experimental site

Area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall in Kharif season (March-September) and scanty rainfall associated with moderately low temperature during, the Kharif season (March-September). Information regarding monthly maximum and minimum temperature, rainfall, humidity as recorded by Bangladesh meteorological department, Agargaon. Dhaka, during the period of study have presented in (appendix II).

3.5 Detail of the experiment

The details of the experimental techniques employed for the present investigation are described as under:

1. Crop: bottle gourd (*Lagenaria siceraria* L.)

2. Source of seed: Laal Teer Seed limited, Gazipur, Dhaka

3. Experimental design: Randomized Complete Block Design

4. Plot area: 300 (m^2)

5. Spacing: 3 (m) x 2.5 (m)

6. Variety: 17 (genotype)

7. Replications: 03

8. Date of sowing: 30/03/2019

9. Date of planting: 21/04/2019

10. Number of sub- plots: 51

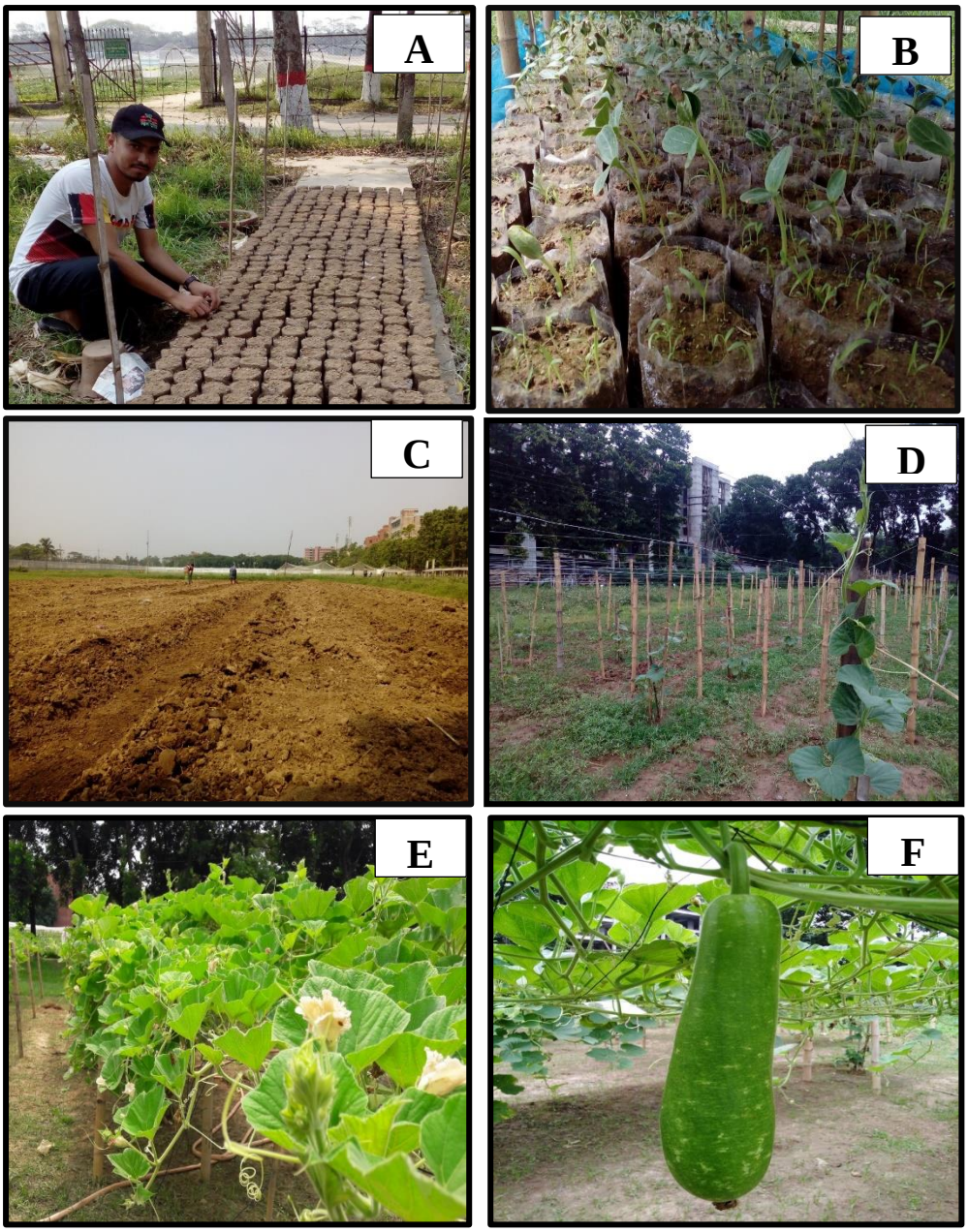

Plate 1. Seed bed preparation (A), Growth stage of seedling (B), Land preparation (C)**,** Growth stage of the plant (D), Flowering stage of the plant (E), Maturity stage of the plant (F)

3.6 Experimental design and layout

The experiment was laid out in randomized complete block design with three replications. The genotypes were distributed into the pit of each block of the prepared layout of the experiment. The seventeen genotypes of the experiment were assigned at random into pits of each replication. The distance maintained spacing pit to pit 2.5 m. The distance maintained between two blocks 3 m (Plate 1**)**.

3.7 Planting materials

17 genotypes of bottle gourd were used for the present research work. The genetically pure and physically healthy seeds of these genotypes were collected from Lal Teer Seed Limited, Gazipur. The name and source of these genotypes are presented in (Table l).

3.8 Selection of seed and sowing

Pure and healthy seeds of each genotype were collected before sowing. The seeds were soaked in water for 12 hours to get good germination. The sowing was done on 30th March 2019 in small polythene bags (14 cm x 10 cm) containing compost and soil at the rate of 1:1. A net was used to cover the poly bags to protect the seedlings from heavy drops of water, severe sunshine and red pumpkin beetle. Watering was done in the late afternoon every day by hose pipe using a fine meshed nozzle. Seedlings were raised in polybag under strong supervision and after 22 days these were transplanted in the main field.

3.9 Land preparation

The experimental land was prepared by ploughing with tractor followed by harrowing and laddering. Weeds and stubbles were removed and irrigation channel were made around each block. Inter plot space also served as irrigation channel (Plate 1).

3.10 Pit preparation

The plots were raised by 20 cm from the ground level. Pits of 50 x 50 x 50 cm size were prepared in each plot at a spacing of 3m from pit to pit.

Table 1. Name and source of 17 bottle gourd genotypes used in the present study

Sl. No.	Genotypes	Source
1.	BG- 6309	Lal Teer Seed Limited
2.	BG-Martina	Lal Teer Seed Limited
3.	BG- 7092	Lal Teer Seed Limited
4.	BG- 6820	Lal Teer Seed Limited
5.	BG- 6813	Lal Teer Seed Limited
6.	BG- 6837	Lal Teer Seed Limited
7.	BG-Diana	Lal Teer Seed Limited
8.	BG-Tafsi	Lal Teer Seed Limited
9.	Higreen	Metal Agro Limited
10.	BG- 6310	Lal Teer Seed Limited
11.	BG- 6523	Lal Teer Seed Limited
12.	BG- 6527	Lal Teer Seed Limited
13.	BG- 6818	Lal Teer Seed Limited
14.	BG- 6816	Lal Teer Seed Limited
15.	BG-Arosh	Lal Teer Seed Limited
16.	BG-Nico	Lal Teer Seed Limited
17.	BG-Barsha	Lal Teer Seed Limited

3.11 Application of manure and fertilizers

Total cow dung, half of TSP and one third MOP were applied in the field during final land preparation remaining TSP and one third MOP and whole Gypsum and Zinc oxide and one third of urea were applied in pit one week prior to transplantation remaining urea and MOP were applied as top dressing in four installments at 20, 40 and 60 days after transplanting. Doses of manure and fertilizers used in the study are shown in (Table 2).

3.12 Seedling transplanting

Seedlings of all genotypes were transplanted to the main field on 21 April, 2019 as per design of the experimental layout accommodating one seedling per pit.

3.13 Intercultural operation

The plants were kept under careful supervision. Irrigation, thinning, gap filling, weeding, mulching etc. Was done as per requirement.

3.14 Irrigation management

Irrigation was provided by furrow irrigation system. First irrigation was given immediately after transplanting. Further, irrigations were given as per the need of the crop.

3.15 Weeding and mulching

Weeding and mulching were done 9 times to keep the plots free from weeds and to conserve soil moisture.

3.16 Plant protection measure

After transplanting in the main field, the young seedling was getting rotten. To overcome such kind of problem autistine mixed with water was prayed at the base portion of the seedling. The bottle gourd seedlings were attacked by red pumpkin beetles at the seedling stage, which were controlled by hand killing and ripcord was sprayed in the field.

3.17 Harvesting

The fruit takes about 7-10 days from setting to reach marketable stage. Fruits were picked on the basis of horticultural maturity, size, color and age being determined for the purpose of consumption as the fruit grew rapidly and soon get beyond the marketable stage, frequent picking was done throughout the harvesting period. Fruits were picked with the sharp knife and care was taken to avoid injury of the vine.

3.18 Experimental observations: Data on different parameters were collected following the procedures outlined below:

3.18.1 Plant characteristics

3.18.1.1 Internodes length (cm)

Internodes distance was measured from three to five internodes in each germplasm in cm and average data was recorded.

3.18.1.2 Tendril length (cm)

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

3.18.1.3 Number of primary branches per plant

The number of branches per plant was recorded from five randomly selected plant of each plot at the time of 90 days after sowing.

3.18.2 Inflorescences characteristics

3.18.2.1 Days to first male flower appears

The number of days taken from the date of sowing to the date of first male flower anthesis was observed in all the five selected plants from each replication and their average was calculated.

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

Manure and fertilizer	Recommended doses
Cow dung	10 ton/ha
TSP	125 kg/ha
Urea	125 kg/ha
MOP	150 kg/ha
Gypsum	75 kg/ha
Zn fertilizer	10 kg/ha

3.18.2.2 Days to first female flower appears

The number of days taken from the date of sowing to the date of first female flower anthesis was observed in all the five selected plants from each replication and their average was calculated.

3.18.2.3 Pedicel length of male flower (cm)

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

3.18.2.4 Pedicel length of female flower (cm)

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

3.18.2.5 Female ovary diameter (cm)

Female ovary diameters were measured with the help of thread and it is compared with meter scale in centimeter. Female ovary diameter was calculated for every genotype.

3.18.3 Fruit characteristics

3.18.3.1 Fruit length (cm)

Five harvested fruits were measured with the help of thread and it is compared with meter scale in centimeter. Then average fruit length was calculated for every genotype.

3.18.3.2 Fruit diameter (cm)

Fruit diameters were measured with the help of thread and it is compared with meter scale in centimeter. Then average fruit diameter circumference was calculated for every genotype.

3.18.3.3 Fruits shape

Every genotype has specific fruit shape. The fruit shape was categorized into pear, oblong and cylindrical.

3.18.3.4 Fruits skin colour

Every genotype has a specific colour of fruit. Colour of fruits was observed by simple visualization of eye. The fruit colour was categorized in to different groups like dark green, light green, whitish green etc.

3.18.3.5 Average fruit weight

Average weight of fruits was recorded on per fruits in kg from five randomly selected plants of each plot in each replication and then average fruit weight was calculated.

3.18.4 Seed characteristics

3.18.4.1 Seed length

The length of 10 randomly selected seeds of each genotypes was measured by digital slid calipers from one end to the other end and the average was expressed in mm.

3.18.4.2 Seed breadth

The breadth of the same 10 randomly selected seeds of each genotypes was measured by digital slide calipers from one end to the other end and the average was expressed in mm.

3.18.4.3 Seed weight

The weight of the same 10 randomly selected seeds of each genotypes was measured by electric balance after harvest and mean weight was expressed in gm.

3.18.4.4 Hundred seed weight (g)

Hundred seeds were weighed by electric balance in gram.

3.18.4.5 Number of seed per fruit

Amount of seed was calculated by cutting five fruits of every genotype.

3.18.5 Yield per plant

Weight of fruits of selected plants from each germplasm was weighed in kilogram.

3.18.6 Duration of crop (sowing to last harvest)

Duration of crop was recorded as days from sowing to last day of harvesting.

3.19 Statistical analysis

Genetic divergence is one of the most important factors considered by the plant breeders in starting a breeding program. This is a compulsory, but not sufficient, condition for the occurrence of heterosis and the generation of a population with broad genetic variability. Consequently, heterosis is directly proportional to genetic divergence and to dominance squared (Falconer, 1981; Cruz, 1990) and is also associated with adaptation. A second methodology is to use multivariate methods to estimate genetic divergence and then predict hybrid performance. In this case, it is not necessary to make crosses. Moreover, a large number of materials may be successfully evaluated (Hallaunder and Miranda Filho, 1981).

A canonical variate technique is often used to reduce the number of these traits, through a linear combination of them, without a significant loss of the total variation. Additionally, this technique takes into account the structure of residual co-variances. The concept of D^2 statistics was initially developed by P. C. Mahalanobis's in 1928. He used this technique in the study of Anthropometry and Psychometric. (Rao, 1952) recommended the application of this technique for the assessment of genetic diversity in plant breeding. Now this technique is widely used in plant breeding and genetics for the study of genetic divergence in the various breeding materials. In plant breeding, Genetic diversity plays an important role because hybrids between lines of diverse origin, generally, display a greater heterosis than those are closely related parents. This has been observed in maize, alfalfa, cotton and several other crops. Genetic diversity arises due to geographical separation or due to genetic barriers to cross ability.

Statistical analysis such as Mahalanobis's D^2 and Canonical Variate Analysis (CVA), which quantify the differences among several quantitative traits are efficient method of evaluating genetic diversity. Mean data of each quantitative character were subjected to both univariate and multivariate analysis. For univariate analysis of variance,

analysis was done individually and least of significance was done by F- Test (Pence and Shukhatme, 1978). Mean, range, co-efficient of variation (CV) and correlation was estimated using MSTAT computer program. Multivariate analysis viz., Principal Component Analysis (PCA). Principal Coordinate Analysis (PCO), Cluster Analysis (CLU) and Canonical Variate Analysis (CVA) were done by using GENSTAT program.

The hierarchical nature of the grouping into various number of classes could impose undue constrains and the statistical properties of the resulting groups were not at all clear (Peyne *et al.,* 1989). Therefore, they have recommended non-hierarchical classification, as an alternative approach to optimize some suitability choosing criteria directly from the data matrix. (Peyne *et al.,* 1989) also reported that the squared distance between means were Mahalanobis's D^2 statistics when all the dimensions were used, could be computed principal coordinate analysis (PCO) they also commended the Canonical Variate Analysis (CVA) for discriminatory purpose.

3.19.1 Variability of Bottle Gourd Genotypes

3.19.1.1 Estimation of Phenotypic and Genotypic Variance

Genotypic and phenotypic variances were estimated according to (Johnson *et al.,* 1955) Genotypic variance was calculated by subtracting genotype mean sum of squire from error mean sum of squire and dividing by the number of replications as given bellow:

$$\textbf{Genotypic Variance } (\delta^2 g) = \frac{EMS - GMS}{\text{Number of replication } (r)}$$

Where,

GMS = Genotypic mean sum of squire

EMS = Error mean sum of squire

The phenotypic variances ($\delta^2 p$) were come from by addition genotypic variances ($\delta^2 g$) with error variance ($\delta^2 e$) as shown by the given formula:

Phenotypic Variances ($\delta^2 p$) = $\delta^2 g + \delta^2 e$

3.19.1.2 Estimation of Genotypic and Phenotypic Coefficient of Variation

According to the (Johnson *et al.*, 1955) genotypic and phenotypic coefficient of variation were estimated. Genotypic and phenotypic co-efficient of variation were calculated by the following formula (Burton, 1952):

$$GCV = \sqrt{\frac{\delta g}{\bar{x}}} \times 100$$

$$PCV = \sqrt{\frac{\delta p}{\bar{x}}} \times 100$$

Where,

GCV= Genotypic co-efficient of variation

PCV=Phenotypic co-efficient of variation

δg = Genotypic standard deviation

δg = Phenotypic standard deviation

$\bar{X}$ = Population means

3.19.1.3 Estimation of Heritability

(Johnson *et al.*, 1955) proposed a formula for estimating broad sense heritability Broad sense heritability was estimated by the formula suggested by Singh and Chaudhury (1985).

$$h^2b\ (\%) = \frac{\delta^2 g}{\delta^2 p} \times 100$$

Where,

h^2 b= Heritability in broad sense

δ^2g= Genotypic variance

δ^2 p =Phenotypic variance

3.19.1.4 Estimation of genetic advance

The following formula was used to estimate the expected genetic advance for different characters under selection as suggested by (Allard, 1960).

$$GA = \frac{\delta^2}{\delta^2 p} \times K.\delta_p$$

Where,

GA= Genetic advance

δ^2g=Genotypic variance

δ^2p=Phenotypic variance

δ_p=Phenotypic standard deviation

K= Selection differential which is equal to 2.06 at 5% selection intensity

3.19.1.5 Estimation of genetic advance in percentage of mean

Genetic advance in percentage of mean was calculated by the following formula given by (Comstock and Robinson, 1952).

$$\text{Genetic Advance in percentage of mean} = \frac{Genetic\ Advance}{\bar{X}} \times 100$$

Where,

x = mean

3.19.1.6 Estimation of simple correlation co-efficient

Simple correlation (r) was assessed from the replicated data with the help of following formula (Singh and Chaudhury, 1985).

$$r = \frac{COVxy}{\sqrt{VxVy}}$$

Where, COVxy =Covariance of x and y traits

Vx= Variance of x traits

Vy=Variance of y traits

3.14.1.7 Path co-efficient analysis

Path co-efficient analysis was done according to the procedure employed by (Dewey and Lu, 1959) also quoted in (Singh and Chaudhary, 1985), using simple correlation values. In path analysis, correlation co-efficient is partitioned into direct and indirect independent variables on the dependent variable. In order to estimate direct and indirect effect of the correlated characters, say, x1, x2 and x3 yield y, a set of simultaneous equations (three equations in this example) is required to be formulated as shown below:

$r_{yxl} = P_{yxl} + P_{yx2} r_{xlx2} + P_{yx3} r_{x1x3}$

$r_{yx2} = P_{yxl} r_{x1x2} + P_{yx2} + P_{YX3}\, r_{x2x3}$

$r_{yx3} = P_{yxl} r_{x1x3} + P_{yx2} r_{x2x3} + P_{yx3}$

Where, r´s indicates simple correlation co-efficient and P´s denote path co-efficient (Unknown). P´s in the above equation may be conveniently solved by arranging them in matrix from.

Total correlation, say between x_1 and y is thus partitioned follows:

P_{yx1} = the direct effect of x_1 via x_2 on y.

$P_{yx2} r_{x1x2}$= the indirect effect of x_1 via x_2 on y.

$P_{yx3} r_{x1x3}$= the indirect effect of x_1 via x_3 on y.

After calculating the direct and indirect effect of the characters, residual effect (R) was calculated by using the formula given below (Singh and Chaudhary, 1985):

$P^2\, RY = 1$

Where,

$P^2\, RY = (R^2)$; and hence residual effect, $R = (P^2\, RY)^{1/2}$

Pij=Direct effect of the character on yield

riy= Correlation of the character with yield

3.19.2 Genetic Diversity Analysis

3.19.2.1 Principal Component Analysis (PCA)

It is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available PCA is a powerful tool for analyzing data. The purpose of principal component analysis is to derive 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. Principal Component Analysis one of the multivariate techniques, is used to relationships among several characters. It can be done from the sum of squares and products matrix for the characters. Principal components were computed from the correlation matrix and genotype scores obtained for the first components and succeeding components with latent roots greater than unity (Jeger *et al.,* 1983). Contributions of different morphological characters towards divergence were discussed from the first two principal components.

3.19.2.2 Principal Coordinate Analysis (PCO)

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

3.19.2.3 Clustering

The term cluster analysis first used by (Tryos, 1939) encompasses a number of different algorithms and methods for grouping objects of similar kind into respective categories.

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. The definition of clusters emerges entirely from the cluster analysis-i.e. from the process of identifying "clumps" of objects.

Cluster analysis is an exploratory data analysis tool for solving classification problems. Its objective is to sort cases (People, plant, things, events, etc) into clusters, so that the degree of association is strong between members of the same cluster and weak between members of different clusters. Each cluster thus describes, in terms of the data collected,

the class to which its members belong; and this description may be abstracted through use from the particular to the general class or type.

To divide the genotypes of a data set into some number of mutually exclusive groups clustering was done using non-hierarchical classification. In GENSTAT, algorithm was used to search for optimal values of chosen criteria which proceed as follows:

Starting from some initial classification of the genotypes in required number of group, the algorithm repeatedly transferred genotypes from one group to another so long as such transfer improved the value of the criterion when no further transfer could be found to improve the criterion, the algorithm switched to a second stage, which examined the effect of swapping two genotypes of different classes and so on.

3.19.2.4 Canonical Variate Analysis (CVA)

Discriminate function or canonical variate analysis attempt to establish whether a set of variables can be used to distinguish between two or more groups.

Canonical variate analysis complementary to D^2 statistic is sort of multivariate analysis where canonical vectors and roots representing different axes of differentiation and the amount of variation accounted for by each of such axes respectively and derived. Canonical variate analysis computed linear combination of original variability that maximized the ratio between ground and within group variations, thereby giving functions of the original variables that could be used to discriminate between the groups. Thus, in this analysis, a series of orthogonal transformation sequentially maximized the ratio of the groups to within group variations. Several techniques that seek to illuminate the ways in which sets of variables are related one another. The term refers to regression analysis, ANOVA, discrimination analysis, and, most often, to canonical correlation analysis.

3.19.2.5 Cluster Diagram

In D^2 analysis a line diagram is constructed with the help of D^2 values which is known as cluster diagram. The squire's roots of average intra and inter cluster D^2 value are used in the construction of cluster diagram. This diagram provides information on the following aspects:

1. It depicts the genetic diversity in an easily understandable manner.

2. The number of clusters represents the number of groups in which a population can be classified on the basis of D^2 analysis.

3. The distance between two clusters in the measure of the degree of diversification. The greater the distance between two cluster the greater the divergence and vice versa.

4. The genotypes filling in the same cluster are more closely related then thoseϖ belonging to another cluster. In other words, the genotypes grouped together in one cluster are less divergent than those are placed in different cluster.

5. It provides information about relationship between various clusters.

A cluster diagram was drawn using the values ($\sqrt{D^2}$) of intra and inter-cluster distance. The diagram represented the brief idea of the patter diversity among the genotypes and relationships between different genotypes included in the cluster.

3.19.2.6 Selection of Genotypes for Future Hybridization Programme

Genotypes were selected from the study for future hybridization programme considering genetic variability and other performances related to yield (kg), number of fruit per plant, color of fruit, 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 etc.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the genetic variability, correlation, path coefficient analysis and genetic diversity of 17 bottle gourd accessions. The data on different yield and yield contributing characters of bottle gourd were computed and statistically analyzed. The results of the present study have been presented and discussed in this chapter under the following heading.

- 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 important traits in bottle gourd for consumer preference marketing. Generally light green, green, dark green and whitish colour fruits are commonly found in the market. In the present study, fruit colour could be classified in distinct groups like light green, dark green and white. Among the 17 genotypes, six genotypes BG- 6309, BG- 6820, BG-Diana, BG-Tafsi, Higreen, BG-Arosh and BG-Barsha produced dark green fruit and another six genotypes BG- Martina, BG- 6813, BG- 6310, BG- 6523, BG- 6527 and BG-Nico produced light green fruits and four genotypes BG-7092, BG- 6837, BG- 6818 and BG- 6816 produced white fruit. (Table 3 and Plate 2).

4.1.1.2 Fruit shape

Fruit shape is an important feature for marketing. Various types of bottle gourd are found. From the 17 genotypes oval, oblong, elongate slim, elongate tapered, elongate, conical, dumbbell shaped were observed. The genotypes BG- 6837 and BG- 6818 oval shaped genotypes, BG- 6820, BG-Tafsi, Higreen and BG-Arosh produced oblong fruits, BG-Diana and BG- 6310 dumbbell shaped, BG- 6309, BG- Martina , BG-7092, BG- 6813, BG- 6523, BG- 6527, BG- 6816, BG-Nico and BG-Barsha elongate shaped fruits (Table 3 and plate 2).

Table 3. Characterization of 17 bottle gourd genotypes

Sl. No.	Genotypes	Fruit color	Fruit shape	Seed colour
1.	BG- 6309	Dark green	Elongate	Light brown
2.	BG- Martina	Light green	Elongate	Dark brown
3.	BG-7092	White	Elongate	Dark brown
4.	BG- 6820	Dark green	Oblong	Light brown
5.	BG- 6813	Light green	Elongate	White
6.	BG- 6837	White	Oval	Black
7.	BG-Diana	Dark green	Dumbbell	Light brown
8.	BG-Tafsi	Dark green	Oblong	Dark brown
9.	Higreen	Dark green	Oblong	Light brown
10.	BG- 6310	Light green	Dumbbell	Dark brown
11.	BG- 6523	Light green	Elongate	Dark brown
12.	BG- 6527	Light green	Elongate	Dark brown
13.	BG- 6818	White	Oval	White
14.	BG- 6816	White	Elongate	Dark brown
15.	BG-Arosh	Dark green	Oblong	Black
16.	BG-Nico	Light green	Elongate	White
17.	BG-Barsha	Dark green	Elongate	Dark brown

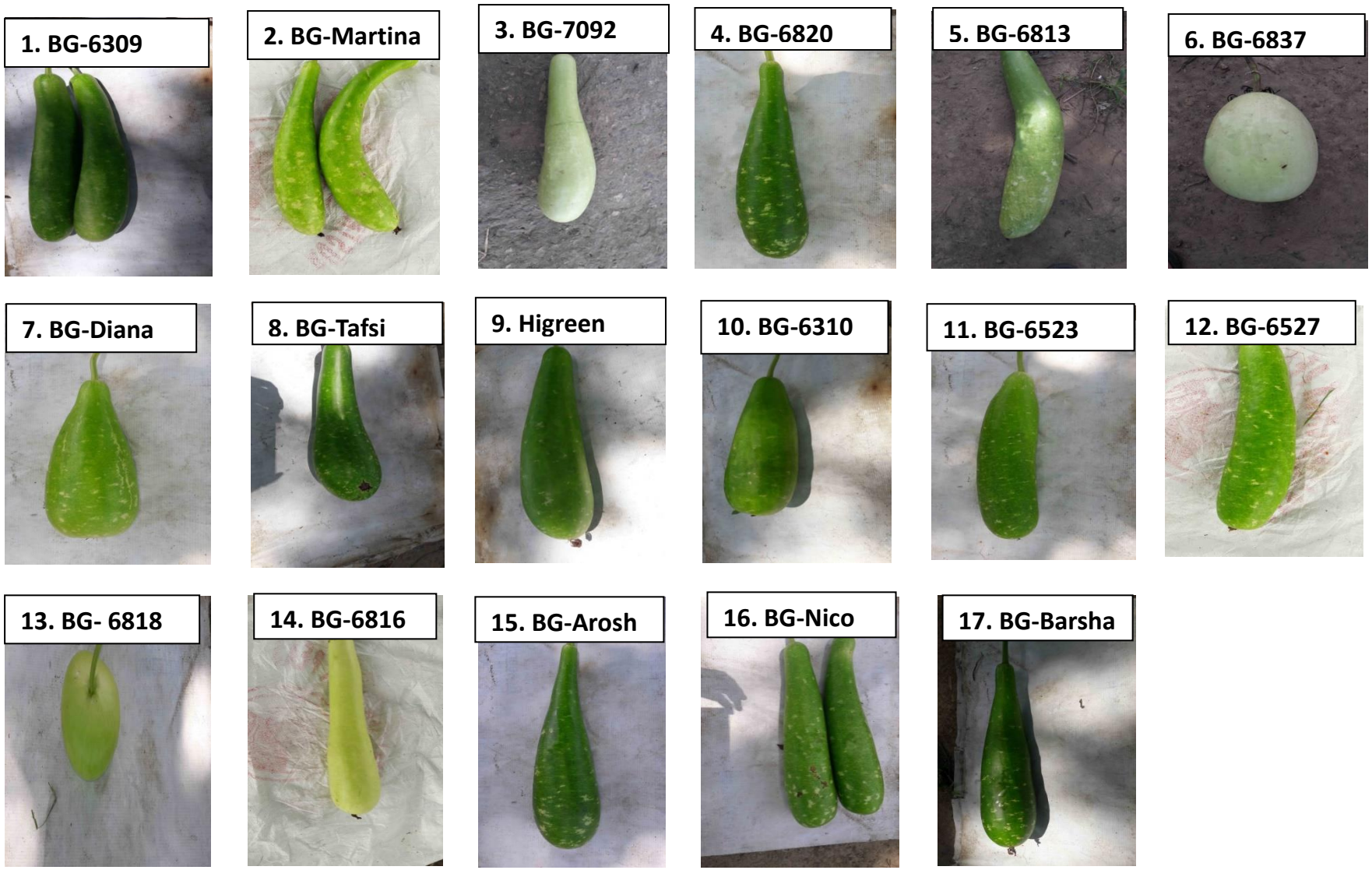

Plate 2. Showing fruits of different genotypes

4.1.1.3 Seed colour

Dark brown, light brown, black and white colour seeds are commonly found in bottle gourd. In the present study light brown, dark brown, black and white coloured seed were observed. Genotypes BG- 6309, BG- 6820, BG- Diana and Higreen produced light brown seed. BG-Martina, BG- 7092, BG-Tafsi, BG-6310, BG- 6523, BG- 6527, BG-6816 and BG- Barsha produced dark green seed, white seeds were produced by BG- 6313, BG-6818 and BG- Nico and black seeds were produced by BG- 6837 and BG- Arosh (Table 3 and Plate 3).

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 and 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 mean square (6.73) (Table 4). The maximum duration was observed 60.00 days in BG-6523 and the minimum duration was observed 54.67 in BG-6813 with mean value 57.59 days (Table 5). The difference between phenotypic variance (4.48) and genotypic variance (1.12) was observed with large environmental influence. The genotypic coefficient of variation and phenotypic co-efficient of variation was observed 1.84% and 3.68% respectively. Heritability showed high (25.07%) with low genetic advance in percent of mean (1.90) revealed that the character was controlled by non-additive genes the selection based on this character would not be effective (Table 4). Karmakar (2015) in her study reported similar result.

4.2.2 Days to first female flowering

Non-significant difference was observed among days to first female flowering in bottle gourd genotypes studied. Mean sum of square was non-significant (7.45) (Table 4). The maximum duration was observed 64.67 days in BG-6523 and the minimum duration was 59.67 days in BG-6818 with mean value 62.10 days (Table 5). The difference between phenotypic variance (6.38) and genotypic variance (0.54) was with large environmental influence. The genotypic co-efficient of variation and phenotypic co-efficient of variation was 1.18% and 4.07% respectively. Heritability showed high (8.40) with low genetic advance in percent of mean (0.70) revealed that character was controlled by non-additive gene so the selection based on this character would not be effective (Table 4).

Plate 3. Showing seeds of different genotypes

4.2.3 Internodes length (cm)

Significant difference for internodes distance was observed among the bottle gourd genotype studied. Mean sum of square was significant (7.05) (Table 4). The maximum internodes distance was observed 15.55 cm in BG-Tafsi and minimum was 10.51 cm which was recorded in BG-Higreen with mean value 12.83 cm (Table 5). The difference between phenotypic variance (3.75) and genotypic variance (1.65) was slightly higher indicating less influence of environment on this character. The genotypic co-efficient of variation was 10.01% and phenotypic co-efficient of variation was 15.10%, respectively. Heritability was high (43.97%) with moderate genetic advance (1.75) and genetic advance in percent of mean (13.68%) revealed that the character was controlled by additive genes. Therefore, the selection based on this character would be effective (Table 4). Singh and Lal (2005) in their study reported similar result.

4.2.4 Tendril length (cm)

Significant difference for tendril length was observed among the bottle gourd genotype studied. Mean sum of square was significant (23.65) (Table 4). The maximum tendril length was observed 22.61 cm in BG-Arosh and minimum was 13.01 cm which was recorded in BG-6310 with mean value 18.41 cm (Table 5). The difference between phenotypic variance (13.60) and genotypic variance (5.03) was slightly higher indicating less influence of environment on this character. The genotypic co-efficient of variation was 12.18% and phenotypic co-efficient of variation was 20.03%, respectively. Gaffar (2008) found the similar result in sponge gourd for this trait. Heritability was high (36.98%) with moderate genetic advance (2.81) and genetic advance in percent of mean (15.26%) revealed that character was controlled by additive genes the selection based on this character would be effective (Table 4).

4.2.5 Length of male petiole (cm)

Genotype mean square for male petiole length was found significant (25.94) as shown in (Table 4). The maximum petiole length was found 15.13 cm in BG-6527 and the minimum was recorded 4.00 cm in BG-Tafsi with mean value 9.71 cm (Table 5). The genotype variance and phenotypic variance were 7.77 and 10.39 respectively. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling male petiole length. The genotypic co-efficient of variation (28.69%) and phenotypic co-efficient of variation (33.19%) were close to each other. Heritability (74.76%) estimates for this trait was high, genotypic advance (4.97) and genotypic advance in percent of mean (51.11) was found moderately high, indicated that the character was controlled by additive gene (Table 4). Rahman *et al.* (1986) also found the similar result in bottle gourd.

4.2.6 Length of female petiole (cm)

Genotype mean square for female petiole length was found significant (11.80) as shown in (Table 4). The maximum petiole length was found 11.00 cm in BG-6310 and the minimum was recorded 3.57 cm in BD-6816 with mean value 7.11 cm (Table 5). The genotype variance and phenotypic variance were 3.59 and 4.62 respectively. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling female petiole length. The genotypic co-efficient of variation (26.63) and phenotypic co-efficient of variation (30.24) were close to each other. Heritability (77.59%) estimates for this trait was high, genotypic advance (3.44) and genotypic advance in percent of mean (48.33) was found moderately high, indicated that the character was controlled by additive gene (Table 4). Rahman et al. (1986) also found the similar result in bottle gourd.

4.2.7 Female ovary diameter (cm)

Significant mean sum of square of female ovary diameter was found (8.17) (Table 4). The maximum female ovary diameter was found 7.08 cm in BG-6310 and the minimum was 2.53 cm in BG-6820 with mean value 4.60 cm (Table 5). The phenotypic variance (2.98) appeared to be higher than genotypic variance (2.59) suggested that influence of environment acted on the expression of this gene controlling this trait. The genotypic co-efficient of variation was 35.05% and phenotypic co-efficient of variation was 37.55% (Table 2). Heritability (87.11%) estimates for this trait was high, genotypic advance (3.10) and genotypic advance in percent of mean (67.38) was found moderately high, indicated that the character was controlled by additive gene (Table 4).

4.2.8 Number of primary branches (cm)

Significant mean sum of square of number of primary branches was found (70.71) (Table 4). Among the genotypes number of branches per plant ranged from 11.67 to 27.00 with an overall mean of 17.35. Maximum number of branch per plant was recorded 27.00 in (BG-7090), which 11.67 in (BG-Diana) was noted for minimum number of Primary branches per plant (Table 5). The phenotypic variance (25.10) appeared to be higher than genotypic variance (22.61) suggested that influence of environment acted on the expression of this gene controlling this trait. The genotypic co-efficient of variation was 27.40% and phenotypic co-efficient of variation was 28.87% (Table 4). Heritability (90.09%) estimates for this trait was high, genotypic advance (9.30) and genotypic advance in percent of mean (53.57) was found moderately high, indicated that the character was controlled by additive gene. Karmakar (2015) in her study reported similar result.

Table 4. Estimation of genetic parameters for morphological characters related to yield of bottle gourd

Characters	Range	Mean	MS	PV	GV	PCV (%)	GCV (%)	Heritability (%)	GA	GA (%)
Days to first male flowering	54.67-60	57.59	6.73*	4.48	1.12	3.68	1.84	25.07	1.09	1.90
Days to first female flowering	59.67-64.67	62.10	7.45^{ns}	6.38	0.54	4.07	1.18	8.40	0.44	0.70
Internode length (cm)	10.51-15.55	12.83	7.05**	3.75	1.65	15.10	10.01	43.97	1.75	13.68
Tendril length (cm)	13.01-22.61	18.41	23.65**	13.60	5.03	20.03	12.18	36.98	2.81	15.26
Male petiole length (cm)	4-15.13	9.71	25.94**	10.39	7.77	33.19	28.69	74.76	4.97	51.11
Female petiole length (cm)	3.57-11	7.11	11.80**	4.62	3.59	30.24	26.63	77.59	3.44	48.33
Female ovary diameter (cm)	2.53-7.08	4.60	8.17**	2.98	2.59	37.55	35.05	87.11	3.10	67.38
Number of primary branches	11.67-27	17.35	70.31**	25.10	22.61	28.87	27.40	90.09	9.30	53.57
Days to first fruit harvest	75.67-83.67	79.90	16.16**	8.79	3.68	3.71	2.40	41.86	2.56	3.20
Number of fruit per plant	2.67-5.33	3.41	1.52**	0.74	0.39	25.13	18.38	53.50	0.95	27.70
Fruit length (cm)	17-54.71	39.38	211.66**	76.93	67.37	22.27	20.84	87.57	15.82	40.18
Fruit diameter (cm)	25.33-45.67	32.89	86.28**	35.84	25.22	18.21	15.27	70.35	8.68	26.38
Fruit weight (kg)	0.81-2.36	1.52	0.46**	0.17	0.15	27.05	25.21	86.84	0.73	48.39
Seed length (cm)	1.53-2.13	1.91	0.09**	0.04	0.03	9.99	8.65	74.97	0.30	15.42
Seed diameter (cm)	0.53-0.87	0.74	0.03**	0.01	0.01	16.12	13.42	69.33	0.17	23.02
Seed thickness (cm)	0.23-0.43	0.32	0.01**	0.01	0.002	23.90	14.32	35.89	0.06	17.67
100 seed weight (gm)	5-23	16.47	85.46**	29.03	28.22	32.71	32.25	97.20	10.79	65.50
Number of seed per fruit	160.67-484.33	310.16	21037.90**	7104.43	6966.73	27.18	26.91	98.06	170.27	54.90
Fruit yield per plant (kg)	2.70-10.29	5.23	11.56**	4.52	3.52	40.62	35.87	77.99	3.41	65.25

** indicates significant at 0.01 probability level, * indicates significant at 0.05 probability level, ^{ns} indicates non-significant.

MS: Mean Sum of Square, PV: Phenotypic variance, PCV: Phenotypic coefficient of variation,

GA: Genetic advance, GV: Genotypic variance, GCV: Genotypic coefficient of variation.

Table 5. Mean performance of bottle gourd genotypes based on different morphological traits related to yield

Variety	Days to first male flowering	Days to first female flowering	Internode length (cm)	Tendril length (cm)	Male petiole length (cm)	Female petiole length (cm)	Female ovary diameter (cm)	Number of primary branches
BG- 6309	56.33 c-f	60.00bc	12.79 b-e	14.52 de	9.55 c-e	7.30 d-g	3.06 d-f	26.00 a
BG-Martina	59.00 a-d	63.33 a-c	11.22 de	17.24 b-e	7.68 ef	6.53 e-i	3.50 c-f	15.33 de
BG-7092	58.33 a-e	62.00 a-c	12.68 b-e	18.37 a-d	8.21 d-f	6.03 f-j	2.80 ef	27.00 a
BG-6820	57.66 a-f	62.66 a-c	11.71 c-e	20.63 a-c	7.93 d-f	5.53 h-j	2.53 f	15.00 de
BG-6813	54.67 f	60.33bc	13.80 a-c	20.74 a-c	13.66 ab	6.16 e-j	2.59 f	24.66 ab
BG-6837	56.66 b-f	61.33 a-c	12.67 b-e	18.91 a-d	8.63 de	7.68 d-f	3.27 c-f	18.00 c
BG-Diana	59.66 ab	64.00 ab	14.51 ab	18.20 a-d	9.43 c-e	7.13 d-h	4.56 b	11.66 f
BG-Tafsi	55.66ef	59.66 c	15.55 a	18.64 a-d	4.00 g	5.16 i-k	4.11bc	13.00 ef
Higreen	59.33 a-c	63.66 a-c	10.51 e	15.18 de	5.81 fg	4.48 jk	3.83 b-e	12.33 f
BG-6310	57.33 a-f	61.66 a-c	10.81 e	13.01 e	7.95 d-f	11.00 a	7.08 a	13.00 ef
BG-6523	60.00 a	64.66 a	11.44 c-e	20.48 a-c	11.45bc	5.96 g-j	6.21 a	15.00 de
BG-6527	56.66 b-f	61.66 a-c	13.70 a-c	16.34 c-e	15.13 a	8.56 b-d	6.26 a	15.33 de
BG-6818	56.00 d-f	59.66 c	14.42 ab	21.89 ab	10.53 cd	7.75 c-e	4.21bc	17.00 cd
BG-6816	58.33 a-e	63.33 a-c	13.56 a-d	20.84 a-c	7.85 d-f	3.56 k	3.90 b-d	23.00 b
BG-Arosh	57.00 a-f	61.33 a-c	12.69 b-e	22.61 a	13.63 ab	9.400 a-c	6.43 a	15.00 de
BG-Nico	57.66 a-f	62.66 a-c	11.09 e	15.00 de	11.65bc	8.733 b-d	7.03 a	17.33 cd
BG-Barsha	58.66 a-e	63.66 a-c	14.91 ab	20.26 a-c	12.01bc	9.86 ab	6.70 a	16.33 cd
LSD	3.05	4.02	2.41	4.87	2.69	1.69	1.03	2.62
SD	2.11	2.50	1.97	3.69	3.21	2.13	1.69	4.91
SE	0.30	0.35	0.28	0.52	0.45	0.30	0.24	0.69
Minimum	54.67	59.67	10.51	13.01	4.00	3.57	2.53	11.67
Maximum	60.00	64.67	15.55	22.61	15.13	11.00	7.08	27.00
Mean	57.59	62.10	12.83	18.41	9.71	7.11	4.60	17.35
CV (%)	3.18	3.89	11.30	15.90	16.67	14.32	13.48	9.09

Table 5 (Cont'd). Mean performance of bottle gourd genotypes

Variety	Days to first fruit harvest	Number 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)	Number of seed per fruit	Fruit yield per plant (kg)
BG- 6309	77.66 de	3.33bc	43.76 b-d	25.33 h	1.54 cd	2.06 ab	0.76a-c	0.33 a-c	21.33 b	281.67 f	5.14 de
BG-Martina	81.66 a-c	3.33bc	45.65bc	29.64 f-h	1.32 de	2.10 ab	0.70 cd	0.30bc	17.66 de	365.67 c	4.41 d-g
BG-7092	80.33 a-d	3.00bc	40.73 c-e	28.43 gh	1.30 de	1.90 cd	0.60 d-f	0.26bc	23.00 a	293.67 ef	3.91 d-h
BG-6820	80.33 a-d	3.00bc	42.00 b-e	28.96 fh	1.18 ef	1.83 d	0.53 f	0.23 c	22.33 ab	256.67 g	3.55 e-h
BG-6813	77.66 de	3.00bc	43.00 b-d	31.20 e-g	1.16 ef	1.86 cd	0.86 a	0.33 a-c	16.33 e	285.67 ef	3.49 f-h
BG-6837	78.33 c-e	3.33bc	26.33 h	45.66 a	1.62 c	2.10 ab	0.76 a-c	0.36 ab	21.33 b	226.33 h	5.46 cd
BG-Diana	83.66 a	5.33 a	37.33 ef	37.98 b-d	1.93 b	1.83 d	0.86 a	0.36 ab	21.33 b	303.67 e	10.28 a
BG-Tafsi	75.66 e	3.00bc	41.46 b-e	35.50 c-e	1.63 c	1.96 b-d	0.66 c-e	0.36 ab	8.33 h	247.33 g	4.89 d-f
Higreen	81.66 a-c	3.33bc	41.53 b-e	32.98 d-g	1.35 de	1.66 e	0.73bc	0.23 c	8.66 h	420.00 b	4.55 d-g
BG-6310	80.33 a-d	2.66 c	31.91 g	33.88 c-f	1.98 b	2.00 a-c	0.86 a	0.36 ab	13.66 f	365.67 c	5.31 d
BG-6523	83.66 a	3.00bc	35.05 fg	29.30 f-h	1.00 fg	2.06 ab	0.86 a	0.26bc	19.66 c	424.33 b	3.02gh
BG-6527	77.66 de	3.00bc	42.00 b-e	38.41bc	2.35 a	1.63 e	0.56 ef	0.33 a-c	5.00 i	160.67 j	7.07bc
BG-6818	77.66 de	3.33bc	17.00 i	41.33 ab	0.80 g	1.53 e	0.66 c-e	0.23 c	11.66 g	202.33 i	2.70 h
BG-6816	79.00 b-e	3.66 b	41.01 b-e	32.08 e-g	1.47 cd	1.86 cd	0.83 ab	0.30bc	17.66 de	294.33 ef	5.41 cd
BG-Arosh	79.00 b-e	5.00 a	39.86 d-f	31.36 e-g	1.63 c	2.13 a	0.73bc	0.36 ab	18.66 cd	327.33 d	8.17 b
BG-Nico	81.66 a-c	3.00bc	46.07 b	29.03 f-h	1.49 cd	2.00 a-c	0.76 a-c	0.43 a	16.33 e	333.00 d	4.48 d-g
BG-Barsha	82.33 ab	3.66 b	54.71 a	27.90gh	1.97 b	1.96 b-d	0.73bc	0.33 a-c	17.00 e	484.33 a	7.04bc
LSD	3.76	0.97	5.14	5.42	0.25	0.16	0.11	0.10	1.50	19.51	1.66
SD	2.95	0.85	8.59	5.88	0.40	0.19	0.12	0.08	5.31	82.62	2.11
SE	0.41	0.12	1.20	0.82	0.06	0.03	0.02	0.01	0.74	11.57	0.30
Minimum	75.67	2.67	17.00	25.33	0.81	1.53	0.53	0.23	5.00	160.67	2.70
Maximum	83.67	5.33	54.71	45.67	2.36	2.13	0.87	0.43	23.00	484.33	10.29
Mean	79.90	3.41	39.38	32.89	1.52	1.91	0.74	0.32	16.47	310.16	5.23
CV (%)	2.83	17.14	7.85	9.91	9.81	5.00	8.92	19.13	5.48	3.78	19.06

4.1.9 Days to first fruit harvest

Significant mean sum of square of days to first fruit harvest was found (16.16) (Table 4). Days to first fruit harvest ranged from 75.67 to 83.67 days with a mean of 79.90 days (Table 5). Significantly earliest days for first fruit harvest was recorded 75.67 days in (BG-Tafsi), however significantly maximum days for first fruit harvest was 83.76 in (BG-Diana). The phenotypic variance (8.79) appeared to be higher than genotypic variance (3.68) suggested that influence of environment acted on the expression of this gene controlling this trait. The genotypic co-efficient of variation was 2.40% and phenotypic co-efficient of variation was 3.71%, respectively (Table 4). Heritability (41.86%) estimates for this trait was high, genotypic advance (2.56) and genotypic advance in percent of mean (3.20) was found moderately high, indicated that the character was controlled by additive gene. Karmakar (2015) in her study reported similar result.

4.2.10 Number of fruits per plant

Significant mean sum of square of number of primary branches was found (1.52) (Table 4). Maximum number of fruits per plant was recorded 5.33 in (BG-Diana). The genotype (BG-6310) of 2.67 recorded for minimum number of fruits per plant with a mean 3.41 (Table 5). The phenotypic variance (0.74) appeared to be higher than genotypic variance (0.39) suggested that influence of environment acted on the expression of this gene controlling this trait. The genotypic co-efficient of variation was 18.38% and phenotypic co-efficient of variation was 25.13%, respectively (Table 4). Heritability (53.55%) estimates for this trait was high, genotypic advance (0.95) and genotypic advance in percent of mean (27.70) was found moderately high, indicated that the character was controlled by additive gene. Sharma and Dhankhar (1990) reported similar heritability (64.23%) and genetic advance in percent of mean (29.30) in bottle gourd for this trait.

4.2.11 Fruit Length (cm)

Mean sum of square of fruit length was significant (211.66) (Table 4). The maximum fruit length was found 54.71 cm in (BG-Barsha) and the minimum number was 17.00 cm in (BG- 6818) with mean value 39.38 cm (Table 5). The phenotypic variance (76.93) appeared to be moderately higher than genotypic variance (67.37) suggested that moderate influence of environment acted on the expression of this gene controlling this trait. The genotypic co-efficient of variation and phenotypic co-efficient of variation were observed 20.84 % and 22.27 %, respectively. High heritability found (87.37) with moderately high genetic advance in percent of mean (40.18) revealed that character was controlled by additive gene so the selection based on this character would be effective (Table 4). Photographs showed variation in fruit length of bottle gourds. Rahman et al. (1986) indicated the minimum differences between GCV and PCV in bottle gourd for fruit length.

4.2.12 Fruit diameter (cm)

Significant mean sum of square of fruit diameter was found (86.28) (Table 4). The maximum fruit diameter was found 45.67 cm in (BG- 6837) and the minimum number was 25.33 cm in (BG- 6309) with mean value 32.89 cm (Table 5). The phenotypic variance (35.84) appeared to be higher than genotypic variance (25.22) suggested that influence of environment acted on the expression of this gene controlling this trait. The genotypic co-efficient of variation was 15.27% and phenotypic co-efficient of variation was 18.21%, respectively (Table 4). Heritability found high (70.35 %) with moderately high genetic advance in percent of mean (26.38) revealed that character was controlled by additive gene so the selection based on this character would be effective. Asmaul Husna (2009) reported GCV and PCV were 15.84 and 17.39 respectively in bottle gourd and heritability (82.93%) estimates for this trait was high along with moderately high genetic advance in percent of mean (38.08).

4.2.13 Fruit weight (kg)

Significant mean sum of square of fruit weight was found (0.46) (Table 4). The maximum fruit weight found 2.36 kg in (BG- 6527) and the minimum fruit weight was 0.81 kg found in (BG- 6818) with mean value 1.52 kg (Table 5). The phenotypic variance (0.17) appeared to be slightly higher than genotypic variance (0.15) suggested that less influence of environment acted on the expression of this gene controlling this trait. The genotypic co-efficient of variation was 25.21% and phenotypic co-efficient of variation was 27.05 %, respectively (Table 4). Heritability found high (86.84 %) with moderately high genetic advance in percent of mean (38.39) revealed that the character was controlled by additive gene so the selection based on this character would be effective. Karmakar (2015) in her study reported similar result.

4.2.14 Seed length (cm)

Significant variation was observed in seed length among 17 genotypes of bottle gourd. Mean sum square was 0.09 and significant (Table 4). The seed length varied from 2.13 cm to 1.53 cm (Table 4). The lowest seed length was recorded 1.1.53 cm in (BG- 6818) and the highest length was recorded was 2.13 cm in (BG-Arosh) with mean value 1.91 cm (Table 5). The phenotypic variance and genotypic variance ware 0.04 and 0.03 respectively. It indicates less influence of environment on this character. The genotypic co-efficient of variation was 8.65% and phenotypic coefficient of variation was 9.99%, respectively (Table 4). Heritability showed high (74.97%) and moderate genetic advance (0.30) and genetic advance in percent of mean (15.42) revealed that character was controlled by additive genes the selection based on this character would be effective. Rahman (2005) also found the similar result.

4.2.15 Seed diameter (cm)

Significant difference was found among 17 genotypes of bottle gourd. Mean sum of square of Seed diameter was significant (0.03) (Table 4). The highest seed diameter

was found 0.87 cm in (BG-Tafsi) and the lowest was found 0.53 cm in (BG- 6820) with mean value 0.74 cm (Table 5). The phenotypic variance (0.01) appeared to be moderately higher than genotypic variance (0.01) suggested that moderate influence of environment acted on the expression of this gene controlling this trait. The genotypic co-efficient of variation and phenotypic co-efficient of variation were observed 13.42% and 16.12%, respectively (Table 4). High heritability found (69.33%) with moderately high genetic advance in percent of mean (23.02). Narayan *et al.* (1996) observed similar result in bottle gourd.

4.2.16 Seed thickness (cm)

The seed thickness varied from 0.23 cm to 0.43 cm. The highest thickness was recorded 0.43 cm in genotype (BG-Nico) and the lowest value were 0.23 cm in (BG-6820), BG-Higreen and (BG- 6818) respectively with mean value 0.32 (Table 5). It indicated less influence of environment on this character. The genotypic variance was 0.002% and phenotypic variance was 0.01% respectively (Table 4). The genotypic co-efficient of variation was 14.32 % and phenotypic co-efficient of variation was 23.90 % respectively (Table 4). Heritability showed high (35.89 %) and moderate genetic advance (0.06) and genetic advance in percent of mean (17.67) revealed that character was controlled by additive genes the selection based on this character would be effective.

4.2.17 100 seed weight (gm)

Hundred seed weight was found significant (85.46) among 17 genotypes of bottle gourd (Table 4). It varied from 5.00 gm to 23.00 gm. The highest weight of 100 seed weight was recorded 23.00 gm in (BG-7090) and the lowest were 5.00 in (BG-6527) respectively with mean value 16.47 (Table 5). The genotypic variance was 28.22 % and phenotypic variance was 29.03 % respectively (Table 2). The genotypic co-efficient of variation was 32.25 % and phenotypic co-efficient of variation was 32.71 %, respectively (Table 4). Heritability showed high (97.20 %) and moderate genetic advance (10.79) and genetic advance in percent of mean (65.50). Rahman (2005) observed thirty nine genotypes of sponge gourd of diverse origin and reported that hundred seed weight varied from 8.06 to 9.46 gm.

4.2.18 Number of seeds per fruit

It is also an important yield contributing character. Significant difference was observed among the genotypes in this trait (Table 4). Mean sum of square of fruit length was significant (21037.00). Number of seeds per fruit varied from 160.67 to 484.33. The mean value was observed as 310.16 seeds per fruit. The highest number of seeds per fruit was recorded 484.33 in (BG-Barsha) respectively. The lowest number was recorded 160.67 in (BG- 6527) (Table 5). The genotypic variance was 6966.73 and phenotypic variance was 7104.43 respectively (Table 2). The genotypic coefficient of variation was 26.91 % and phenotypic co-efficient of variation was 27.78 %,

respectively (Table 4). Heritability showed high (98.06 %) and moderate genetic advance (170.27) and genetic advance in percent of mean (54.90).

4.2.19 Yield per plant (kg)

Significant mean sum of square for yield per plant (11.56) indicated considerable difference among the genotypes studied (Table 4). The maximum yield per plant was found 10.29 kg in (BG-Diana) and the minimum was recorded 2.70 kg in G14 (BG-6818) with mean value 5.23 kg (Table 5). The differences in magnitudes in between genotypic (3.53) and phenotypic (4.52) variances was relatively high for this trait indicating large environmental influence on these characters. The genotypic coefficient of variation and phenotypic co-efficient of variation were 35.87 % and 40.62 % respectively for yield per plant which indicating that significant variation exists among different genotypes. The heritability value (77.99 %) as well as genetic advance (3.41) and genetic advance in percent of mean (65.25) were observed very high. The very high heritability with moderate genetic advance provided opportunity for selecting high valued genotypes for breeding programme. Narayan *et al.* (1996) observed similar result in bottle gourd.

4.3 Correlations co-efficient

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

4.3.1 Days to first male flowering

It was observed that days to first male flowering showed significant and positive correlation with days to first female flowering (g=0.955, p=0.944), days to first fruit harvest (g=0.938, p=0.881), number of fruit per plant (g=0.338), fruit length (cm) (g=0.347), 100 seed weight (gm) (g=0.414) and number of seed per fruit (g=0.917, p=0.439). It also observed a significant but negative correlation with number of primary branches (g=-0.466), fruit diameter (cm) (g=-0.989) and seed thickness (cm) (g=-0.409). It showed non-significant and positive correlation with number of fruit per

plant (p=0.245), fruit length (cm) (p=0.120), fruit weight (kg) (g=0.047), seed length (cm) (g=0.154, p=0.065), seed diameter (cm) (g=0.150, p=0.177), 100 seed weight (gm) (p=0.178) and fruit yield per plant (kg) (g=0.267, p=0.179). It found a non-significant but negative correlation with number of primary branches (p=-0.238), fruit weight (kg) (p=-0.002) and seed thickness (cm) (p=-0.162) (Table 6). Karmakar (2015) in her study reported similar result.

4.3.2 Days to first female flowering

It was observed that days to first female flowering showed significant and positive correlation with days to first fruit harvest (g=0.962, p=0.844), number of fruit per plant (g=0.382), fruit length (cm) (g=0.816), seed diameter (cm) (g=0.368), 100 seed weight (gm) (g=0.565) and number of seed per fruit (g=0.414, p=0.393), fruit yield per plant (kg) (g= 0.416). It also observed a significant but negative correlation with number of primary branches (g=-0.656), fruit diameter (cm) (g=-0.975) and seed thickness (cm) (g=-0.393). It showed non-significant and positive correlation with number of fruit per plant (p=0.192), fruit length (cm) (p=0.174), fruit diameter (cm) (p= 0.032), fruit weight (kg) (p=0.201), seed length (cm) (g=0.191, p=0.077), seed diameter (cm) (p=0.200), 100 seed weight (gm) (p=0.144) and fruit yield per plant (kg) (p=0.159). It found a non-significant but negative correlation with number of primary branches (p=-0.288) and seed thickness (cm) (p=-0.100) (Table 6).

4.3.3 Number of primary branches

It was observed that number of primary branches showed significant and positive correlation with 100 seed weight (gm) (g=0.414, p=0.392). It also observed a significant but negative correlation with days to first fruit harvest (g=-0.398), fruit diameter (cm) (g=-0.373, p=-0.301), fruit weight (kg) (g=-0.286) and fruit yield per plant (kg) (g=-0.346, p=-0.300). It showed non-significant and positive correlation with fruit length (cm) (g=0.128, p=0.112), seed length (cm) (g=0.102, p=0.092), fruit diameter (cm) (p= 0.032), and seed diameter (cm) (g=0.004, p=0.024). It found a non-significant but negative correlation with days to first fruit harvest (p=-0.266), no of fruit per plant (g=-0.263, p=-0.194), fruit weight (kg) (p=-0.256), seed thickness (cm) (g=-0.123, p=-0.043) and number of seed per fruit (g=-0.210, p=-0.202) (Table 6). Karmakar (2015) in her study reported similar result.

4.3.4 Days to first fruit harvest

It was observed that days to first fruit harvest showed significant and positive correlation with number of primary branches (g=0.304), fruit length (cm) (g=0.313), seed diameter (cm) (g=0.370), 100 seed weight (gm) (g=0.458, p=0.278), no of seed per fruit (g=0.884, p=0.551). It also observed a significant but negative correlation with no of fruit per plant (g=-0.501). It showed non-significant and positive correlation with no of fruit per plant (p=0.229), fruit length (cm) (p=0.158), fruit weight (kg)

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

Trait		DFMF	DFFF	NPB	DFFH	NFPP	FL (cm)	FD (cm)	FW (kg)	SL (cm)	SD (cm)	ST (cm)	HSW (gm)	NSPF
DFMF	G	0.955**												
	P	0.944**												
NPB	G	-0.466**	-0.656**											
	P	-0.238^{NS}	-0.228^{NS}											
DFFH	G	0.938**	0.962**	-0.398**										
	P	0.881**	0.884**	-0.266^{NS}										
NFPP	G	0.338*	0.382**	-0.263^{NS}	0.304*									
	P	0.245^{NS}	0.192^{NS}	-0.194^{NS}	0.229^{NS}									
FL (cm)	G	0.347*	0.816**	0.128^{NS}	0.313*	0.033^{NS}								
	P	0.120^{NS}	0.174^{NS}	0.112^{NS}	0.158^{NS}	0.017^{NS}								
FD (cm)	G	-0.589**	-0.975**	-0.373**	-0.501**	0.167^{NS}	-0.777**							
	P	0.012^{NS}	0.032^{NS}	-0.301*	-0.106^{NS}	0.095^{NS}	-0.629**							
FW (kg)	G	0.047^{NS}	0.201^{NS}	-0.286*	0.001^{NS}	0.282*	0.343*	0.152^{NS}						
	P	-0.002^{NS}	0.026^{NS}	-0.258^{NS}	-0.037^{NS}	0.154^{NS}	0.328*	0.193^{NS}						
SL (cm)	G	0.154^{NS}	0.191^{NS}	0.108^{NS}	0.154^{NS}	0.114^{NS}	0.319*	-0.382**	0.096^{NS}					
	P	0.065^{NS}	0.077^{NS}	0.092^{NS}	0.163^{NS}	0.076^{NS}	0.226^{NS}	-0.319*	0.073^{NS}					
SD (cm)	G	0.150^{NS}	0.368**	0.004^{NS}	0.370**	0.314*	-0.098^{NS}	-0.022^{NS}	-0.008^{NS}	0.423**				
	P	0.177^{NS}	0.200^{NS}	0.024^{NS}	0.243^{NS}	0.160^{NS}	-0.074^{NS}	0.006^{NS}	0.027^{NS}	0.254^{NS}				
ST (cm)	G	-0.409**	-0.393**	-0.123^{NS}	-0.123^{NS}	0.295*	0.248^{NS}	0.134^{NS}	0.735**	0.671**	0.459**			
	P	-0.162^{NS}	-0.100^{NS}	-0.043^{NS}	-0.080^{NS}	0.144^{NS}	0.197^{NS}	0.065^{NS}	0.468**	0.343*	0.296*			
HSW (gm)	G	0.414**	0.565**	0.416**	0.458**	0.346*	0.060^{NS}	-0.345*	-0.275*	0.576**	0.210^{NS}	-0.001^{NS}		
	P	0.178^{NS}	0.144^{NS}	0.392**	0.278*	0.202^{NS}	0.048^{NS}	-0.314*	-0.271*	0.502**	0.187NS	-0.014NS		
NSPP	G	0.917**	0.417**	-0.210^{NS}	0.884**	0.111^{NS}	0.461**	-0.587**	-0.042^{NS}	0.393**	0.461**	-0.072^{NS}	0.180^{NS}	
	P	0.439**	0.393**	-0.202^{NS}	0.551**	0.067^{NS}	0.440**	-0.495**	-0.022^{NS}	0.338*	0.386**	-0.005^{NS}	0.175^{NS}	
FYPP (kg)	G	0.267^{NS}	0.416**	-0.346*	0.219^{NS}	0.792**	0.244^{NS}	0.201^{NS}	0.808**	0.131^{NS}	0.192^{NS}	0.655**	0.050^{NS}	0.040^{NS}
	P	0.179^{NS}	0.159^{NS}	-0.300*	0.159^{NS}	0.797**	0.214^{NS}	0.181^{NS}	0.713**	0.096^{NS}	0.148^{NS}	0.388**	0.004^{NS}	0.037^{NS}

DFMF: Days to first male flowering, DFFF: Days to first female flowering, NPB: Number of primary branches, DFFH: Days to first fruit harvest, FL: Fruit length, FD: Fruit diameter, FW: Fruit weight, SL: Seed length, SD: Seed diameter, ST: Seed thickness, HSW: 100 seed weight, NSPF: Number of seed per fruit, FYPP: Fruit yield per plant, G: Genotypic, P: Phenotypic, * * 1 % level of significant, * 5% level of significant, ^{NS} non-significant

(g=0.001), seed length (cm) (g=0.154, p=0.163), seed diameter (cm) (p=0.243) and fruit yield per plant (kg) (g=0.219, p=0.159). It found a non-significant but negative correlation with fruit diameter (cm) (p=-0.106), fruit weight (kg) (p=-0.037) and seed thickness (cm) (g=-0.123, p=-0.080) (Table 6).

4.3.5 Number of fruit per plant

It was observed that no of fruit per plant showed significant and positive correlation with fruit weight (kg) (g=0.282), seed diameter (cm) (g=0.314), seed thickness (cm) (g=0.295), 100 seed weight (gm) (g=0.346), fruit yield per plant (kg) (g=0.792, p=0.797). It showed non-significant and positive correlation with fruit length (cm) (g=0.033, p=0.158), fruit diameter (cm) (g=0.167, p=0.095), fruit weight (kg) (p=0.154), seed length (cm) (g=0.114, p=0.076), seed diameter (cm) (p=0.160), seed thickness (cm) (p=0.144), 100 seed weight (gm) (p=0.202) and number of seed per fruit (g=0.111, p=0.067) (Table 6). Husna (2009) also found similar result in bottle gourd.

4.3.6 Fruit length (cm)

It was observed that fruit length (cm) showed significant and positive correlation with fruit weight (kg) (g=0.343, p=0.328), seed length (cm) (g=0.319), number of seed per fruit (g=0.461, p=0.440). It also observed a significant but negative correlation with fruit weight (kg) (g=-0.777, p=-0.629). It showed non-significant and positive correlation with seed thickness (cm) (g=0.248, p=0.144), 100 seed weight (gm) (g=0.060, p=0.202) and fruit yield per plant (kg) (g=0.244, p=0.214). It found a non-significant but negative correlation with fruit diameter (cm) (g=-0.098, p=-0.074) (Table 6). Husna (2009) also found similar result in bottle gourd.

4.3.7 Fruit diameter (cm)

It was observed that fruit diameter (cm) showed significant but negative correlation with seed length (cm) (g=-0.382, p=-0.319), 100 seed weight (gm) (g=-0.345, p=-0.314), number of seed per fruit (g=-0.587, p=-0.495). It showed non-significant and positive correlation with fruit weight (kg) (g=0.152, p=0.193), seed diameter (cm) (p=0.006), seed thickness (cm) (g=0.134, p=0.065), and fruit yield per plant (kg) (g=0.201, p=0.181). It found a non-significant but negative correlation with seed diameter (cm) (p=-0.022) (Table 6).

4.3.8 Fruit weight (kg)

It was observed that fruit weight (kg) showed significant and positive correlation with seed thickness (cm) (g=0.735, p=0.468), fruit yield per plant (kg) (g=0.808, p=0.713). It also observed a significant but negative correlation with 100 seed weight (gm) (g=-0.275, p=-0.27). It showed non-significant and positive correlation with seed length (cm) (g=0.098, p=0.073), seed diameter (cm) (p=0.027). It found a non-significant but

negative correlation with seed diameter (cm) (g=-0.008) and number of seed per fruit (g=-0.042, p=-0.022) (Table 6).

4.3.9 Seed length (cm)

It was observed that seed length (cm) showed significant and positive correlation with seed diameter (cm) (g=0.423), seed thickness (cm) (g=0.671, p=0.343), 100 seed weight (gm) (g=0.576, p=0.502), number of seed per fruit (g=0.393, p=0.338). It also showed non-significant and positive correlation with seed diameter (cm) (p=0.254) and fruit yield per plant (kg) (g=0.131, p=0.148) (Table 6).

4.3.10 Seed diameter (cm)

It was observed that seed diameter (cm) showed significant and positive correlation with seed thickness (cm) (g=0.459, p=0.296), number of seed per fruit (g=0.461, p=0.386). It also showed non-significant and positive correlation with 100 seed weight (gm) (g=0.210, p=0.254) and fruit yield per plant (kg) (g=0.192, p=0.148) (Table 6).

4.3.11 Seed thickness (cm)

It was observed that seed thickness (cm) showed significant and positive correlation with fruit yield per plant (kg) (g=0.655, p=0.388). It also showed non-significant but negative correlation with 100 seed weight (gm) (g=-0.001, p=-0.014) and number of seed per fruit (kg) (g=-0.072, p=-0.005) (Table 6).

4.3.12 100 seed weight (gm)

It was observed that 100 seed weight (gm) showed non-significant and positive correlation with number of seed per fruit (kg) (g=0.180, p=0.175) and fruit yield per plant (kg) (g=0.050, p=0.004) (Table 6).

4.3.13 Number of seed per fruit

It was observed that number of seed per fruit showed non-significant and positive correlation with fruit yield per plant (kg) (g=0.040, p=0.037) (Table 6).

4.4 Path 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. In order to find out a clear picture of the inter relationship between 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. Estimation of direct indirect effect of path co-efficient analysis for bottle gourd and represented in (Table 7).

4.4.1 Days to first male flowering

Path co-efficient analysis revealed that days to first male flowering had a positive direct effect (0.006) on fruit yield per plant. Days to the first male flowering had a positive indirect effect on number of primary branches (0.009), days to first fruit harvest (0.059), number of fruit per plant (0.167), fruit length (cm) (0.005), fruit diameter (cm) (0.001), seed diameter (cm) (0.007), seed thickness (cm) (0.0006), 100 seed weight (gm) (0.009). While the negative indirect effect on days to first female flowering (-0.061), fruit weight (kg) (-0.001), seed length (cm) (-0.002) and number of seed per fruit (-0.020) (Table 7). It showed non-significant positive genotypic correlation (0.267) with fruit yield per plant (kg) (Table 8).

4.4.2 Days to first female flowering

Path co-efficient analysis revealed that days to first female flowering had a negative direct effect (-0.064) on fruit yield per plant. Days to first female flowering had a positive indirect effect on days to first male flowering (0.006), number of primary branches (0.008), days to first fruit harvest (0.059), number of fruit per plant (0.131), fruit length (cm) (0.007), fruit diameter (cm) (0.0003), fruit weight (kg) (0.016), seed diameter (cm) (0.008), seed thickness (cm) (0.0004), 100 seed weight (gm) (0.007). While the negative indirect effect on seed length (cm) (-0.002) and number of seed per fruit (-0.018) (Table 7). It showed significant positive genotypic correlation (0.416) with fruit yield per plant (kg) (Table 8).

4.4.3 Number of primary branches

Path co-efficient analysis revealed that number of primary branches had a negative direct effect (-0.037) on fruit yield per plant. Number of primary branches had a positive indirect effect on days to first female flowering (0.015), days to first male flowering (0.006), fruit length (cm) (0.005), seed diameter (cm) (0.001), seed thickness (cm) (0.0002), 100 seed weight (gm) (0.0019), number of seed per fruit (0.009). While the negative indirect effect on days to first male flowering (-0.002), days to first fruit harvest (-0.018), number of fruits per plant (-0.132), fruit diameter (cm) (-0.003), fruit weight (kg) (-0.156) and seed length (cm) (-0.003) (Table 7). It showed significant negative genotypic correlation (-0.346) with fruit yield per plant (kg) (Table 8). Husna (2009) also found similar result in bottle gourd.

4.4.4. Days to first fruit harvest

Path co-efficient analysis revealed that days to first fruit harvest had a positive direct effect (0.067) on fruit yield per plant. Days to first fruit harvest had a positive indirect effect on days to first male flowering (0.006), number of primary branches (0.010), number of fruit per plant (0.156), fruit length (cm) (0.007), seed diameter (cm) (0.010), seed thickness (cm) (0.0003), 100 seed weight (gm) (0.0014). While the negative indirect effect on days to first female flowering (-0.057), fruit diameter (cm) (-0.001),

fruit weight (kg) (-0.022), seed length (cm) (-0.004) and number of seed per fruit (-0.025) (Table 7). It showed non-significant positive genotypic correlation (0.219) with fruit yield per plant (kg) (Table 8).

4.4.5. Number of fruits per plant

Path co-efficient analysis revealed that no of fruit per plant had a positive direct effect (0.680) on fruit yield per plant. No of fruit per plant had a positive indirect effect on days to first male flowering (0.002), number of primary branches (0.007), days to first fruit harvest (0.015), fruit length (cm) (0.001), fruit diameter (cm) (0.0009), fruit weight (kg) (0.093), seed diameter (cm) (0.006), 100 seed weight (gm) (0.010). While the negative indirect effect on days to first female flowering (-0.012), seed length (cm) (-0.002), seed thickness (cm) (-0.0006) and number of seed per fruit (-0.003) (Table 7). It showed significant positive genotypic correlation (0.792) with fruit yield per plant (kg) (Table 8).

4.4.6. Fruit length (cm)

Path co-efficient analysis revealed that fruit length (cm) had a positive direct effect (0.043) on fruit yield per plant. Fruit length (cm) had a positive indirect effect on days to first male flowering (0.0008), days to first fruit harvest (0.011), number of fruits per plant (0.011), fruit weight (kg) (0.198), 100 seed weight (gm) (0.002). While the negative indirect effect on days to first female flowering (-0.011), number of primary branches (-0.004), fruit diameter (cm) (-0.006), seed length (cm) (-0.006), seed diameter (cm) (-0.003), seed thickness (cm) (-0.0008) and number of seed per fruit (-0.020) (Table 7). It showed non-significant positive genotypic correlation (0.244) with fruit yield per plant (kg) (Table 8).

4.4.7. Fruit diameter (cm)

Path co-efficient analysis revealed that fruit diameter (cm) had a positive direct effect (0.009) on fruit yield per plant. Fruit diameter (cm) had a positive indirect effect on days to first male flowering (0.00008), number of primary branches (0.011), number of fruit per plant (0.064), fruit weight (kg) (0.116), seed length (cm) (0.009), seed diameter (cm) (0.009), number of seed per fruit (0.023). While the negative indirect effect on days to first female flowering (-0.002), days to first fruit harvest (-0.007), fruit length (cm) (-0.027), seed thickness (cm) (-0.0003), 100 seed weight (gm) (-0.016) (Table 7). It showed non-significant positive genotypic correlation (0.201) with fruit yield per plant (kg) (Table 8).

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

Trait	DFMF	DFFF	NPB	DFFH	NFPP	FL (cm)	FD (cm)	FW (kg)	SL (cm)	SD (cm)	ST (cm)	HSW (gm)	NSPF	FYPP (kg)
DFMF	**0.006**	-0.061	0.009	0.059	0.167	0.005	0.0001	-0.001	-0.002	0.007	0.0006	0.009	-0.020	0.179^{NS}
DFFF	0.006	**-0.064**	0.008	0.059	0.131	0.007	0.0003	0.016	-0.002	0.008	0.0004	0.007	-0.018	0.159^{NS}
NPB	-0.002	0.015	**-0.037**	-0.018	-0.132	0.005	-0.003	-0.156	-0.003	0.001	0.0002	0.019	0.009	-0.300*
DFFH	0.006	-0.057	0.010	**0.067**	0.156	0.007	-0.001	-0.022	-0.004	0.010	0.0003	0.014	-0.025	0.159^{NS}
NFPP	0.002	-0.012	0.007	0.015	**0.680**	0.001	0.0009	0.093	-0.002	0.006	-0.0006	0.010	-0.003	0.797**
FL (cm)	0.0008	-0.011	-0.004	0.011	0.011	**0.043**	-0.006	0.198	-0.006	-0.003	-0.0008	0.002	-0.020	0.214^{NS}
FD (cm)	0.00008	-0.002	0.011	-0.007	0.064	-0.027	**0.009**	0.116	0.009	0.0002	-0.0003	-0.016	0.023	0.181^{NS}
FW (kg)	-0.00001	-0.002	0.010	-0.002	0.105	0.014	0.002	**0.602**	-0.002	0.001	-0.0018	-0.013	0.001	0.713**
SL (cm)	0.0004	-0.005	-0.003	0.011	0.052	0.010	-0.003	0.044	**-0.028**	0.010	-0.0014	0.025	-0.016	0.096^{NS}
SD (cm)	0.001	-0.013	-0.0009	0.016	0.109	-0.003	0.00005	0.017	-0.007	**0.039**	-0.0012	0.009	-0.018	0.148^{NS}
ST (cm)	-0.001	0.006	0.002	-0.005	0.098	0.008	0.0006	0.282	-0.009	0.012	**-0.0039**	-0.001	0.0002	0.388**
HSW (gm)	0.001	-0.009	-0.015	0.019	0.137	0.002	-0.003	-0.163	-0.014	0.007	0.0001	**0.050**	-0.008	0.004^{NS}
NSPF	0.003	-0.025	0.007	0.037	0.046	0.019	-0.005	-0.013	-0.009	0.015	0.0000	0.009	**-0.046**	0.037^{NS}
														Residual effect = 0.004

* * 1 % level of significance, * 5% level of significance, ^{NS} non-significant

DFMF: Days to first male flowering, DFFF: Days to first female flowering, NPB: Number of primary branches, DFFH: Days to first fruit harvest, FL: Fruit length, FD: Fruit diameter, FW: Fruit weight, SL: Seed length, SD: Seed diameter, ST: Seed thickness, HSW: 100 seed weight, NSPF: Number of seed per fruit, FYPP: Fruit yield per plant.

Table 8. Partitioning of genotypic correlation into direct and indirect effects of morphological characters of 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	Number 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)	Number of seed per fruit	Fruit yield per plant (kg)
Days to first male flowering	**-0.492**	0.144	-0.005	0.157	0.266	-0.178	0.237	0.033	-0.007	-0.047	-0.065	-0.021	0.246	0.267^{NS}
Days to first female flowering	-0.470	**0.143**	-0.007	0.194	0.300	-0.417	0.392	0.141	-0.009	-0.116	-0.062	-0.029	0.381	0.416**
Number of primary branches	0.229	-0.094	**0.011**	-0.067	-0.207	-0.066	0.150	-0.201	-0.005	-0.001	-0.020	-0.021	-0.056	-0.346*
Days to first fruit harvest	-0.462	0.138	-0.005	**0.167**	0.240	-0.160	0.202	0.001	-0.007	-0.117	-0.020	-0.023	0.238	0.219^{NS}
Number of fruit per plant	-0.167	0.055	-0.003	0.051	**0.787**	-0.017	-0.067	0.198	-0.005	-0.099	0.047	-0.018	0.030	0.792**
Fruit length (cm)	-0.171	0.117	0.001	0.052	0.026	**-0.512**	0.313	0.241	-0.014	0.031	0.039	-0.003	0.124	0.244^{NS}
Fruit diameter (cm)	0.290	-0.139	-0.004	-0.084	0.131	0.398	**-0.402**	0.107	0.017	0.007	0.021	0.018	-0.158	0.201^{NS}
Fruit weight (kg)	-0.023	0.029	-0.003	0.0001	0.222	-0.176	-0.061	**0.702**	-0.004	0.003	0.117	0.014	-0.011	0.808**
Seed length (cm)	-0.076	0.027	0.001	0.026	0.090	-0.163	0.154	0.068	**-0.045**	-0.134	0.107	-0.029	0.106	0.131^{NS}
Seed diameter (cm)	-0.074	0.053	0.000	0.062	0.247	0.050	0.009	-0.006	-0.019	**-0.316**	0.073	-0.011	0.124	0.192^{NS}
Seed thickness (cm)	0.201	-0.056	-0.001	-0.021	0.232	-0.127	-0.054	0.516	-0.030	-0.145	**0.159**	0.0001	-0.019	0.655**
100 seed weight (gm)	-0.204	0.081	0.005	0.077	0.272	-0.031	0.139	-0.193	-0.026	-0.066	-0.0002	**-0.051**	0.048	0.050^{NS}
Number of seed per fruit	-0.451	0.059	-0.002	0.148	0.087	-0.236	0.236	-0.029	-0.018	-0.146	-0.011	-0.009	**0.269**	0.040^{NS}
Residual effect = 0.009														

** indicates significant at 0.01 probability level, * indicates significant at 0.05 probability level, ^{NS} indicates non-significant**.**

4.4.8. Fruit weight (kg)

Path co-efficient analysis revealed that fruit weight (kg) had a positive direct effect (0.602) on fruit yield per plant. Fruit weight (kg) had a positive indirect effect on number of primary branches (0.010), number of fruits per plant (0.105), fruit length (cm) (0.014), fruit diameter (cm) (0.002), seed diameter (cm) (0.001), number of seed per fruit (0.001). While the negative indirect effect on days to first male flowering (-0.000001), days to first female flowering (-0.002), days to first fruit harvest (-0.002), seed length (cm) (-0.002), seed thickness (cm) (-0.0018) and 100 seed weight (gm) (-0.013) (Table 7). It showed significant positive genotypic correlation (0.808) with fruit yield per plant (kg) (Table 8).

4.4.9. Seed length (cm)

Path co-efficient analysis revealed that seed length (cm) had a negative direct effect (-0.028) on fruit yield per plant. Seed length (cm) had a positive indirect effect on days to first male flowering (0.0004), days to first fruit harvest (0.011), number of fruit per plant (0.052), fruit length (cm) (0.010), fruit weight (kg) (0.044), seed diameter (cm) (0.010), 100 seed weight (gm) (0.025). While the negative indirect effect on days to first female flowering (-0.005), number of primary branches (-0.003), fruit diameter (cm) (-0.003), seed thickness (cm) (-0.0014) and number of seed per fruit (-0.016) (Table 7). It showed non-significant positive genotypic correlation (0.131) with fruit yield per plant (kg) (Table 8).

4.4.10. Seed diameter (cm)

Path co-efficient analysis revealed that seed diameter (cm) had a positive direct effect (0.039) on fruit yield per plant. Seed diameter (cm) had a positive indirect effect on days to first male flowering (0.001), days to first fruit harvest (0.016), number of fruits per plant (0.109), fruit diameter (cm) (0.00005), fruit weight (kg) (0.017), 100 seed weight (gm) (0.009). While the negative indirect effect on days to first female flowering (-0.0013), number of primary branches (-0.0009), fruit length (cm) (-0.003), seed length (cm) (-0.007), seed thickness (cm) (-0.0012) and number of seed per fruit (-0.018) (Table 7). It showed non-significant positive genotypic correlation (0.192) with fruit yield per plant (kg) (Table 8).

4.4.11. Seed thickness (cm)

Path co-efficient analysis revealed that seed thickness (cm) had a negative direct effect (-0.0039) on fruit yield per plant. Seed thickness (cm) had a positive indirect effect on days to first female flowering (0.006), number of primary branches (0.002), number of fruit per plant (0.098), fruit length (cm) (0.008), fruit diameter (cm) (0.0006), fruit weight (kg) (0.282), seed diameter (cm) (0.012), number of seed per fruit (0.0002). While the negative indirect effect on days to first male flowering (-0.001), days to first fruit harvest (-0.005), seed length (cm) (-0.009) and 100 seed weight (gm) (-0.001)

(Table 7). It showed significant positive genotypic correlation (0.655) with fruit yield per plant (kg) (Table 8).

4.4.12. 100 seed weight (gm)

Path co-efficient analysis revealed that 100 seed weight (gm) had a positive direct effect (0.050) on fruit yield per plant. 100 seed weight (gm) had a positive indirect effect on days to first male flowering (0.001), days to first fruit harvest (0.019), number of fruit per plant (0.137), fruit length (cm) (0.002), seed diameter (cm) (0.007) and seed thickness (cm) (0.0001). While the negative indirect effect on days to first female flowering (-0.009), number of primary branches (-0.015), fruit diameter (cm) (-0.003), fruit weight (kg) (-0.163) and seed length (cm) (-0.014) (Table 7). It showed non-significant positive genotypic correlation (0.050) with fruit yield per plant (kg) (Table 8).

4.4.13. Number of seed per fruit

Path co-efficient analysis revealed that number of seed per fruit had a negative direct effect (-0.046) on fruit yield per plant. Number of seed per fruit had a positive indirect effect on days to first male flowering (0.0031), number of primary branches (0.007), days to first fruit harvest (0.037), number of fruit per plant (0.046), fruit length (cm) (0.019), seed diameter (cm) (0.015), seed thickness (cm) (0.000), 100 seed weight (gm) (0.009). While the negative indirect effect on days to first female flowering (-0.025), fruit diameter (cm) (-0.005), fruit weight (kg) (-0.013) and seed length (cm) (-0.009) (Table 7). It showed non-significant positive genotypic correlation (0.040) with fruit yield per plant (kg) (Table 8).

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). 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 1 as X-axis and component score 2 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

Principal components were computed from the correlation matrix from genotype scores obtained from first components and succeeding components with latent roots greater than the unity. The principal component analysis yielded Eigen values of each principal component axes with the first axes totally accounting for the variation among the genotypes is 310.07 %, while two of these with Eigen values above unity accounted for 51.36 % (Table 9).

Genotypes were grouped into five clusters. Cluster-I consists of five genotypes. These genotypes produced the highest mean for number of seed per fruit (291.8) and the lowest mean value (0.32) 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 (181.5) and the lowest mean value (0.28) was the seed thickness (cm) (Table 10 & 11). Among the five clusters, cluster-III composed of three genotypes. In cluster-III the highest mean for number of seed per fruit (442.89) and the lowest mean value for cluster- III (0.28) was the seed thickness (cm) (Table 8 & 9). Cluster-IV consists of four genotypes. From the clustering mean values, it was observed that cluster-IV produced the highest mean values for number of seed per fruit (347.92) and the lowest mean value for cluster-IV (0.37) was the seed thickness (cm) (Table 8 & 9). Similar findings were mentioned by Rahman (2005). Cluster-V constituted with three genotypes (Table 8). In cluster-V the highest mean for number of seed per fruit (243.44) and the lowest mean value for cluster-V (0.32) was the seed thickness (cm) (Table 11).

Joshi *et al*. (2003) assessed the nature and magnitude of genetic divergence using non hierarchical 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. Dharmatti et al. (2001) in the population of 402 tomato lines was observed 4 Clusters based on the similarities of D^2 values. Considerable diversity within and between the clusters was noted, and it was observed that the characters TLCV resistance, fruit yield per plant and number of whiteflies per plant contributed maximum to the divergence.

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

Principle component axes	Eigen value	% Variance	Cumulative (%)total variance
Days to first male flowering	4.35	31.07	31.07
Days to first female flowering	2.841	20.29	51.36
Number of primary branches	2.203	15.73	67.09
Days to first fruit harvest	1.584	11.31	78.4
Number of fruit per plant	1.153	8.23	86.63
Fruit length (cm)	0.656	4.68	91.31
Fruit diameter (cm)	0.535	3.82	95.13
Fruit weight (kg)	0.233	1.66	96.79
Seed length (cm)	0.17	1.21	98
Seed diameter (cm)	0.122	0.87	98.87
Seed thickness (cm)	0.112	0.8	99.67
100 seed weight (gm)	0.023	0.17	99.84
Number of seed per fruit	0.02	0.14	99.98
Fruit yield per plant (kg)	0.001	0	100

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

Cluster number	Number of genotypes	Percent (%)	Name of genotypes
I	5	29.41	BG- 6309, BG-7092, BG-6813, BG-Diana, BG-6816
II	2	11.76	BG-6527, BG-6818
III	3	17.65	Higreen, BG-Barsha, BG-6523
IV	4	23.53	BG-6310, BG-Arosh, BG-Nico, BG-Martina
V	3	17.65	BG-6820, BG-6837, BG-Tafsi

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

Characters	I	II	III	IV	V
Days to first male flowering	57.47	56.34	59.33	57.75	56.67
Days to first female flowering	61.93	60.67	64	62.25	61.22
Number of primary branches	22.47	16.16	14.55	15.16	15.33
Days to first fruit harvest	79.67	77.67	82.56	80.67	78.11
Number of fruits per plant	3.67	3.16	3.33	3.5	3.11
Fruit length (cm)	41.17	29.5	43.77	40.88	36.6
Fruit diameter (cm)	31	39.88	30.07	30.98	36.71
Fruit weight (kg)	1.48	1.58	1.45	1.61	1.48
Seed length (cm)	1.91	1.58	1.9	2.06	1.97
Seed diameter (cm)	0.79	0.62	0.78	0.77	0.66
Seed thickness (cm)	0.32	0.28	0.28	0.37	0.32
100 seed weight (gm)	19.93	8.34	15.11	16.58	17.33
Number of seed per fruit	291.8	181.5	442.89	347.92	243.44
Fruit yield per plant (kg)	5.65	4.88	4.88	5.6	4.64

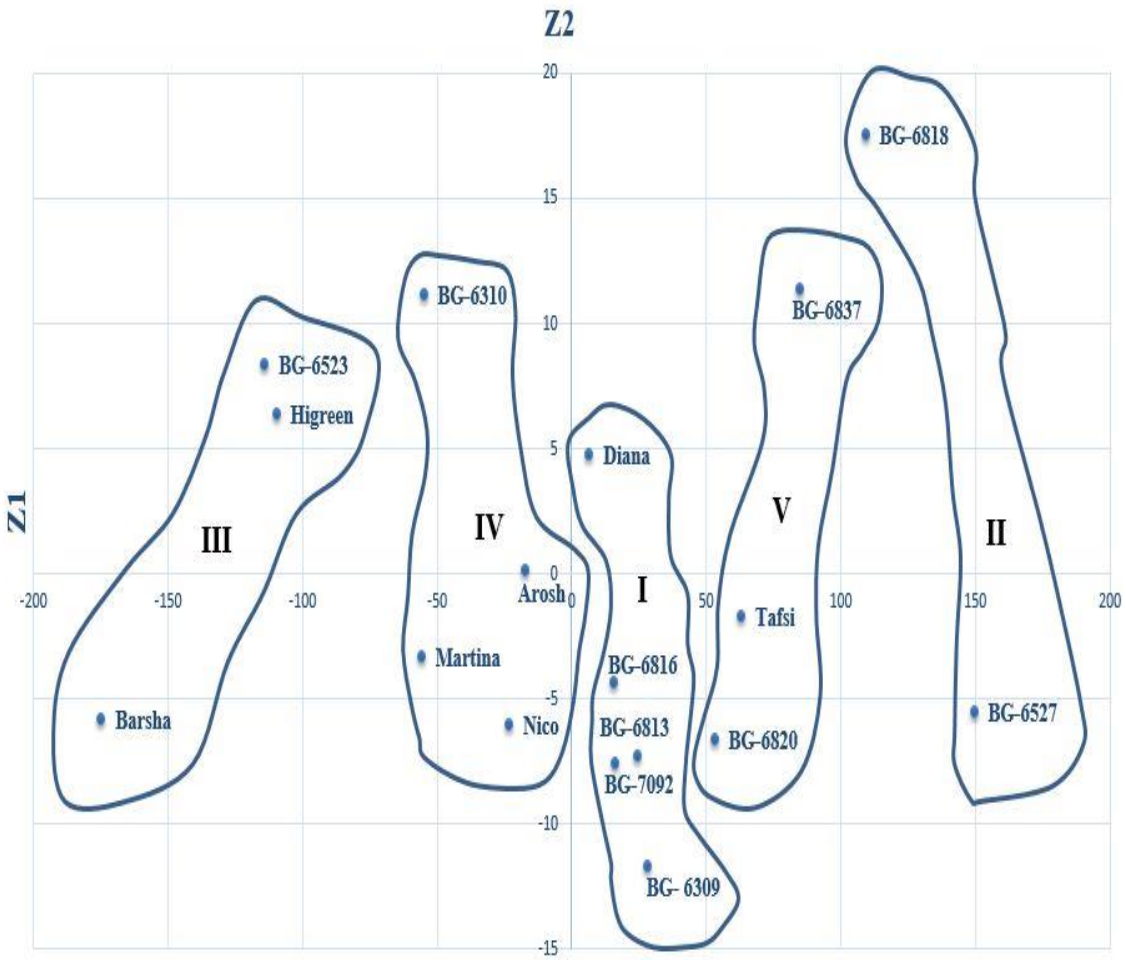

Figure 1. Scatter diagram of 17 bottle gourd genotypes of based on their principal component scores

4.5.3 Principal coordinate analysis

By using these inter-genotypic distances intra-cluster genotypic distances were calculated (Table 10 & Figure 2) as suggested by Singh *et al.* (1977). Cluster-II which (1.547) composed of two genotypes showed the maximum intra cluster distances and cluster IV showed the lowest intra-cluster distance (0.585) which composed of four 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.

4.5.4 Canonical variate analysis

To compute the inter-cluster Mahalanobis's D^2 values canonical variate analysis was used. (Table 12), indicates the intra and inter-cluster distance (D^2) values. The inter-cluster distances suggesting wider genetic diversity among the genotypes of different groups. Results indicated that the highest inter cluster distance was observed between cluster-II and Cluster-III (14.771) followed by between cluster-I to cluster-V (12.368), Cluster-I to Cluster-III (11.735), cluster-I to Cluster-IV (11.363), Cluster-III to Cluster-V (11.299), Cluster-I to Cluster-II (10.786). The lowest inter-cluster distances was observed between the Cluster-III to Cluster-IV (4.919), followed by Cluster-IV to Cluster-V (6.477), (Table 12). Inter-cluster distances were larger than the intra-cluster distances suggesting wider genetic diversity among the genotypes of different groups (Table 10 & Table 12).

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 that 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. Furthermore, there is a free exchange of seed material among different region, as a consequence, the characters constellation that might be associated with particular region in nature lose their individuality under human interference and however, in some cases effect of geographic origin influenced clustering that is why geographic distribution was not the sole criterion of genetic diversity. This would suggest that it was not necessary to choose diverse parents for diverse geographic regions for hybridization.

4.5.5. 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 principle 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 8. 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.

4.5.5.1. Cluster-I

Cluster-I had five genotypes namely BG-6309, BG-7092, BG-6813, BG-Diana and BG-6816 (Table 10). From the clustering mean values (Table 11), it was observed that cluster-I produced the highest mean for number of seed per fruit (291.8) followed by days to first fruit harvest (79.67), days to 1st female flowering (61.93), days to 1st male flowering (57.47), fruit length (cm) (41.17), fruit diameter (cm) (31), number of primary branches (22.47), 100 seed weight (gm) (19.93), fruit yield per plant (kg) (5.65), number of fruit per plant (3.67), seed length (1.91), fruit weight (kg) (1.48), Seed diameter (cm) (0.79). The lowest mean value in cluster-I (0.32) was for the seed thickness (cm).

4.5.5.2. Cluster-II

Cluster-II had two genotypes namely BG-6527 and BG-6818 (Table 8). From the clustering mean values (Table 11), it was observed that cluster-II produced the highest mean for number of seed per fruit (181.5) followed by days to first fruit harvest (77.67), days to 1st female flowering (60.67), days to 1st male flowering (56.34), fruit length (cm) (29.5), fruit diameter (cm) (39.88), number of primary branches (16.16), 100 seed weight (gm) (8.34), fruit yield per plant (kg) (4.88), number of fruit per plant (3.16), seed length (1.58), fruit weight (kg) (1.58), Seed diameter (cm) (0.62). The lowest mean value in cluster-II (0.28) was or the seed thickness (cm).

4.5.5.3. Cluster-III

Cluster-III had three genotypes namely BG-Higreen, BG-Barsha and BG-6523 (Table 10). From the clustering mean values (Table 11), it was observed that cluster-III produced the highest mean for number of seed per fruit (442.89) followed by days to first fruit harvest (82.56), days to 1st female flowering (64), days to 1st male flowering (59.33), fruit length (cm) (43.77), fruit diameter (cm) (30.07), number of primary branches (14.55), 100 seed weight (gm) (15.11), fruit yield per plant (kg) (4.88), number of fruit per plant (3.33), seed length (1.9), fruit weight (kg) (1.45), Seed diameter (cm) (0.78). The lowest mean value in cluster-III (0.28) was for the seed thickness (cm).

Table 12. Intra-inter cluster distance

Characters	I	II	III	IV	V
I	**0.675**				
II	10.786	**1.547**			
III	11.735	14.771	**0.915**		
IV	11.363	10.638	4.919	**0.585**	
V	12.368	5.436	11.299	6.477	**0.964**

4.5.5.4. Cluster-IV

Cluster-IV had four genotypes namely BG-6310, BG-Arosh, BG-Nico and BG-Martina (Table 10). From the clustering mean values (Table 11), it was observed that cluster-IV produced the highest mean for number of seed per fruit (347.92) followed by days to first fruit harvest (80.67), days to 1st female flowering (62.25), days to 1st male flowering (57.75), fruit length (cm) (40.88), fruit diameter (cm) (30.98), number of primary branches (15.16), 100 seed weight (gm) (16.58), fruit yield per plant (kg) (5.6), number of fruit per plant (3.5), seed length (2.06), fruit weight (kg) (1.61), Seed diameter (cm) (0.77). The lowest mean value in cluster-IV (0.37) was for the seed thickness (cm).

4.5.5.5. Cluster-V

Cluster-V had three genotypes namely BG-6820, BG-6837 and BG-Tafsi (Table 8). From the clustering mean values (Table 11), it was observed that cluster-V produced the highest mean for number of seed per fruit (243.44) followed by days to first fruit harvest (78.11), days to 1st female flowering (61.22), days to 1st male flowering (56.67), fruit length (cm) (36.6), fruit diameter (cm) (36.71), number of primary branches (15.33), 100 seed weight (gm) (17.33), fruit yield per plant (kg) (4.64), number of fruit per plant (3.11), seed length (1.97), fruit weight (kg) (1.48), Seed diameter (cm) (0.66). The lowest mean value in cluster-V (0.32) was for the seed thickness (cm).

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.

CHAPTER V

SUMMARY AND CONCLUSION

The investigation was conducted during Kharif season (March to August) in 2019 at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The experiment was comprised of 17 genotypes of bottle gourd laid out in Randomized Complete Block Design (RCBD) with three replications to estimate the genetic variability, correlation coefficient and path analysis. It was observed that significant variation exists among all the genotypes used for most of the characters studied.

Five randomly selected plants were considered for observations of different characters viz., days to first male and female flower appears, Internode length, sex ratio, tendril length, male petiole length, female petiole length, female ovary diameter, fruit length, fruit diameter, days to first fruit harvest, number primary of branches per plant, number of fruits per plant, seed length, seed diameter, seed thickness, 100 seed weight, number of seed per fruit and fruit yield per plant.

This analysis of variance revealed that mean sum of squares due to genotypes was highly significant for all characters except days to first female flower. Significant mean sum of squares due to fruit yield and attributing characters revealed existence of considerable variability in material studied for improvement of various traits.

The maximum days to first male flowering was observed (60.00 days) in BG-6523 and the minimum duration was observed (54.67) in BG-6813. The maximum days to first female flowering was observed (64.67 days) in BG-6523 and the minimum duration was (59.67 days) in BG-6818. The maximum internodes distance was observed (15.55 cm) in (BG-Tafsi) and minimum was (10.51) cm which was recorded in BG-Higreen. The maximum tendril length was observed (22.61) cm in BG-Arosh and minimum was (13.01) cm which was recorded in BG-6310. Maximum number of primary branch per plant was recorded (27.00) in BG-7090, however was (11.67) in BG-Diana noted for minimum number of Primary branches per plant. Earliest days for first fruit harvest was recorded (75.67 days) in BG-Tafsi, however a maximum day for first fruit harvest was (83.76) in BG-Diana. Maximum number of fruits per plant was recorded 5.33 in BG-Diana. The genotype BG-6310 of (2.67) recorded for minimum number of fruits per plant. The maximum fruit length was found (54.71 cm) in BG-Barsha and the minimum number was (17.00 cm) in BG- 6818. The maximum fruit diameter was found (45.67 cm) in BG- 6837 and the minimum number was (25.33 cm) in BG- 6309. The maximum fruit weight found (2.36 kg) in BG- 6527 and the minimum fruit weight was (0.81 kg) found in (BG- 6818). The maximum yield per plant was found (10.29 kg) in BG-Diana and the minimum was recorded (2.70 kg) in BG- 6818.

The highest genotypic and phenotypic coefficient of variation was recorded for fruit yield per plant (40.62 % and 35.87 %) respectively. The phenotypic coefficients of

variation were higher than the genotypic coefficient of variation, indicating greater influence of environment on the expression of these characters. The highest heritability was recorded in yield contributing characters viz. number of seed per fruit (98.06), 100 seed weight (97.20), number of primary branches (90.09), female ovary diameter (87.11), fruit length (87.57) and fruit weight (86.84). Whereas, highest heritability coupled with highest genetic advance were observed for characters viz., female ovary diameter (67.38), 100 seed weight (65.50), fruit yield per plant (65.25), number of seed per fruit (54.90) and number of primary branches (53.57). The lowest heritability was days to first female flowering (8.40) with lowest genetic advance (0.70). Hence, these characters might be improved by simple selection.

Correlation coefficients among the characters were studied to determine the association between yield and yield components. In general, most of the characters showed higher genotypic correlation co-efficient where was higher than the corresponding phenotypic correlation co-efficient suggesting a strong inherent association between the characters under study and suppressive effect of the environment modified the phenotypic expression of these characters by reducing phenotypic correlation values. In few cases, corresponding phenotypic correlation co-efficient were higher than their genotypic correlation co-efficient suggesting that both environmental and genotypic correlation in these cases acted in the same direction and finally maximize their expression at phenotypic level. Correlation analysis revealed that fruit yield per plant showed the high positive and significant correlation with number of fruits per plant (g= 0.792, p= 0.797), Fruit weight (g= 0.808, p= 0.713) and Seed thickness (g= 0.655, p= 0.388) at both genotypic and phenotypic level. Days to first female flowering (g= 0.416) at genotypic level only.

The path coefficient analysis revealed that positive and direct effect for fruit yield on days to first male flowering (0.006),days to first fruit harvest (0.067),number of fruit per plant (0.680), fruit length (0.043), fruit diameter (0.009), fruit weight (0.602), seed diameter (0.039) and 100 seed weight (0.050). Such results indicated that direct selection based on these characters would be effective for yield improvement in bottle gourd. Whereas days to first female flowering (-0.064), number of primary branches (-0.037), seed length (-0.028), seed thickness (-0.0039) and number of seed per fruit (-0.046) showed negative and direct effects on fruit yield. So direct selection based on these characters would not be effective.

The highest inter cluster distance was observed between cluster-II and Cluster-III (14.771) followed by between cluster-I to cluster-V (12.368), Cluster-I to Cluster-III (11.735), cluster-I to Cluster-IV (11.363), Cluster-III to Cluster-V (11.299), Cluster-I to Cluster-II (10.786). The lowest inter-cluster distances were observed between the Cluster-III to Cluster-IV (4.919), followed by Cluster-IV to Cluster-V (6.477).

Therefore, considering group distance and other agronomic performances the genotypes BG- Diana, BG- 6818, BG- Arosh, BG- 6309 and BG-Tafsi may be selected for future breeding programme.

Conclusion:

Based on the experimental results, it may be concluded that

1. BG- 6818 and BG- Tafsi was the earliest (59 DAS) population followed by BG-6309 (60 DAS) in case of days to first female flowering.

2. Shortest time for days to first fruit harvest was observed in BG- Tafsi (76 DAS) followed by BG- 6309 (78 DAS) and BG- 6527 (78 DAS).

3. Highest Number of fruit per plant was observed in BG- Diana followed by BG-Arosh and BG- 6816.

4. Highest fruit yield/ plant was observed in BG- Diana followed by BG- Arosh and BG-6527.

Recommendations:

From the research findings of the experiment, the following recommendations could be made:

The genotypes such as BG-Diana, BG- Tafsi, BG- 6818, BG- 6309 and BG- Arosh and BG-6527 has the potentiality to release as the most promising population that might be used in future breeding programs.

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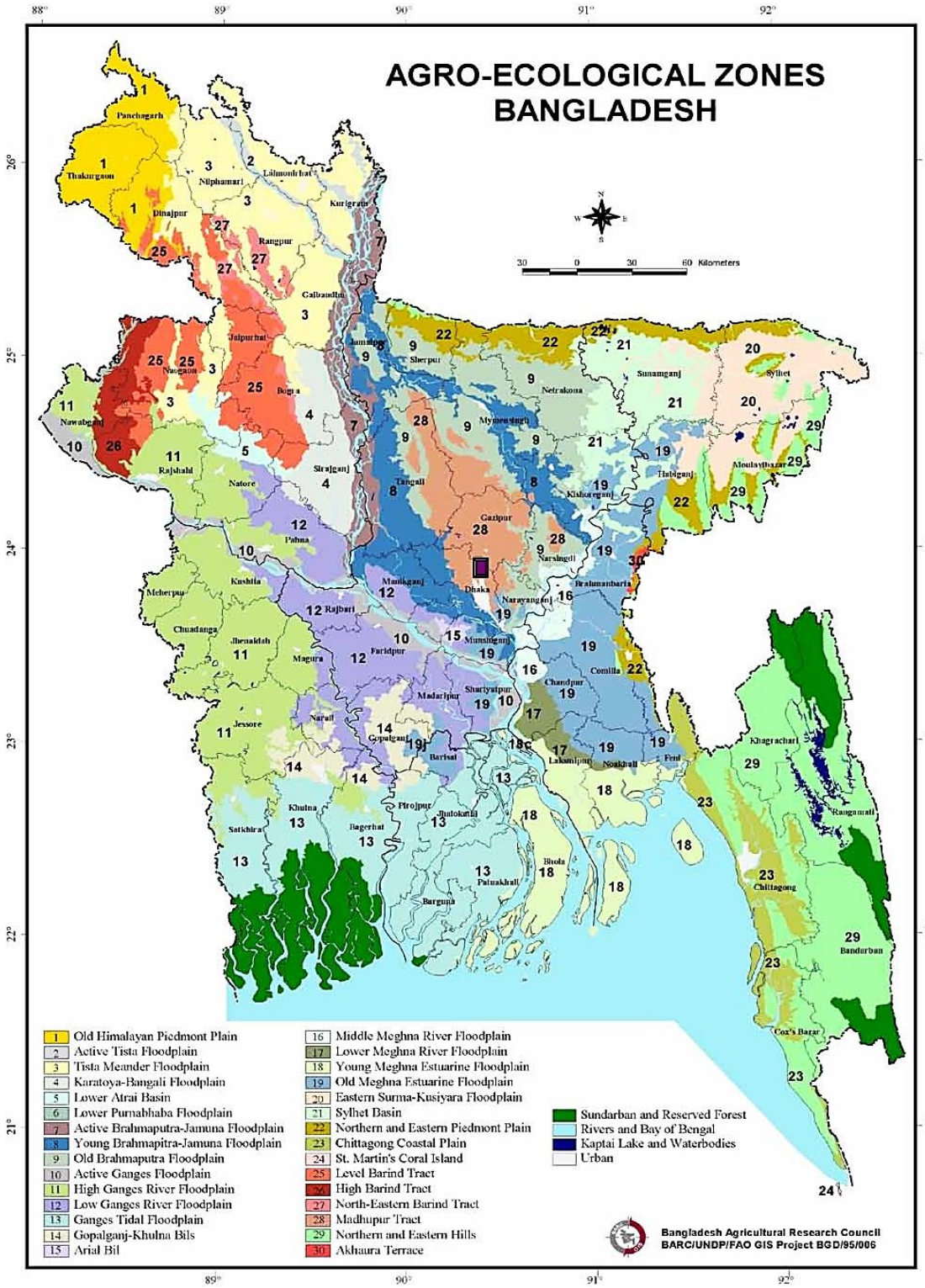
APPENDICES

Appendix I. Map showing the experimental sites under study



The experimental site under study

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

Month	Air temperature		Relative Humidity (%)	Rainfall (mm) (total)	Sunshine (hr)
	Maximum	Minimum			
March, 2019	31.5	21.1	69	72	7.58
April, 2019	33.7	23.6	72	173	6.67
May , 2019	34.9	26.4	75	195	3.54
June, 2019	33.6	26.6	85	260	3.05
July, 2019	33.1	26.9	88	368	2.06
August, 2019	33.8	27.2	81	216	7.5
September, 2019	33.3	26.5	71	162	9.5

Source: Bangladesh Metrological Department (Climate division), Agargaon, Dhaka-1207

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 for different morphological plant characters of 17 bottle gourd genotypes

Source of variation	Degrees of freedom	Days to first male flowering	Days to first female flowering	Internode length (cm)	Tendril length (cm)	Number of flower (male)	Number of flower (female)	Male petiole length (cm)	Female petiole length (cm)	Female ovary diameter (cm)	Number of primary branches
Replication	2	3.588	3.196	6.762	14.523	0.549	0.529	8.531	2.841	0.037	0.529
Genotypes	16	6.730*	7.449**	7.052**	23.653**	2.292**	1.588**	25.936**	11.796**	8.168**	70.311**
Error	32	3.359	1.842	2.102	8.568	0.862	0.654	2.624	1.036	0.384	2.488

** indicates significant at 0.01 probability level. * indicates significant at 0.05 probability level.

Appendix IV (Cont'd).

Source of variation	Degrees of freedom	Days to first fruit harvest	Number 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)	Number of seed per fruit	Fruit yield per plant (kg)
Replication	2	6.196	0.529	0.269	4.426	0.017	0.004	0.001	0.010	8.647	129.500	2.643
Genotypes	16	16.157**	1.522**	211.658**	86.278**	0.461**	0.091**	0.034**	0.010**	85.461**	21037.900**	11.558**
Error	32	5.113	0.342	9.563	10.628	0.022	0.009	0.004	0.004	0.814	137.700	0.994

** indicates significant at 0.01 probability level. * indicates significant at 0.05 probability level.