

**GENETIC STUDIES IN F₃ AND F₄ GENERATIONS OF BOTTLE
GOURD (*Lagenaria siceraria* (Mol.) Standl.)**

By

Mr. Vaidya Aashish Vivek

(Reg. No. 012/80)

A Thesis submitted to the
**MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA**

in partial fulfillment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY (HORTICULTURE)

in

VEGETABLE SCIENCE

DEPARTMENT OF HORTICULTURE

**POST GRADUATE INSTITUTE
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MAHARASHTRA, INDIA.**

2018

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institution
for a Degree or
Diploma

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Date : / /2018

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CERTIFICATE

This is to certify that the thesis entitled, “**GENETIC STUDIES IN F₃ AND F₄ GENERATIONS OF BOTTLE GOURD [*Lagenaria siceraria* (Mol.) Standl.]**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY (HORTICULTURE)** in **VEGETABLE SCIENCE**, embodies the results of a piece of *bona fide* research work carried out by **Mr. VAIDYA AASHISH VIVEK**, under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

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Place : MPKV, Rahuri

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ABBREVIATIONS

%	: Per cent
/	: per
&	: and
σ^2	: Variance
C ₁	: Cross number-1
C ₂	: Cross number-2
C ₃	: Cross number-3
cm	: Centimeter (s)
cv.	: Cultivar
d.f.	: Degrees of freedom
DAS	: Days after sowing
ECV	: Environment coefficient of variation
<i>et al.</i>	: et alli (and others)
etc	: Et cetera
F ₁	: First filial generation
F ₂	: Selfed of F ₁
F ₃	: Selfed of F ₂
F ₄	: Selfed of F ₃
FYM	: Farm yard manure
g	: Gram (s)
G	: Genotypic (correlation coefficient)
G. A.	: Genetic advance
GAM	: Per cent mean of genetic advance
GCV	: Genotypic coefficient of variation
H ² bs	: Broad sense heritability
ha	: Hectare
i.e.	: id est (that is)
kg	: Kilogram (s)

m ²	: Square meter
MT	: Metric tonne
No.	: Number (s)
P	: Phenotypic (correlation coefficient)
P ₁	: Parent one
P ₂	: Parent two
P ₃	: Parent three
P ₄	: Parent four
PCV	: Phenotypic coefficient of variation
PDI	: Per cent incidence of disease
S	: Symbol
Sr. No.	: Serial number
Sig.	: Significant
T.S.S.	: Total soluble solids
<i>viz.</i>	: Namely
x	: Cross with

ABSTRACT

GENETIC STUDIES IN F₃ AND F₄ GENERATIONS OF BOTTLE GOURD [*Lagenaria siceraria* (Mol.) Standl.]

By

Mr. Aashish Vivek Vaidya

A candidate for the degree of

DOCTOR OF PHILOSOPHY (HORTICULTURE)
in
VEGETABLE SCIENCE

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Research Guide	:	Dr. M.N. Bhalekar
Department	:	Horticulture (Vegetable Science)

The present investigation entitled “Genetic studies in F₃ and F₄ generation of Bottle gourd (*Lagenaria siceraria* (mol.) StandL.)” was conducted during summer seasons of 2014 and Kharif 2014. Ten F₃ and F₄ progenies of each of crosses Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) were evaluated for yield and yield contributing characters. This investigation highlighted the magnitude of variability, heritability, genetic advance and correlation coefficient in F₃ and F₄ generations of bottle gourd.

Wide range of variability was observed in all quantitative characters in two crosses of F₃ and F₄ generations. Phenotypic coefficient of variation (PCV) was higher than the respective genotypic coefficient of variation (GCV) for all the characters studied in both F₃ and F₄ generations indicating environmental factors influencing their expression to some extent. In F₃ and F₄ generations in most of the crosses the GCV and PCV were higher

for length of vine, number of primary branches per vine, sex ratio, number of fruits per vine, yield per vine, average weight of fruit, average length of fruit and fruit diameter at pedicel, center and stylar end which showed greater phenotypic and genotypic variability among the progenies and sensitiveness of the attributes for making further improvement by selection.

High heritability coupled with high genetic advance as per cent of mean was observed for most of the characters i.e. number of primary branches per vine, yield per vine, average length of fruit, fruit diameter at pedicel, fruit diameter at center, number of fruits per vine, average weight of fruit in both the crosses of F_3 and F_4 progenies which indicates preponderance of additive gene action. These characters could be improved by pure line selection or mass selection method.

High/moderate heritability combined with low genetic advance was observed for some of the traits for which simple selection would not be rewarding. More the less, they could be utilized as a inbred lines in the hybrid development programme. In such condition selection should be delayed so as to minimize the dominance effect.

In all two crosses of F_3 and F_4 generations significant and positive correlation was observed both at phenotypic and the genotypic level between yield per vine and the yield contributing characters such as length of vine, number of primary branches, number of fruits per vine, average weight of fruit, average length of fruit and fruit diameter at pedicel, center and stylar end. Most of these characters were also positively associated among them.

Medium fruit shape with cylindrical shape is an important fruit character in bottle gourd as compared to long. In the present investigation, among the F_3 and F_4 segregating progenies of the two crosses most of the progenies observed medium and cylindrical shaped of fruit.

Among the two crosses, *viz.*, Pusa Samridhi x DBG-5 (C_1 : 3 x 9) and DBG-5 x Bhagirathi (C_2 : 9 x 10) showed light green colour of fruits along with presence of pubescence in F_3 and F_4 generation.

Eventually from the present investigation the genotypes or progenies were identified in the bottle gourd for further crop improvement based on maximum fruit yield per vine with medium fruit weight, medium and cylindrical fruit shape, light green fruit colour with presence of pubescence for advancement of F_5 generation through simple pedigree selection method.

1. INTRODUCTION

Bottle gourd [*Lagenaria siceraria* (Molina) Standl.] is one of the most popular vegetables of the family cucurbitaceae, with a chromosome number $2n=22$. It is a highly cross pollinated crop due to its monoecious and andromonecious nature (Swiander and Maccollum, 1994). It can be grown in both summer and rainy season, but it can't tolerate cold. (Rastogi, 1998). The names "lagenaria" and "siceraria" are derived from Latin words "lagena" for bottle and "sicera" for drinking utensil. Cucurbitaceous family is economically most significant family, supplying edible and nutritious fruits to humanity (Bisognin, 2002). Plants of this family, whilst possessing similar characteristics of the sprouting segments, are characterised by great genetic diversity in fruit shape, fruit length and texture of fruit, resulting in variability and wide range of diversity.

Bottle gourd was originated in Africa (Singh, 1990) and from there by floating on the seas, it travelled to India, where it has evolved into numerous local varieties, and has spread to China, Indonesia and far to New Zealand.

In areas with mild climate, it can be grown throughout the year. In India the exact figures on area and production are not available but it is commercially grown in most of the states like U.P, Bihar, West Bengal, Assam, Punjab and Gujarat. The total area under cultivation in the country is approximately 1,19,940 hectares with annual production of 18,28,296 tones (NHB, 2016). Productivity of bottle gourd is still low in India; hence, enhancement of crop yield is still an important goal for bottle gourd breeders in India. In spite of the extensive cultivation and

consumption, bottle gourd has not been taken up for systematic research work in order to understand the genetic architecture and endeavour in an improvement programme. Many important features of cultivated crops are not associated with discrete Mendelian traits, but are of a continuous or quantitative nature. Yielding ability is a prime example of such a trait and is of obvious importance.

Although bottle gourd is a modest source of nutrients, it is very popular among a large section of people. It is easily digestible and is used extensively as vegetable. Fruits are used in sweets, pickles (especially on hills), kofta, petha, halwa, kopoorkand, paratha and rayata. It is digestible easily, therefore, it is recommended during convalescence. The young shoots and leaves of a few cultivars are occasionally used as a pot herb. Dry hard shells of the fruits have been used for making a wide range of articles of common use, including bowls, bottles, containers, floats for fishing nets, pipes and musical instruments. In addition, the seeds and seed oil are also edible. Immature fruits are consumed in a number of ways. Bottle gourd has got cooling effect, so in the eastern countries; fruits are often used as cooling vegetable. Fruit pulp is used as purgative and is very useful in coughs. It is an antidote to certain poisons. The cut surface of small size fruit is rubbed on the underside of the feet and hands to reduce the effect of heat. The fruit ash with honey is useful to eyes for night blindness. It is ideal for people suffering from jaundice and allied diseases and also very much useful in preventing constipation. Seeds contain oil, which is helpful for brain development and body smoothness. Hence, it is being used in Ayurvedic preparations

(Robinson and Decker-Walter, 1999). Besides this, the whole fruit is used in cosmetic and soap industries.

The fruits contain 96.3 per cent moisture; Vitamin C (11 m.g), Thiamine (0.044 m.g), Riboflavin (0.023 m.g), Niacin (0.33 m.g), Mineral matters (0.05 %), Carbohydrates (2.9 %), Fats (0.5 %) and Protein (0.2 %) and its different parts possess large number of medicinal properties (Desai and Musmade, 1998).

The basic problem in bottle gourd is concerning the low marketable yield. The reduced marketability of the fruits is due to the misshapening of the fruits. The causes for such misshaped fruits have not been clearly documented. Any stress factor during the crop growth could result in misshaped fruits. Apart from stress factors, genetic background could also be a factor determining the misshapening of the fruits. Bottle gourd fruits may be long, oblong or round depending upon the variety. Bottle gourd shows large variation for various economic traits of which the most interesting variation is found for size, shape and color of fruits. On the basis of fruit shape, the cultivars of bottle gourd are broadly classified into two group's viz.; long fruited and round fruited. Bottle gourd is characterized by differently shaped fruits that can be used as utensils or decorative ornaments, whilst younger juicy fruits are edible and nutritious. Prasad and Prasad (1979) have created unique bottle gourd varieties in India, primarily for human consumption. It has been used in varied and specific ways in cultures of different nations. Scientists believe that, of all currently known plants, bottle gourd is the only species that had been used worldwide in prehistoric times.

The variation in bottle gourds is sometimes spectacular. The background colour is either light green or dark green. The dark

green can be distributed as a solid colour, as regular or irregular stripes, and as an irregular blotch. The size of the fruit varies from 2-12 inches in diameter and from 4-40 inches in length. The fruit can have a sterile (seedless) neck that varies from a few to 15 inches in length and from 1-2 inches in width. Wider necks usually contain seeds, and the neck may have a seed-containing bulge. The seed-containing portion of the fruit varies from flat to round, cylindrical, club-shaped, or long and narrow. The long and narrow forms are best for vegetables.

The essential prerequisite for launching a breeding programme in any crop is the extent of genetic variability and genetic divergence in the breeding material. Wide differences between morphological traits such as size, color, resistance to pest and diseases and yield are of immense importance to the breeders since number of cultivars could be developed to suit various requirements.

Bottle gourd is a monoecious and cross pollinated crop in which large amount of variation has been observed for many economically important traits. Precise information regarding the extent of genetic divergence in the breeding lines is crucial in heterosis breeding programme. The available diversity within the species for desired fruit enables a breeder in choosing the most suitable combinations to use for exploitation of hybrid vigor in a given crop.

The genetic parameters such as heritability, genetic advance, genotypic and phenotypic coefficient of variability provide an effective tool in the hands of a breeder to select a genotype having the most desirable traits for yield.

Most of the quantitative traits such as number of fruits plant⁻¹ and yield plant⁻¹ are highly influenced by location, cultivar and environmental conditions portioning the overall variability into heritable and non-heritable components which will be of immense help in any planned breeding programme.

Though bottle gourd is extensively cultivated in India no systematic studies have so far been reported on the extent of genetic variability and divergence in this fairly popular vegetable. There is hardly any information available on the various genetic parameters like heritability, genetic advance, gene action and genetic architecture of bottle gourd.

As the area and production of bottle gourd are increasing fast but the crop still remains less explored on aspects of crop improvement by breeding methods. Thus, there is much need of cultivars with early fruiting, high yield, and high female to male sex ratio, medium sized fruits with light green color, presence of pubescence and resistance to fruit flies, leaf minor, gummosis, fusarium wilt, downey and powdery mildew. Therefore, to introgress these horticultural traits, the F₃ and F₄ progenies were assessed for variability, heritability, genetic advance and correlation for the utilization in crop improvement, the present investigation was undertaken with the following objectives :

1. To assess the variability for important qualitative and quantitative traits in F₃ and F₄ generations.
2. To estimate heritability and genetic advance for yield contributing characters in F₃ and F₄ generations.
3. To study the correlation between yield and yield contributing characters in F₃ and F₄ generations.

2. REVIEW OF LITERATURE

The objective of any breeding programme is the improvement of quantitative and qualitative characters of a crop. Information on inheritance of various quantitative traits, particularly of economic importance will be most useful in planning and successful implementation of breeding programme. Information on genetic variability, heritability, genetic advance and correlation for growth, yield and fruit quality in bottle gourd are rather limited. The available literature on these aspects in bottle gourd and related cucurbitaceous crops like bitter gourd, musk melon, ridge gourd, snake gourd, cucumber, ash gourd, melons, pumpkin has been reviewed and presented under the following sub-headings.

- 2.1 Variability
- 2.2 Heritability and genetic advance
- 2.3 Correlation coefficient
- 2.4 Fruit characters (Qualitative)
- 2.5 Per cent incidence of diseases and pests

2.1 Variability

The study of genetic variability is an important prerequisite in any successful breeding programme. The knowledge of the nature and magnitude of genetic variation in respect of quantitative plant growth characters coupled with yield and its components is essential in efficient crop improvement programme. The variability in the population can be estimated by variability parameters like mean, range, genotypic and phenotypic coefficient

of variation i.e. GCV and PCV along with heritability and genetic advance.

Genetic variability is the most important parameter of variability helpful for improvement of particular character. Phenotypic coefficient of variation (PCV) represents total variability which normally includes both genotypic and environmental variations. The genotypic variation refers to genetic or inherent variability which remains unaltered by environmental conditions. Therefore, PCV values more or less equal to GCV values denotes that the character is less influenced by environmental factors. High estimates of PCV than the GCV indicating that the trait is particularly affected by environment (Reddy, 1989). High PCV and GCV estimates facilitate more scope for selection of individual among the population.

2.1.1 Bottle gourd

Prasad and Prasad (1979) studied 40 genotypically diverse lines of bottle gourd and reported high estimates of heritability for vine length, fruit length and fruit diameter. Number of fruits plant⁻¹, girth of fruit and length of fruit showed high heritability values accompanied by high genetic gain which may be attributed to considerable additive gene effects. Yield was also found to have significant association with the characters having high heritability estimates.

Pal and Vani (1988) observed thirty seven bottle gourd lines for variability and reported that fruit number and size were highly correlated with yield. High narrow sense heritability for days to first male flower and days to first female flower opening, fruit length, fruit girth, number of fruits vine⁻¹ and fruit weight.

Sharma and Dhankar (1990) evaluated thirty five genotypes of bottle gourd during summer season for two years under Hissar conditions for studying the variability. Hissar local-3, a round genotype was earliest and highest yielder. PSPL, Hissar Sel-1 and Hissar Sel-2 were most promising for earliness and higher yield among long types. High heritability along with high genetic advance was recorded for male to female flower, vine length, total number of branches and fruits plants⁻¹.

Prasad *et al.* (1993) observed thirty genotypes for their variability, the studies revealed highest genotypic and phenotypic coefficient of variability for fruit yield plant⁻¹ followed by number of male flowers on primary laterals and fruits vine⁻¹. The magnitude of PCV was higher than GCV for all characters suggesting the effect of environment. GCV and PCV were high for fruit yield plant⁻¹ and fruit length.

Narayan *et al.* (1996) studied the genetic variability, heritability, genetic advance, correlation and path coefficient analysis in 25 diverse population of bottle gourd. Wide zone of variation was observed in most of the characters. The high value of GCV and heritability estimates associated with greater genetic advance observed for number of primary branches plant⁻¹ and yield vine⁻¹ indicated that these two characters had additive gene effect and therefore they are more reliable for effective selection.

Munshi *et al.* (2005) evaluated the performance of 12 bottle gourd (*Lagenaria siceraria* L.) cultivars. High genotypic and phenotypic coefficient of variation were observed for vine length, number of primary branches vine⁻¹ number of nodes on the main axis, peduncle length, sex ratio number of fruits plant⁻¹, fruit length, girth and weight, crop yield⁻¹. Fruit length, number of days

to first fruit harvest and number of days to first female flower anthesis exhibited.

Yadav *et al.* (2008) studied 18 bottle gourd (*L. siceraria*) strains/cultivars based on nine characters namely days to first male flowering, days to first female flowering, number of nodes of first male flowering, number of nodes of first female flowering. Days to edible fruit, fruit length, fruit width, number of fruits plant⁻¹ and yield plant⁻¹. All the characters showed considerable amount of variability. The fruit width had the highest coefficient of genotypic and phenotypic variability.

Singh *et al.* (2008) studied genetic variability in bottle gourd, the analysis of variance revealed significant differences among the parents and their F₁ hybrids in both summer and rainy seasons for all the characters studied. The highest genotypic and phenotypic coefficients of variation were recorded for yield vine⁻¹. All the characters under study were highly heritable excepting number of days for bearing first male and female flowers.

Pandit *et al.* (2009) evaluated fifteen genotypes of bottle gourd (*Lagenaria siceraria*) during autumn-winter season of 2003-2004 to study genetic variability, heritability and potential for screening suitable genotypes for future improvement programmers'. There was considerable variability in all traits except fruits plant⁻¹.

Patil (2010) evaluated twenty five genotypes of bottle gourd for variability analysis and reported that high estimates of GCV and PCV were observed for average fruit weight, number of fruits per vine and fruit yield per vine. Whereas the character days to first harvest showed low estimates of GCV and PCV. The wide range of variability was observed for all the characters. The estimates of GCV were lower than that of PCV for all characters.

Arvindkumar *et al.* (2011) studied the magnitude of genetic variability in bottle gourd. Analysis of variance revealed the adequate variability among all genotypes for all characters. The PCV was slightly higher than their corresponding GCV for all characters. The estimates of GCV and PCV were high for fruit yield per vine followed by fruit length and number of seeds per fruit.

Yadav and Kumar (2012) reported that highest estimates of PCV and GCV were recorded for vine length, number of primary branches, node number of first female flower appearance, number of fruits per vine, average weight of fruit and yield per vine in bottle gourd. PCV estimate was higher than GCV estimate for all the studied traits.

2.1.2 Other Cucurbits

2.1.2.1 Muskmelon

Vijay (1987) observed high phenotypic coefficient of variation for fruits per vine, flesh thickness and yield per vine. High heritability as well as high genetic advance was noticed for fruits per vine, yield per vine and flesh thickness.

Somkumar *et al.* (1997) recorded highest PCV and GCV in muskmelon for per cent disease intensity of downey mildew. The other characters *viz.* average fruit weight, number of fruits per vine and fruit yield per vine recorded high PCV and GCV estimates. Low GCV and PCV estimate was recorded for days to first harvest.

Tarsem and Sanjay (1997) studied genetic variability in muskmelon and reported that high values of variability (PCV and GCV) were recorded for node at which first female flower appeared, average weight of fruit, marketable yield per vine and total yield per vine. Also reported that estimates of PCV were higher than GCV

and obtained high mean estimates for fruit yield per vine, average fruit weight and average weight of pulp per fruit in muskmelon.

Rakhi and Rajamony (2005) reported high estimates of GCV and PCV in muskmelon for fruit yield per plant followed by average fruit weight, number of fruits per plant, keeping quality of fruits and 100-seed weight. They also observed high estimates of PCV than GCV with high magnitudinal differences.

Torkadi and Musmade (2007) studied fifty one genotypes of muskmelon for genetic variability and reported that, the PCV was higher than GCV for all the characters. The high phenotypic as well as genotypic coefficient of variation was observed for economically important characters such as number of fruits per vine, average weight of fruit, fruit cavity, average weight of pulp per fruit and average rind thickness. High mean estimates were recorded for average fruit weight and yield per vine.

Mehta *et al.* (2010) conducted experiment on genetic variability for 12 quantitative characters in 44 diverge genotypes of muskmelon and reported that high genotypic and phenotypic coefficient of variation was observed for fruit yield per plant followed by acidity percentage, number of fruits per plant and total soluble solids, while moderate estimates were obtained for number of node at which first female flower appeared and fruit weight. Higher estimate of PCV were observed as compared to GCV. Besides high mean estimates were obtained for average fruit length, number of fruits per vine and fruit yield.

Reddy *et al.* (2013) reported that highest estimates of PCV and GCV were obtained for fruit yield (28.30 and 26.08 %) followed by fruit cavity length (28.20 and 26.66 %), rind thickness (26.39 and 22.14 %) and average fruit weight (24.01 and 22.82 %)

in muskmelon. The estimates of GCV signify that there is greater potential for favourable advance in selection. In general magnitude of PCV was higher than the corresponding GCV all the traits, which indicated that these attributes had to some extent interacted with the environment. For some of the characters the PCV and GCV values were close to one another, implying that genotype contributed more to the expression of these characters than environment, suggesting greater possibilities of improvement through selection.

Mali (2015) reported that highest estimates of PCV and GCV for final vine length, number of primary branches per vine, number of male flowers per vine, number of female flowers per vine, sex ratio, number of fruits per vine, fruit yield per vine, average weight of fruit, average rind thickness, average fruit cavity, average weight of pulp per fruit, average weight of seed per fruit and TSS in muskmelon.

2.1.2.2 Bitter gourd

Srivastava and Srivastava (1976) studied variability in ten bitter gourd lines for ten different characters under Rajasthan condition. They observed maximum value of genotypic coefficient of variation for number of fruits per plant and minimum for number of male flowers per plant.

Indresh (1982) observed high genotypic coefficient of variation for fruit weight, yield per vine, fruit cavity, leaf area and fruit length when studied twenty four lines of bitter gourd.

Mangal *et al.* (1983) studied twenty one varieties of bitter gourd for genetic variability. The average fruit yield per vine (39.08 %), number of branches per vine (33.63 %), average fruit weight (31.61 %) and average number of fruits per vine (28.32 %)

showed high genetic coefficient of variation. The least genotypic coefficient of variation was observed for number of days to first flower (9.17 %).

Lawande (1987) studied parents and 55 F₁ hybrids of bitter gourd for the yield and its main components, *viz.*, fruit yield per vine, fruit weight, length and diameter of fruit, number of fruits per vine which showed high genotypic and phenotypic coefficient of variation.

Raja *et al.* (2007) studied the forty-six genotypes of bitter gourd collected from diversified areas of the country and assessed under zero irrigation condition for mean, genetic variability in respect of fourteen quantitative characters. The genotype MCC-23 recorded the highest number of primary branches per plant, fruit yield per plot and fruit weight. The genotypic and phenotypic coefficient of variation for different characters ranged from 6.37 to 37.25 and 8.37 to 38.63 respectively. The highest PCV and GCV were observed for number of female flowers per plant followed by fruit weight and number of primary branches per plant indicating the extent of variability based in these characters.

Rajput (2012) assessed the variability in F₂ and F₃ generations of bitter gourd and reported that wide range of variability was observed in all quantitative traits. Phenotypic coefficient of variation was noticed higher than genotypic coefficient of variation. The high estimates for both GCV and PCV were observed for number of primary branches per vine, number of female flowers per vine, sex ratio, number of fruits per vine, fruit yield per vine, average yield per vine, average weight of fruit and fruit flesh thickness in F₂ and F₃ generations. Thus, presence of

greater amount variability particularly for yield attributes could be further improved by simple selection method.

Pathak *et al.* (2014) studied genetic variability in 20 bitter gourd hybrids, and observed wide range of variation in most of the characters. High genotypic (GCV) and phenotypic coefficient of variation (PCV) was observed for number of fruits per plant, fruit weight and fruit length whereas low GCV and PCV was observed for days to first male and female flower anthesis (days after sowing). For most of the parameters under study, PCV was found to be higher than GCV.

2.1.2.3 Cucumber

Solanki and Seth (1980) observed considerable phenotypic variability among twenty four varieties of cucumber for vine length, number of leaves per plant and number of days to maturity.

Joshi *et al.* (2005) reported that genotypic coefficients of variation and phenotypic coefficients of variation in cucumber ranged from 9.48 to 93.76 per cent, showing sufficient genetic diversity among the genotypes. The traits such as node number with first fruit, number of fruits per vine, fruit yield, fruit circumference and fruit length had high estimates of PCV and GCV which indicated scope for improvement by selection. PCV estimates were higher than GCV estimates.

Gaikwad (2007) observed high degree of variation in all the characters studied in cucumber. The high GCV and PCV was observed for length of fruit, number of fruits per vine, fruit weight and node number of first female flower appearance.

Arunkumar *et al.* (2011) studied the genetic variability in F₂ population of BGD L x White long, BGD L x Hot season and

BGDL x Hyderabad cucumber. The high variability in the form of PCV and GCV was observed in BGDL x White long for number of misshaped fruits per vine, whereas moderate PCV and GCV was observed for number of good fruits per vine and total number of fruits per vine followed by BGDL x Hyderabad cucumber and BGDL x Hot season.

Azcon (2012) reported that highest variability (PCV and GCV) was recorded for fruit length, fruit shape index, number of fruits per plant and total fruit yield per plant in cucumber genotypes. The estimation of PCV was higher than the GCV estimation.

Kumar *et al.* (2014) observed high degree of variation in all the characters studied in cucumber. The maximum phenotypic and genotypic coefficient (PCV and GCV) was observed for acidity of fruit followed by weight of fruit, total yield per vine, rind thickness and total soluble solids.

2.1.2.4 Pointed gourd

Khan *et al.* (2009) reported that in pointed gourd high GCV and PCV for vine length at final harvest, days required for first female flower appearance, number of node at first harvest, fruit breadth, fruit weight, pulp weight per fruit, number of fruits per vine, average weight of fruit and fruit yield in pointed gourd.

Thus, presence of considerable amount of variability indicated wide scope of selection for the improvement of these characters. PCV estimates were observed to be higher than the GCV estimates.

2.1.2.5 Ridge gourd

Karuppaiah *et al.* (2002) studied 12 genotypes of ridge gourd to assess variability and reported high estimates of GCV and PCV for number of female flowers per vine, yield per vine and number of fruits per vine and flesh thickness.

Choudhary and Kumar (2011) conducted genetic study in ridge gourd and reported that the range of variation was higher in fruit length (3.66-26.93 cm) followed by node at which first female flower appeared (2.93-20.27) and fruit weight (18.25-112.16g). The minimum range of variability was recorded in days to first female flower (42.27-53.60). The height GCV and PCV were recorded for node at which first female flower appeared (29.40 and 32.29 %) followed by number of marketable fruits per plant (25.48 and 29.33 %). High magnitude of GCV is an indication of high genetic variability among the genotypes which provides ample scope for improvement of these characters through selection. Also reported that the PCV estimates were higher than the GCV estimates.

Rabbani *et al.* (2012) reported that high PCV and GCV was recorded for vine length, petiole length, number of primary branches at harvest, sex ratio, fruit length, fruit circumference, peduncle length, dry weight of flesh, number of fruits per vine, average fruit weight and fruit yield per vine in ridge gourd. The values of GCV were smaller than PCV, indicating the effect of environment to some extent in the expression of the characters.

2.1.2.6 Sponge gourd

Arora *et al.* (1983) observed significant varietal differences for all the characters studied. Yield per plant, number of fruits per plant and sex ratio exhibited maximum range of genotypic and phenotypic coefficient of variation in sponge gourd.

Abusaleha and Dutta (1990) recorded genetic variability and heritability for different characters in sponge gourd with forty five genetic stocks. High magnitude of genotypic and phenotypic variance were observed for all characters.

Prasad and Singh (1990) observed that high estimates of phenotypic and genotypic coefficient of variation were observed for fruit length, fruit yield per vine and vine length in sponge gourd. Moderately high GCV and PCV was recorded for number of fruits, number of nodes and fruit width.

Kumar *et al.* (2013) revealed high values of genotypic as well as phenotypic coefficient of variation for total yield per vine, number of seeds per fruit, average weight of fruit and T.S.S. in sponge gourd. The high magnitude of GCV revealed the greater extent of variability presence in these characters suggesting good scope for improvement through selection. Also obtained the lower estimation of GCV than the PCV.

2.1.2.7 Summer squash

Raju *et al.* (1998) studied genetic variability in summer squash and observed that the coefficients of variation (PCV and GCV) for number of fruits per vine (36.84 and 36.02 %), vine length (32.39 and 32.35 %) and total fruit yield per vine (30.10 and 30.00 %). Thus, maximum variability in these traits attributed ample scope for effective improvement through selection.

2.1.2.8 Watermelon

Thakur and Nandpuri (1974) observed high variability (PCV and GCV) for 100-seed weight and number of seeds per kg of fruit where as other traits *viz.*, branches per vine, days to first picking and yield per vine indicated low variability in watermelon.

The estimation of PCV was higher than GCV. High variability showed ample scope of improvement through selection.

Kadam (1997) evaluated variability in seven cultivars of watermelon for growth and yield attributes. The estimates of PCV were slightly higher than GCV for all the traits studied indicating the minor role of environment in the expression of traits. The estimates of PCV and GCV were high for average number of fruits per vine followed by average weight of fruit, average fruit yield per vine, average number of seeds per fruit, average length of fruit and shelf life of fruits whereas, average number of primary branches, average diameter of fruit, total soluble solids, days required for 50 per cent harvest and female flowering recorded low estimates of PCV and GCV.

Gusmini and Wehner (2007) studied genetic variance in watermelon and reported that high estimates of GCV and PCV were observed for number of fruits per vine, average weight of fruit, average fruit yield per vine, average weight of flesh and average number of seeds per fruit. Comparatively higher estimates were observed for phenotypic coefficient of variations than the genotypic coefficient of variations.

2.1.2.9 Snake gourd

Deepa Devi and Mariappan (2013) studied genetic variability in 50 genotypes of snake gourd to determine the magnitude of variability in the population and to identify genotypically diverse and economically desirable genotypes for utilization in crop improvement. Higher values of phenotypic coefficient of variation and genotypic coefficient of variation were recorded for fruit length, fruit weight and number of fruits per plant while, moderate phenotypic and genotypic coefficient of

variation were observed for yield, fruit girth and number of seeds per fruit indicating the extent of available genetic variability for these traits.

2.1.3 Other Vegetables

Shirkole (2006) evaluated segregating progenies of tomato involving three F₂ crosses with six divergent parents. The estimates of GCV were low as compared to PCV. The highest GCV was observed for pericarp thickness (40.03) followed by number of locules per fruit (34.86 %). indicating predominance of additive gene effect and greater scope for further selection.

Gupta *et al.* (2009) revealed that, wide range of variability observed in all the characters in chilli. Relatively higher values of phenotypic and genotypic coefficient of variation were observed. The highest phenotypic coefficient of variation was recorded for the traits incidence of virus (41.67 %), number of fruits per plant (31.38 %), fruit yield per plant (26.79 %), fruit weight (24.67 %). The genotypic coefficient of variation were high for number of fruits per plant (30.35 %), incidence of virus (27.42 %), fruit yield per plant (25.98 %), fruit weight (22.98 %) revealing better scope of improvement through selection. Hence, these traits are likely to respond to selection on a better way.

Kshirsagar (2009) observed wide range of variability in F₃ and F₄ generation of tomato. GCV and PCV were higher for fruit yield per plant, average fruit weight and number of locules per fruit indicates presence of substantial amount of genetic variability.

2.2 Heritability and genetic advance

Phenotype of an individual is determined by genotype and environment in which it grows. Success of a breeder in changing and improving the heredity of character depends upon

the degree of correspondence between phenotypic and genotypic value. Heritability is a measure that provides this information. Heritability in broad sense or degree of genetic determination is proportion of total hereditary variance to phenotypic variance. The more useful estimate i.e. narrow sense heritability or degree of resemblance between relatives is ratio of additive genetic variance to phenotypic variance. The most important function of heritability in the genetic studies is its predictive role in expressing the reliability of phenotypic value as a guide to breeding value (Falconer, 1981).

Heritability is the index of transmissibility of characters from parental to next generation and need to be studied in order to determine the extent to which the observed variation is inheritable. Heritability estimates facilitate evaluation of hereditary and environmental effect of phenotypic variation and thus aids in selection while genetic advance is a product of heritability and indicates the potentiality of selection intensity. Genetic advance as quoted by Johnson *et al.* (1955) when considered along with heritability gives an available assessment of the resultant effect of selection in breeding populations. Genetic advance means improvement in the performance of selected lines over original population. A brief summary of work done for estimating heritability and genetic advance of yield and yield contributing characters is reviewed as below.

2.2.1 Bottle gourd

Prasad and Prasad (1979) studied 40 genotypically diverse lines of bottle gourd and reported high estimates of heritability for vine length, fruit length and fruit diameter.

Sharma *et al.* (1983) conducted genetical studies on bottle gourd and reported high heritability estimates for days to opening of first male and female flower and marketable maturity. Low heritability was recorded for fruit weight, number of fruits and total yield. The characters having high heritability failed to express high genetic advance.

Singh *et al.* (1996) evaluated genetic variability and correlation studies in bottle gourd and reported that most of characters under study should have high magnitudes of heritability. However, from selection point of view only that part of heritability is desirable which is due to additive gene effects. High heritability with high genetic advance is considered more useful than heritability estimated alone in predicting resultant effect in the selection programme inference traits like node at which first female flower appeared, fruits plant⁻¹, yield plant⁻¹ could be more responsive to selection in bottle gourd.

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

Arunkumar *et al.* (2000) studied 45 F₁ hybrids in bottle gourd and reported low narrow range of heritability for all the nutritional characters.

Patil (2010) evaluated twenty five genotypes of bottle gourd for heritability and genetic advance and reported that high

estimates of heritability in broad sense were recorded for fruit yield per vine, number of fruits per vine and nodal position of first female flower where as lower values were recorded for days to first male and female flowers. High heritability value with high genetic advance was obtained for fruit yield per vine, indicating additive gene effects in their inheritance and scope for selection.

Arvindkumar *et al.* (2011) studied the magnitude of heritability and genetic advance in bottle gourd. High heritability along with high genetic advance as a per cent of mean was obtained for fruit yield per vine, number of seeds per fruit and fruit diameter indicated presence of additive gene action and further scope for improvement through selection.

Yadav and Kumar (2012) reported highest estimates of heritability coupled with highest genetic advance as per cent of mean for vine length, number of primary branches, node number of first female flower appearance, number of fruits per vine, fruit length, and yield per vine. This might be due to additive gene effects in their inheritance and indicated scope for improvement through selection.

2.2.2 Other cucurbits

2.2.2.1 Muskmelon

Somkumar *et al.* (1997) studied heritability and genetic advance as per cent of mean in muskmelon and obtained high heritability and moderate genetic advance as per cent mean for F:C ratio, per cent disease intensity of downey mildew, fruit yield per vine, number of fruits per vine and fruit weight indicated that hybridization followed by selection will be effective for genetic improvement.

Prasad *et al.* (2004) reported that heritability and genetic advance as per cent of mean in muskmelon was higher for days to appearance of first female flower, number of male and female flower per vine, node at which male flower appeared and yields per plot.

Pandey *et al.* (2005) recorded high heritability along with high expected genetic advance for number of days to 50 per cent female flower anthesis, T.S.S. and number of days to first male flower anthesis while the characters such as average fruit length and average fruit diameter showed high heritability and low expected genetic advance.

Rakhi and Rajamony (2005) revealed high heritability coupled with high genetic advance as per cent of mean for number of primary branches per vine, fruit length, 100-seed weight, average fruit weight and keeping quality of fruits. This might be due to high additive gene effects and consequently the scope for improvement of yield through selection.

Singh and Lal (2005) revealed that high heritability coupled with high genetic advance as per cent of mean was observed for node at which first female flower opens followed by rind thickness and fruit weight which implies that these traits are more reliable for improvement through selection in muskmelon. The characters viz., total sugar contents, average rind and pulp thickness recorded high heritability with low genetic advance as per cent of mean.

Torkadi and Musmade (2007) studied fifty one genotypes of muskmelon for estimation of heritability and genetic advance as a per cent mean and reported that, high heritability (broad sense) coupled with high genetic advance as a per cent

mean was recorded for days to first male flower opening (89.24 and 24.32 %), days to first female flower opening (95.56 and 34.12 %), days to first harvest of fruit (89.32 and 34.23 %), fruit length (92.10 and 24.36 %), fruit diameter (90.45 and 21.47 %), number of fruits per vine (97.70 and 109.29 %), average weight of fruit (99.60 and 41.48 %), fruit yield per vine (83.75 and 34.15 %), flesh thickness (96.65 and 31.75%), fruit cavity size (99.00 and 114.40%), average weight of pulp per fruit (92.65 and 26.54 %), average rind thickness (94.31 and 20.48 %) and total soluble solids (84.25 and 35.67 %). The presence of high heritability along with high genetic advance as per cent mean for the above traits might be attributed due to additive gene effects and is desirable for effective selection in breeding programme. They also recorded high heritability along with low genetic advance as per cent mean for total sugars and acidity percentage.

Tomar *et al.* (2008) studied fifty genotypes of muskmelon and found that the heritability (broad sense) for days to first female flower opens, fruit diameter, acidity and total sugar characters was moderate, suggesting that non-additive genetic variance was largely predominating.

Mehta *et al.* (2010) conducted experiment on heritability and genetic advance for 12 quantitative characters in 44 diverge genotypes of muskmelon and reported that high estimates of heritability accompanied with high genetic advance was observed for node number at which first female flower appeared, number of fruits per vine, fruit yield per vine, average fruit weight and total soluble solid which indicated the importance of additive gene effects and selection based on this would bring significant improvement in the genotypes of muskmelon.

Ibrahim (2012) obtained high estimates of heritability associated with high genetic advance for fruit weight, number of fruits per vine, fruit length, fruit width, flesh thickness and total fruit yield per vine. This indicated the presence of large number of fixable additive factors. Breeding methods based on progeny testing and mass selection could be useful in improving these traits.

Reddy *et al.* (2013) reported that the traits like days to appearance of first staminate flower, fruit length, average fruit weight, fruit cavity length and width, rind thickness, T.S.S. and seed yield in muskmelon recorded high genetic advance as a per cent of mean coupled with high heritability estimates, indicating that these traits were under the strong influence of additive gene action and hence selection based on phenotypic performance of these traits would be more effective. While high heritability and low genetic advance as per cent of mean was observed for days to first fruit harvest, indicated that the character is highly influenced by environmental effects and selection would be ineffective.

Patil (2014) in this study on muskmelon reported high heritability accompanied with high genetic advance was observed in the cross 5 (IVMM-3 x Punjab Sunheri) for most of the characters like vine length, days required for initiation of male and female flowering, number of female flowers per vine, node at which first female flower appeared, days required for first harvest of fruits, yield per vine, weight of fruit, length of fruit, diameter of fruit, rind thickness, pulp thickness, fruit cavity, weight of pulp per fruit, weight of seed per fruit, total soluble solids, acidity, downey mildew, powdery mildew, fruit fly and leaf miner. It indicated that most likely high heritability is due to additive gene effects and selection may be effective. Whereas highest heritability coupled with lowest

genetic advance was observed for the number of primary branches per vine, ascorbic acid, total sugar, reducing sugar, non reducing sugar it indicated that non additive effects involved in controlling the inheritance of characters.

Mali (2015) studied heritability and genetic advance in muskmelon and reported that high estimates of heritability were obtained for characters like final vine length, number of primary branches per vine, number of fruits per vine, fruit yield per vine, average weight of fruit, average pulp and rind thickness, average fruit cavity, average weight of pulp per fruit, average weight of seeds per fruit and T.S.S. in most of the crosses of F3 and F4 progenies which indicates preponderance of additive gene action. High heritability combined with low genetic advance was observed for some of the traits for which simple selection would not be rewarding.

2.2.2.2 Bitter gourd

Srivastava and Srivastava (1976) studied heritability in ten bitter gourd lines for ten different characters under Rajasthan conditions. Highest percentage of heritability in broad sense (99.31) was observed for number of fruits while, the lowest for number of male flowers. The characters like number of branches, number of female flowers, number of fruits, fruit length, weight and yield of fruits showed higher percentage of heritability. The values of genetic advance were maximum for number fruits per plant followed by fruit weight and yield per vine.

Indresh (1982) observed high heritability estimates were for all the characters except yield per vine and days for fruit development in bitter gourd.

Lawande (1987) studied parents and 55 F₁ hybrids of bitter gourd for the yield and its main components, *viz.*, number of primary branches, fruit yield per vine, fruit weight, length of fruit, number of fruits per vine except diameter of fruit, shelf life of fruit, node at which first female flower appeared, days to first female flower appearance showed high heritability and high genetic advance.

Raja *et al.* (2007) studied the forty-six genotypes of bitter gourd collected from diversified areas of the country assessed under zero irrigation condition for heritability and genetic advance in respect of fourteen quantitative characters. The genotype MCC-23 recorded the highest number of primary branches per plant, fruit yield per plot and fruit weight. High heritability coupled with greater genetic gain was observed for number of female flowers per plant followed by fruit weight, number of primary branches per plant and yield per plot indicating the additive gene action. Fruit girth showed moderate heritability with low genetic gain.

Rajput (2012) assessed heritability and genetic advance as a per cent of mean in F₂ and F₃ generations of bitter gourd and reported that high estimates of heritability coupled with high genetic advance as per cent of mean was observed for the characters *viz.*, number of primary branches per vine, number of female flowers per vine, sex ratio, average yield per vine and number of fruits per vine in both F₂ and F₃ generations. Whereas the high heritability with low genetic advance as percent of mean was observed for other characters.

Pathak *et al.* (2014) studied the twenty varieties of bitter gourd for the yield and its main components. High heritability with high genetic advance was observed for fruit weight, fruit length and

number of fruits per plant which is an indicative of greater proportion of additive genetic variance and consequence a high genetic gain from selection. High heritability with low genetic advance was observed for days to first male and female flower anthesis and days to marketable maturity from anthesis, indicated that non-additive gene effects were involved for the expression of these characters.

2.2.2.3 Cucumber

Solanki and Seth (1980) observed considerable high heritability and high expected genetic advance among twenty four varieties of cucumber for length, number of leaves per plant and number of days to maturity and fruit yield. However, higher heritability with low expected genetic advance was recorded for average fruit weight, duration of flowering, number of primary branches per plant and number of fruits harvested per plant.

Joshi *et al.* (2005) reported that the high heritability accompanied with high genetic advance as per cent of mean was observed for vine length, number of primary branches, node number of first fruit, fruit length, fruit circumference, number of fruits per vine and fruit yield revealed the considerable effect of additive genes in these traits.

Kumar *et al.* (2007) reported that range of heritability values were recorded from 12.50 to 100.00 per cent for the studied characters in cucumber. The heritability estimate were high for fruit length, node number bearing first male flower and fruit weight while moderate estimates of heritability was observed for number of days to first female flower anthesis, number of days to 50 per cent germination. The high estimate of genetic advance was recorded for number of days to first fruit harvest, while low estimate of genetic

advance were recorded for fruit cavity, number of days to germination and vine length.

Kumar *et al.* (2010) observed low narrow sense heritability for fruit length, fruit diameter, fruit weight and vine length in cucumber. This might be attributed due to presence of non-additive gene action.

Arunkumar *et al.* (2011) studied the heritability in F₂ population of BGDL x White long, BGDL x Hot season and BGDL x Hyderabad cucumber of cucumber. Higher heritability coupled with moderate to low genetic gain was noticed in all F₂ population for different characters but, number of misshaped fruits per vine where it recorded moderate heritability and genetic gain.

Azcon (2012) reported that the broad sense heritability was higher for fruit length, fruit shape index, number of fruits per vine and total fruit yield per vine but it was moderate for fruit diameter in cucumber genotypes. Higher values of heritability indicated that phenotypic selection for these traits could be highly efficient.

Ramesh Kumar *et al.* (2014) reported that the broad sense heritability was higher for days to anthesis of first female flower (96.66 %), weight of fruit (92.67 %) and diameter of fruit (92.51 %) with high genetic advance. The maximum genetic gain in per cent was observed for acidity of fruit (54.06), weight of fruit (47.71) and total yield per vine (47.49).

2.2.2.4 Ridge gourd

Karuppaiah *et al.* (2002) studied 12 genotypes of ridge gourd to assess variability, heritability and genetic advance. High heritability was observed for number of female flowers per vine, yield per vine, number of fruits per vine and flesh thickness. When

heritability and genetic advance as per cent mean were considered together the number of female flowers per vine, number of fruits per vine and yield per vine were recorded highest values.

Choudhary and Kumar (2011) conducted genetic study in ridge gourd and reported that the high heritability along with high genetic advance as per cent of mean was observed for node at which first female flower appeared (82.91 and 55.14 %), fruit length (83.60 and 42.84 %), marketable fruits per vine (82.05 and 47.54 %) and fruit weight (89.09 and 45.27 %) indicated the presence of additive gene action thus these characters could be used in selection on the basis of phenotypic performance.

Rabbani *et al.* (2012) reported that high heritability was recorded for vine length, sex ratio, fruit length, dry weight of flesh, number of fruits per vine, average fruit weight and fruit yield per vine.

2.2.2.5 Sponge gourd

Panwar *et al.* (1977) recorded high estimates of heritability along with high genetic advance for fruit length and days to flower in sponge gourd.

Arora *et al.* (1983) observed significant varietal differences for all the characters studied. Yield per plant, number of fruits per plant and sex ratio exhibited maximum range of heritability and genetic advance. Heritability estimates were lower for length of vine, internodal length and fruit diameter in sponge gourd.

Abusaleha and Dutta (1990) recorded heritability for different characters in sponge gourd with forty five genetic stocks. The high estimates of heritability coupled with high genetic

advance as per cent mean was observed for fruits per vine, fruit length, vine length and yield per vine.

Prasad and Singh (1990) reported that high heritability accompanied with high genetic advance was observed for yield per vine, fruit length, fruit width whereas the characters vine length and number of nodes per vine showed high heritability with moderate estimates of genetic advance as per cent mean.

Kumar *et al.* (2013) revealed that high values of heritability along with high genetic advance as per cent mean was recorded in sponge gourd for number of primary branches per vine, number of fruits per vine, fruit length, average weight of fruit, total yield per vine and T.S.S., indicated that these characters had additive gene effect and therefore, they are more reliable for effective selection.

2.2.2.6 Summer squash

Raju *et al.* (1998) reported that the highest values of heritability accompanied with highest genetic advance was recorded for early fruit yield per vine, number of fruits per vine, vine length, fruit weight and total fruit yield per vine indicated that these traits might be under control of additive gene action which can be improved through selection.

2.2.2.7 Watermelon

Kadam (1997) evaluated heritability and genetic advance in seven cultivars of watermelon and reported that heritability estimates were high for average number of fruits per vine followed by average weight of fruit, average fruit yield per vine, average weight of flesh, average number of seeds per fruit, average length of fruit average diameter of flesh, average number of primary branches, average diameter of fruit, total soluble solids, days

required for 50 per cent harvest and female flowering and shelf life of fruits. The genetic advance as per cent mean was high for average number of seeds per fruit while it was low for remaining traits.

Gusmini and Wehner (2007) studied heritability and genetic advance as per cent mean in watermelon and reported that high estimates of heritability along with high estimates of genetic advance as per cent mean were observed for number of fruits per vine, average weight of fruit, average fruit yield per vine, average weight of flesh and average number of seeds per fruit.

2.2.2.8 Snake gourd

Deepa Devi and Mariappan (2013) studied heritability and genetic advance as per cent mean in snake gourd and reported that high heritability along with high genetic advance was observed for fruit length, fruit yield, fruit girth and number of fruits per plant is indicative of additive gene action in control of these traits and phenotypic selection based on these traits in the segregating population is likely to yield desired individuals.

2.2.2.9 Ash gourd

Singh *et al.* (2002) studied heritability and genetic advance in ash gourd and reported that high estimates of heritability were obtained for characters like fruit length, fruit diameter, average fruit weight, total yield and number of fruits per vine. This shows that these characters were least affected by environment. Higher value of genetic advance (>20 %) were observed for fruit diameter and total fruit yield.

2.2.2.10 Pointed gourd

Singh *et al.* (1992) estimated heritability and genetic advance for ten characters in 36 F1 genotypes of pointed gourd and

reported that high heritability coupled with high genetic advance as per cent of mean was observed for fruit yield and number of fruits per vine.

2.2.2.11 Pumpkin

Chandrakumar (2006) studied genetic variability in pumpkin and found that TSS had the highest heritability and high genetic advance as a per cent of mean (74.57 and 31.68). Whereas fairly high heritability percentage was observed for number of primary branches (42.61), days to first female flowering (65.14), number of fruits per vine (65.27), fruit yield per vine (71.99), fruit length (38.10), fruit diameter (64.67) and flesh thickness (45.29). The genetic advance as a per cent of mean for the above characters was considerably low.

2.2.2.12 Other vegetables

Biradar *et al.* (1993) studied F_1 , F_2 and F_3 generations in crosses involving two indigenous and one exotic cowpea line reported importance of additive gene effects for most of the traits. The heritability estimates for all the characters were of moderate to high magnitude and the coupled with high heritability and genetic advance for the most yield components indicated predominance of additive genetic variance and good potential for improvement by selection.

Shirkole (2006) evaluated segregating progenies of tomato involving three F_2 crosses with six divergent parents. The high heritability with high estimates of genetic advance was recorded for days to 50 % flowering (99.30, 22.44 %), equatorial diameter (86.49, 37.31%), plant height (79.44, 35.06 %) and fruit yield per plant (76.61, 54.97 %) indicating predominance of additive gene effect and greater scope for further selection.

Gupta *et al.* (2009) revealed that, high heritability with high genetic advance in chilli for the number of fruits per plant (93.55 and 60.47 %), fruit yield per plant (94.03 and 51.89 %) and fruit weight (86.74 and 44.09 %) respectively. Hence, these traits are likely to respond to selection on a better way.

Kshirsagar (2009) observed wide range of variability in F3 and F4 generation of tomato. High heritability coupled with high genetic advance was recorded in average fruit weight (97.38 and 35.89 %), number of locules per fruit (98.02 and 29.92 %). Whereas, fruit weight (97.70 and 38.22 %), number of locules per fruit (89.90 and 27.33 %) and fruit yield per plant (85.00 and 26.87 %) for F3 and F4 generation of cross M-3-1 X18-1-1 respectively. Also, fruit yield per plant (80.00 and 31.70 %), number of locules (95.00 and 23.89 %) and average fruit weight per fruit (92.48 and 18.48 %) in F3 generation, whereas, average fruit weight (94.98 and 36.98 %), number of locules per fruit (90.63 and 34.29 %), fruit yield per plant (80.00 and 29.28 %) pericarp thickness (83.20 and 24.79 %) in F4 generation of cross M-3-1 x H-36 respectively.

2.3 Correlation coefficient

Direct selection for yield is often misleading as yield is polygenically controlled and also subjected to the effect of fluctuating environment. Efficiency of selection in any breeding programme is enhanced and mainly depends on the knowledge of association of characters. The work done for association of relationship between yield and yield contributing characters is reviewed as below.

2.3.1 Bottle gourd

Prasad *et al.* (1993) observed thirty genotypes for their correlation studies revealed highly significant and positive

association of fruit yield with number of fruits vine⁻¹, average weight of fruit and number of female flowers vine⁻¹.

Sharma and Dhankar (1993) studied correlation in 35 genotypes of bottle gourd and observed the positive correlation between yield and number of fruits was mainly due to highest direct effect of number of fruits. Days to first female flowering showed negative association with vine length.

Narayan *et al.* (1996) reported that yield was positively and significantly correlated with number of fruits plant⁻¹ and average weight of fruit. Negative and significant correlation between yield and days to anthesis of first male flower was observed.

Badade *et al.* (2001) reported that the yield was significantly and positively correlated with number of branches vine⁻¹, percentage of female flower and number of fruits vine⁻¹ in bottle gourd, while significantly and negatively correlated with days to first male and female flower appearance at both phenotypic and genotypic levels. At genotypic level, vine length, diameter of fruit, number of seeds fruit⁻¹ and 100 seed weight showed significant and negative correlation, where as percentage of powdery mildew intensity showed positive correlation with fruit yield plant⁻¹. Fruit length showed positive but non-significant correlation with fruit yield plant⁻¹.

Singh *et al.* (2002) studied genotypic and phenotypic coefficients of variation, heritability and genetic advance for 14 characters of bottle gourd (*Lagenaria siceraria*) in 10 lines, 2 testers and 20 F₁'s. The phenotypic coefficient of variation was higher than genotypic coefficient of variation for fruit yield plant⁻¹, fruit diameter, fruit length, fruit height, number of nodes to first male

flower and vine length which were also characterized by high genetic variation.

Kumar *et al.* (2007) observed that the value of correlation at genotypic level was higher than the phenotypic correlations, indicating that there is strong inherent association between the various characters studied. The fruit yield vine⁻¹ showed positive and significant correlation with number of branches vine⁻¹, vine length, node number of first female flower, length of edible fruits, number of fruits vine⁻¹, number of seeds fruit⁻¹ and 100 seed weight at genotypic and phenotypic levels. This indicated that fruit yield can be improved by making selection on the basis of number of branches vine⁻¹, vine length, nodes number of first female flower, length of edible fruit and number of fruit vine⁻¹.

Yadav *et al.* (2007) while studying 18 strains of bottle gourd revealed that yield plant⁻¹ was positively and significantly associated with the number of fruits plant⁻¹, but has a negatively significant correlation with days to first female flowering at both genotypic and phenotypic levels.

Pandit *et al.* (2009) while evaluating 15 genotypes of bottle gourd revealed that the correlation between both genotypes and phenotypes indicated the over-riding importance of fruit length and fruit width in determining the average fruit weight, which in turn adequately described the increase in fruit yield plant⁻¹.

Patil (2010) assessed twenty five bottle gourd genotypes and revealed that the fruit yield per vine showed positive correlation with average fruit weight, fruit fly incidence, leaf miner incidence, number of primary branches per vine and number of fruits per vine at genotypic and phenotypic level. The number of

fruits per vine showed significant and positive correlation with fruit yield per vine and negative correlation with percent disease intensity for downey mildew and leaf miner incidence at both phenotypic and genotypic levels.

Yadav *et al.* (2010) reported that fruit yield per plant in bottle gourd had positive and significant phenotypic and genotypic correlation coefficient with number of fruits per vine, weight per fruit, length of fruits, number of primary branches per vine, number of nodes per vine, vine length and days to first female flower anthesis.

Kumar *et al.* (2012) studied correlation in bottle gourd and noticed that fruit yield per vine had highly significant positive association with days to fruit setting, days to maturity and number of fruits per vine at genotypic and phenotypic level.

Sharma and Sengupta (2012) reported that fruit yield per vine in bottle gourd exhibited significantly positive correlation with vine length, number of primary branches per vine, number of female flowers per vine, number of fruits per vine and fruit length.

Yadav and Kumar (2012) studied phenotypic and genotypic correlation coefficient in 15 genotypes of bottle gourd and revealed that fruit yield per vine had positive and highly significant correlation coefficient with average fruit weight followed by days to first female flower anthesis, number of fruits per vine, length of fruit, node number of first female flower and number of primary branches per vine at phenotypic and genotypic level.

2.3.2 Other cucurbits

2.3.2.1 Muskmelon

Monila *et al.* (1989) observed significant and positive correlation between total fruit yield with average weight of fruit,

fruit length, fruit width, flesh thickness and rind thickness in muskmelon.

Tarsem and Sanjay (1997) studied correlation in muskmelon and reported that total fruit yield per vine showed highly significant and positive phenotypic correlation with flesh thickness, marketable fruit yield per vine, average weight per fruit, seed cavity size and vine length. Thus, in breeding programme positive correlations among the characters would be considered desirable. Hence selection for these traits would bring about an improvement of total fruit yield per vine.

Choudhary *et al.* (2003) observed that fruit yield per vine had significant and positive correlation with average fruit weight, number of fruits per vine, harvest duration, rind thickness, shelf life and vine length in muskmelon.

Chamnan and Kasem (2006) studied correlation coefficient in F₂ generation of muskmelon and revealed that fruit yield per vine had positive and significant correlation with number of fruits per vine. The results indicated that number of fruits per vine had a close association with the yield. Thus, components of fruit number per vine should be considered for yield improvement in muskmelon breeding programme.

Jagtap (2010) studied correlation in muskmelon and reported that yield per vine showed positive and significant association with number of fruits per vine, diameter of fruit, pulp thickness and pulp weight per fruit in both summer and *kharif* seasons.

Naroui *et al.* (2010) conducted experiment on yield traits relationship in muskmelon and reported that fruit yield had

significant and positive correlation with fruit weight and flesh diameter.

Cheema *et al.* (2011) studied correlation based on 11 morphological traits in muskmelon and reported that fruit yield per vine was positively correlated with number of lateral branches per vine, number of green leaves per vine, fruit weight, number of fruits per vine and total number of leaves per vine. Numbers of green leaves per plant was positively correlated with total soluble solids (T.S.S.) and yield per vine.

Mali (2015) studied correlation in F₃ and F₄ generations of muskmelon and reported that significant and positive correlation was observed both at phenotypic and the genotypic level between fruit yield per vine and the yield contributing characters such as final vine length, number of primary branches per vine, number of female flowers per vine, number of fruits per vine, average weight of fruit, average length of fruit, average diameter of fruit and average weight of pulp per fruit.

2.3.2.2 Bitter gourd

Khattra *et al.* (1994) reported a significant and positive correlation of total fruit yield per vine with average fruit weight and number of fruits per vine while negative correlation was recorded with days to anthesis of first female flower and days to first harvest in bitter gourd.

Dey *et al.* (2005) studied correlation in bitter gourd and revealed that the fruit yield had the highest positive correlation with fruit weight followed by number of fruits per vine, flesh thickness, days from fruit set to maturity, fruit index, fruit length and fruit diameter where as other traits like number of male flowers per vine, ascorbic acid, total carotenoids content and days

to first male flower exhibited negative correlation coefficient with fruit yield.

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

Pathak *et al.* (2014) studied correlation in bitter gourd and revealed that number of fruits per plant had significant positive correlation for yield. Further, path coefficient analysis partitioned the correlation into direct and indirect effects. Yield was found to be directly correlated with fruit weight, number of fruits per plant and fruit length, hence selection based on these characters would be more rewarding.

Gupta *et al.* (2015) studied correlation in bitter gourd with 26 genotypes including check (Solan Hara) for yield and yield components, their direct and indirect influence on total marketable fruit yield. Correlation of various characters with yield is useful and provides criteria for direct selection of component characters. The characters average fruit weight, marketable fruits per vine, and seeds per fruit exhibited positive phenotypic association while marketable fruits per vine, seeds per fruit, average fruit weight and node at which first female flower appears showed genotypically positive association with total marketable fruit yield per hectare. Marketable fruits per vine had maximum positive direct effect on total marketable fruit yield per hectare followed by average fruit weight, seeds per fruit, number of days to first female flower appearance, branches per plant and node at which first female flower appears.

2.3.2.3 Cucumber

Rao *et al.* (2003) reported that fruit yield was positively correlated with fruit weight, fruit length and flesh thickness at both genotypic and phenotypic levels in cucumber.

Joshi *et al.* (2005) reported that correlation coefficient of fruit yield was observed positive with vine length, number of primary branches, node number of first fruit, fruit length, fruit circumference and number of fruits per vine in cucumber.

Bhande *et al.* (2012) revealed that fruit yield per vine in cucumber showed highly significant positive association with number of fruits per vine, volume of fruit, length of fruit, weight of fruit and girth of fruit where as other traits *viz.*, node at first pistillate flower and days to first harvest exhibited negative and significant association with fruit yield per vine at both genotypic and phenotypic level.

2.3.2.4 Ridge gourd

Choudhary and Kumar (2011) investigated correlation of different yield and yield contributing characters of ridge gourd and revealed that the marketable fruit yield per vine had positive and significant correlation with fruit weight and fruit length at phenotypic level. Days to first fruit harvest exhibited positive and highly significant correlation with days to first female flower opening and node at which first female flower appeared. Also reported that the magnitude of genotypic correlation coefficients was higher than respective phenotypic correlation coefficients which establishes inherent relationship among the characters.

Hanumegowda *et al.* (2012) studied correlation coefficients in ridge gourd and revealed that fruit yield per vine showed positive and significant correlation with number of fruits

per vine, average fruit weight, fruit length, fruit diameter, per cent fruit set, number of seeds per fruit, 100 seed weight, seed yield per fruit and rind thickness at genotypic level. Thus, the association of these characters are in the desirable direction, selection for these traits may improve the yield per vine.

Rabbani *et al.* (2012) studied correlation coefficients in 60 genotypes of ridge gourds for yield versus eight important yield contributing traits and reported that fruit yield per vine had highly significant positive relationship with the number of fruits per vine, average fruit weight, vine length at harvest and length of fruit. While sex ratio and circumference of fruit exhibited negative association with fruit yield.

2.3.2.5 Sponge gourd

Khule *et al.* (2011) studied correlation in 30 genotypes of sponge gourd and revealed that marketable fruit yield per vine exhibited significant positive correlation with number of fruits per vine and fruit length. Also noticed that genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients suggesting that the environmental influence reduces the relationship between yield and yield contributing characters.

Kumar *et al.* (2013) observed the correlation in 20 genotypes of sponge gourds for yield and yield contributing characters and reported that total fruit yield per vine exhibited significant and positive correlation with number of fruits per vine, average weight of fruit, number of seeds per fruit and total soluble solids both at genotypic and phenotypic levels. Also revealed that estimates of genotypic correlation were slightly higher than their corresponding phenotypic correlation for all the characters.

2.3.2.6 Watermelon

Kadam (1997) studied phenotypic and genotypic correlation coefficient between yield and yield contributing characters in watermelon and revealed that average fruit yield per vine was highly and positively correlated with average length of main vine, average number of primary branches, average length of fruit, average diameter of fruit, average weight of fruit, average diameter of flesh, average number of seeds per fruit and average weight of flesh.

Rolania *et al.* (2003) reported that fruit yield was positively correlated with main vine length, number of primary branches per vine, number of nodes per vine, number of female flowers per vine, number of fruits per vine and harvest duration in watermelon.

2.3.2.7 Snake gourd

Narayankutty *et al.* (2006) revealed that fruit yield was strongly correlated with fruit weight, number of fruits per vine, fruit girth, days to first harvest, flesh thickness and days to first female flower opening in snake gourd.

2.3.2.8 Ash gourd

Dewan *et al.* (2014) conducted an experiment to study the correlation between yield and yield contributing characters of 46 accessions of ash gourds. Correlation coefficient indicated that fruit yield per vine had highly significant and positive association with the number of fruits per vine, average weight of fruit, fruit length, fruit diameter, flesh thickness and vine length at the time of harvest while sex ratio exhibited a negative association with yield.

2.3.2.9 Pointed gourd

Khan *et al.* (2009) studied correlation among eight important yield components with fruit yield in 24 accessions of pointed gourd and revealed that fruit yield exhibits significant and positive correlation with number of female flowers, single fruit weight and number of fruits per vine. Whereas fruit yield exhibited negative correlation with number of node at first harvest and pulp seed ratio.

2.4 Fruit characters (Qualitative)

Ramaswamy *et al.* (1977) studied inheritance of fruit shape in oblong x flat, flat x round and oblong x round and concluded that fruit shape in muskmelon was inherited in a simple way, and several genes may be involved. The crosses were made between crossed netted type with smooth type of muskmelon and observed netted character was dominant over smoothness. Also made crosses between green fleshed fruit (Durgapura Madhu) with white fleshed (Lucknow Safeda) fruit and obtained all white fleshed fruit in F₁.

Jagtap (2010) conducted experiment on heterosis and combining ability in muskmelon and reported that the progenies of crosses P₄ x P₆ (IVMM-3 x MHY-3), P₄ x P₇ (IVMM-3 x Punjab Sunheri), P₂ x P₇ (Durgapura Sel x Punjab Sunheri), P₁ x P₃ (GMM-3 x Hara Madhu) and P₃ x P₄ (Hara Madhu x IVMM-3) were found superior in case of qualitative traits like round fruit shape, greenish yellow with ridges fruit colour, netted fruit surface, flavor and orange pulp colour.

Dalamu *et al.* (2012) in their study on inheritance of fruit colour and surface in bitter melon reported that the crosses sel-1 x Pusa Do Mousami and sel-1 x Pusa vishesh exhibited found

green fruit colour of bitter gourd. The inheritance of ridgeness in cross sel-1 x Pusa vishesh indicated that the fruit surface (discontinuous ridge) was governed by single dominant gene.

Rajput (2012) reported that the crosses PGG x DVBTG-5, PGG x Delhi Local and Delhi Local x Co-White Long were found superior for further selection of desirable bitter gourd cultivars where dark green fruits are mostly preferred in export market followed by light green fruits while white in local markets and prickly, smooth fruit surface and long fruit length were observed in F₂ and F₃ progenies.

Patil (2014) reported that the cross 1 (Durgapura Selection x Punjab Sunheri), cross 3 (Hara Madhu x Punjab Sunheri) and cross 5 (IVMM-3 x Punjab Sunheri) were found superior for further selection of desirable muskmelon cultivars with high yield and best quality in respect of round fruit shape, greenish yellow with ridges fruit colour, netted fruit surface, flavor and orange pulp colour.

2.5 Per cent incidence of diseases and pests

Jagtap (2010) reported that by considering overall performance coupled with the minimum incidence of disease (downy mildew, fusarium wilt and gummosis) and pests (fruit fly and leaf miner) in muskmelon the crosses P4 x P6 (IVMM-3 x MHY-3), P4 x P7 (IVMM-3 x Punjab Sunheri), P2 x P7 (Durgapura Sel. x Punjab Sunheri), P1 x P3 (GMM-3 x Hara Madhu) and P3 x P4 (Hara Madhu x IVMM-3) could be effectively exploited for heterosis breeding programme. Whereas the parents Durgapura Selection (P2), Hara Madhu (P3), IVMM-3 (P4) and Punjab Sunheri (P7) were identified as the best combiner and could be used in further

breeding programme for improvement of (OP) cultivars in muskmelon.

Rajput (2012) reported all the four parents and their progenies were observed resistant to downey mildew, powdery mildew, fruit fly and leaf minor in F_2 and F_3 generations in bitter gourd.

Patil (2014) in their study on muskmelon reported that the cross 5 (IVMM-3 $\times$ Punjab Sunheri) showed the least incidence of downey mildew (26.04 and 29.11%), powdery mildew (13.34 and 22.14%), fusarium wilt (5.00 and 5.00%), fruit fly (7.71 and 13.05 %) and leaf miner (17.51 and 20.84 %) in both summer and *kharif* seasons respectively in F_2 generation which can be further exploited for obtaining tolerant variety against them.

3. MATERIAL AND METHODS

The present investigation entitled “Genetic studies in F₃ and F₄ generations of Bottle gourd (*Lagenaria siceraria* Mol. StandL.)” was carried out at the All India Coordinated Research Project on Vegetable Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) during the summer 2014 and *kharif* 2014. The details of material used and procedure adopted for the present investigation are given below.

3.1 Material

The seeds of F₂ plant progenies from 2 crosses along with 3 parents were obtained from the previous Ph.D. research work carried out at AICRP on vegetable crops, MPKV., Rahuri. Parents involved in these crosses are.

1. Pusa Samridhi (3),
2. DBG-5 (9),
3. Bhagirathi (10)

Table 1. Details of cross and generation wise progenies

Sr. No.	Cross	Symbol	Progenies selected for F ₃ generation	Progenies selected for F ₄ generation
C ₁	Pusa Samridhi x DBG-5	3 x 9	5	5
C ₂	DBG-5 x Bhagirathi	9 x 10	5	5
	Total :	-	10	10

Table 2. Silent feature of parent material used for present investigation

Code No.	Parent	Source	Salient features
P1	Pusa Samridhi	MPKV, Rahuri	Fruits are long and yield 300 q/ha
P2	DBG-5	MPKV, Rahuri	Fruits cylindrical, high yielding
P3	Bhagirathi	MPKV, Rahuri	Long fruits, cylindrical, vigorous vine, high yielding

3.2 Methods

3.2.1 Design and layout of experiment for F₃ and F₄ generations

Following F₂ hybrid derivatives has been selected for study.

1. 3 x 9 (Pusa samridhi x DBG-5).....5 progenies
2. 9 x 10 (DBG-5 x Bhagirathi).....5 progenies
 - a. Design : Randomized Block Design(RBD)
 - b. Total number of genotypes : 03
 - c. Replications : 02
 - d. Spacing : 3 x 1 m
 - e. Number of progenies : 10
 - f. No. of plants per progeny : 20
 - g. Number of plants per replications : 200

3.2.2 Details of Experiment

F₂ progenies from the two crosses were selected on the basis of earliness, shape of fruit, node at which first female flower appeared, average length and diameter of fruit (cm), colour of fruit, average weight of fruit(g) and yield per vine.

Initially, ten progenies along with three parents were sown during summer 2014 and evaluated for F₃ generation. A total of 13 genotypes (10 progenies + 3 parents) were developed from three hybrids and their respective parents. Again 13 F₃ progenies (selections) (10 progenies + 3 parents) were sown in *kharif* 2014 and evaluated for F₄ generation. The F₃ and F₄ generations of both crosses were evaluated in randomized block design with three replications. For evaluation of F₃ and F₄ progenies, 600 vines of selected progenies and parents were planted in three replications for recording the observations. A recommended dose of fertilizer for bottle gourd is 20 t FYM + 100:50:50 kg NPK ha⁻¹. The dose of FYM 20 tones ha⁻¹ and the 50 per cent recommended dose of nitrogen (50 kg/ha) and full dose of phosphorus (50 kg/ha) and potassium (50 kg/ha) were incorporated in the furrows and mixed in the soil during both the seasons. Seeds of these generations were sown at a spacing of 3m x 1m. The vines were thinned to one seedling per hill after germination. The remaining 50 per cent of nitrogen (50 kg/ha) was applied as a top dress on 30th day after sowing. The vines were allowed to trail on the kniffen system irrigation, weed control and other cultural practices were followed as per the package of practices to grow good healthy crop.

3.3 Observations recorded

In F₃ generation and F₄ generation vine populations of both the crosses and their parents were taken for observations to study the variability, heritability, genetic advance and correlation for yield contributing traits. The observations were recorded for the following characters.

3.3.1 Growth characters

3.3.1.1 Length of vine (m)

The final length of vine at last harvest was measured in centimeter from the base of the vine to the growing tip of the vine at last harvesting.

3.3.1.2 Number of primary branches per vine

All the primary branches on shoot of the vine was recorded at last crop harvest.

3.3.2 Flowering characters

3.3.2.1 Days required for appearance of first female flower

The number of days required for the appearance of first female flower from date of sowing was recorded separately for each parents and progenies.

3.3.2.2 Number of male and female flowers per vine (sex ratio)

The node number at which the first female flower appears gives an indication of earliness in cucurbits (Swarup, 1977). Therefore the node at which the first pistillate flower appeared was noted for all the observational plants and mean was calculated.

3.3.2.3 Node at which first female flower appeared

The number of days required to first fruit harvesting from the date of sowing was recorded for each parent and progenies.

3.3.2.4 Days required for first fruit harvest

The number of days required to last fruit harvesting from the date of sowing was recorded for each parent and progenies.

3.3.3 Yield characters

3.3.3.1 Number of fruits per vine

Number of fruits per vine were recorded for each picking from all the observational vine separately and summed up after last picking and the average number of fruits per vine were worked out.

3.3.3.2 Yield per vine (kg)

The yield of harvested fruits of all pickings from each observational vine was summed up and the average fruit yield per vine was calculated.

3.3.4 Fruit characters (quantitative)

3.3.4.1 Average weight of fruit (g)

The weight of five individual fruits harvested at the full (edible) maturity stage was recorded in gram and the average weight of fruit was calculated.

3.3.4.2 Average length of fruit (cm)

The length of each fruit was measured from the peduncle to the distant end by measuring tape and average was worked out.

3.3.4.3 Fruit diameter at center, pedicel and stylar end (cm)

The diameter of each fruit was measured at the centre, pedicel and stylar end with the help of digital vernier calliper and average diameter was worked out.

3.3.5 Fruit characters (qualitative)

3.3.5.1 Shape of fruit (cylindrical, bottle neck)

Fruit shape of each progeny of F₃ and F₄ generation was recorded at full mature stage by visual observation as cylindrical and bottle neck.

3.3.5.2 Colour of fruit (light green, green,)

Fruit colour of each progeny of F₃ and F₄ generation was recorded at full mature stage by visual observation as light green and green.

3.3.5.3 Presence of pubescence (present, absent)

Presence of pubescence on fruit of each generation was recorded at full mature stage by visual observation as present or absent.

3.3.6 Per cent incidence of diseases and pests

3.3.6.1 Per cent incidence of diseases

Number of plants affected by incidence of downey mildew, powdery mildew, *Fusarium* wilt and gummosis were counted and the per cent disease incidence (PDI) was worked out as per following formula.

$$\text{PDI} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

3.3.6.2 Per cent incidence of pests

Number of fruits affected by the infestation of fruit fly was counted and the per cent incidence was worked out. The percentage of pest incidence was calculated by the following formula.

$$\text{Per cent incidence of fruit fly} = \frac{\text{Number of infected fruits}}{\text{Total number of fruits}} \times 100$$

3.4 Statistical methodology

The individual vine data was used for statistical and genetical analysis. These have been presented under the following sub-heads.

3.4.1 Estimation of mean and range

The mean value for each character was worked out by using following formula

$$\bar{X} = 1/n \left(\sum_{i=1}^n X_i \right)$$

Where,

$\sum X_i$ = Sum of total of the character

N = Number of observations

The lowest and the highest value from mean of each character were recorded as range.

3.4.2 Estimation of components of variations

The phenotypic and genotypic variances were calculated by respective mean square values (Johnson *et al.*, 1955a).

- i. Environmental variance (σ^2_e) = MSe
- ii. Genotypic variance (σ^2_g) = MSg – MSe/r
- iii. Phenotypic variance (σ^2_p) = $\sigma^2_g + \sigma^2_e$

Where,

MSg = Genotypic mean sum of square

MSe = Error mean sum of square

r = Number of replications

3.4.3 Estimation of coefficient of variations

The genotypic and phenotypic coefficients of variation were calculated by Burton and De Vane (1953).

i. Phenotypic coefficient of variation (PCV)

$$PCV = \frac{\sqrt{\sigma^2_p}}{\bar{X}} \times 100$$

Where,

σ^2_p = Phenotypic variance

$\bar{X}$ = Mean of population

ii. Genotypic coefficient of variation (GCV)

$$\text{GCV} = \frac{\sqrt{\sigma^2 g}}{\bar{X}} \times 100$$

Where,

$\sigma^2 g$ = Genotypic variance

$\bar{X}$ = Mean of population

The GCV and PCV values are categorized by Sivasubramanian and Madhamenon (1973) as follows.

Low : Less than 5 %

Moderate : 5-10 %

High : More than 10 %

3.4.4 Estimation of heritability (%)

Heritability is the ratio of genotypic variance to the phenotypic variance. Heritability percentage in broad sense was estimated for various characters as below (Lush, 1949).

$$h^2 (\text{b.s.}) = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where,

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

The heritability in broad sense values are categorized by Johnson *et al.* (1955) as follows.

Low : Less than 50 %

Moderate : 50-75 %

High : More than 75 %

3.4.5 Estimation of genetic advance

The genetic advance was calculated as per Johnson *et al.* (1955).

$$GA = \frac{\sigma^2_g}{\sigma^2_p} \times \sqrt{\sigma^2_p} \times K$$

Or

$$GA = K \cdot h^2(b.s.) \times \sqrt{\sigma^2_p}$$

Where,

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

σ_p = Phenotypic standard deviation

K = Selection differential at 5 % selection intensity
(i.e. 2.06)

$h^2(b.s.)$ = Heritability broad sense

$\bar{X}$ = Mean of the character

Genetic advance expressed as percentage of mean was calculated by the following formula.

$$GA \text{ as percentage of mean} = \frac{GA}{\bar{X}} \times 100$$

The range of genetic advance as per cent of mean values is categorized by Johnson *et al.* (1955) as follows.

Low : Less than 10 %

Moderate : 10-20 %

High : More than 20 %

3.4.6 Estimation of correlation coefficient

In order to study the inter relationship between different characters, the genotypic and phenotypic correlation coefficients (r) were calculated for the pooled data were computed by the following formula.

$$r_g = \frac{\text{Co-variance XY (G)}}{\sqrt{\text{Variance X (G)} \times \text{Variance Y (G)}}}$$

$$r_{ph} = \frac{\text{Co-variance XY (PH)}}{\sqrt{[\text{Variance X (PH)} \times \text{Variance Y (PH)}]}}$$

Where,

r_g : Genotypic correlation coefficient between character X and Y

r_{ph} : Phenotypic correlation coefficient between character X and Y

X,Y : Two variables under consideration

The significance of these correlation coefficients were compared with statistical table value of correlation coefficient at 1 and 5 per cent level of significance (Snedecor and Cochran, 1967).

4. EXPERIMENTAL RESULTS

Bottle gourd (*Lagenaria siceraria* (Molina) StandL.) is an important vegetable crop grown worldwide. Its variability is being used for improvement and thereby developing high yielding varieties and hybrids. The present investigation entitled “Genetic studies in F₃ and F₄ generations of bottle gourd [*Lagenaria siceraria* (Molina) StandL.]” was undertaken to study the genetical parameters such as variability, heritability, genetic advance and correlation. The selection pressure was applied to identify the superior genotypes for early fruit harvest, high average fruit weight and fruit yield per vine for development of open pollinated cultivar.

The observations on growth, flowering, yield, fruit quantitative, qualitative characters and incidence of diseases and pest were recorded to study the genetical parameters. The results pertaining to these observations are presented as under.

4.1 Genetical parameters of variability, heritability and genetic advance

Success of breeding programme is largely dependent on the extent of genetic variability present in the population. Since heritable and non-heritable components of variation are important to assess the true breeding nature of a character. Information on heritability is a prerequisite for improving the characters and the productivity, through a systematic breeding programme. Selected ten progenies of F₃ and F₄ generations respectively of two crosses *viz.*, Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂:

9 x 10) along with their parents were studied for growth, yield and quality traits for genetical parameters. (Table 3 to 6).

4.1.1 Variability, heritability and genetic advance of cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) for F₃ and F₄ generations

Ten F₃ and F₄ progenies along with their parents was studied for growth, flowering, yield and fruit characters.

4.1.1.1 Vine growth characters

4.1.1.1.1 Length of vine (m)

In F₃ generation wide range of vine length at last harvest (7.91-10.28 m) was recorded with an average value of 9.03 m. The genotypic co-efficient of variation (GCV) and phenotypic coefficient of variation (PCV) was observed 8.99 % and 11.73 % respectively with environmental co-efficient of variation ECV (7.54 %). The medium estimates of heritability (59 %), genetic advance as per cent mean (17.94 %) with lower estimates of genetic advance (1.62) were observed (Table 3). Whereas in F₄ generation wide range (7.45-10.48 m) with an average value of 8.85 m was observed for this trait. The GCV (10.87 %) and PCV (14.42 %) was observed with ECV (9.47 %). The medium estimates of heritability (57 %), genetic advance as per cent mean (21.80 %) with lower estimates of genetic advance (1.93) was observed respectively. indicating preponderance of additive gene action and the character can be improved through simple selection (Table 4).

Table 3. Mean, range, GCV, PCV, ECV, heritability, genetic advance and percent mean of genetic advance of two parents and F₃ population of cross Pusa Samridhi x DBG-5 (C₁: 3 x 9)

Sr. No.	Character	Mean	Range	GCV (%)	PCV (%)	ECV (%)	h² bs (%)	GA	GAM (%)
1.	Length of vine (m)	9.03	7.91-10.28	8.99	11.73	7.54	59	1.62	17.94
2.	Number of primary branches per vine	7.42	5.33-10.66	20.53	24.28	12.95	72	3.40	45.82
3.	Days required for appearance of first female flower	54.18	50.35-58.00	2.27	3.63	2.83	39	2.02	3.69
4.	Sex ratio (M:F)	14.97	14.63-15.30	12.46	13.13	4.14	90	1.72	11.38
5.	Node at which first female flower appeared	9.16	8.00-10.33	9.26	13.41	9.71	48	1.55	17.24
6.	Days required for first harvest of fruit	64.86	60.45-71.25	4.47	6.54	4.77	47	5.47	8.43
7.	Average weight of fruit (g)	720.23	634.66-772.33	10.70	11.60	4.48	85	193.91	26.92
8.	Average length of fruit (cm)	28.64	26.53-30.80	14.63	15.28	4.39	92	11.16	38.96
9.	Fruit diameter at pedicel (cm)	5.13	4.90-5.43	13.30	15.33	7.62	75	1.60	31.18
10.	Fruit diameter at center (cm)	5.52	4.96-6.06	12.69	16.42	10.43	60	1.52	27.53
11.	Fruit diameter at stylar end (cm)	5.75	5.06-6.28	8.49	10.19	5.63	69	1.04	18.08
12.	Number of fruits per vine	21.05	16.00-27.00	28.12	30.41	11.58	85	13.24	64.20
13.	Yield per vine (kg)	15.77	12.06-19.24	22.78	23.60	6.19	93	8.75	55.48

Table 4. Mean, range, GCV, PCV, ECV, heritability, genetic advance and percent mean of genetic advance of two parents and F₄ population of cross-1 (Pusa Samridhi x DBG-5)

Sr. No.	Character	Mean	Range	GCV (%)	PCV (%)	ECV (%)	h² bs (%)	GA	GAM (%)
1.	Length of vine (m)	8.85	7.45-10.48	10.87	14.42	9.47	57	1.93	21.80
2.	Number of primary branches per vine	8.01	7.33-9.00	7.80	11.20	8.04	49	1.14	14.23
3.	Days required for appearance of first female flower	54.81	52.33-57.33	3.78	4.24	1.92	79	4.79	8.74
4.	Sex ratio (M:F)	15.04	14.23-15.46	11.00	11.79	4.26	87	1.52	10.10
5.	Node at which first female flower appeared	9.23	8.66-10.33	5.68	9.01	7.00	40	0.89	9.64
6.	Days required for first harvest of fruit	66.15	60.69-71.33	3.12	4.02	2.54	60	4.33	6.46
7.	Average weight of fruit (g)	721.91	634.66-809.66	11.20	12.31	5.11	83	200.56	27.78
8.	Average length of fruit (cm)	28.53	26.03-31.50	15.58	16.67	5.94	87	11.55	40.48
9.	Fruit diameter at pedicel (cm)	5.08	4.70-5.63	13.26	17.34	11.17	59	1.43	28.14
10.	Fruit diameter at center (cm)	5.55	4.73-6.21	14.95	17.58	9.24	72	1.89	34.05
11.	Fruit diameter at stylar end (cm)	5.77	4.83-6.58	12.44	15.97	10.02	61	1.48	25.64
12.	Number of fruits per vine	18.85	16.00-25.00	23.25	26.95	13.63	74	9.40	49.86
13.	Yield per vine (kg)	14.34	12.38-18.12	16.81	20.92	12.45	65	4.93	34.37

4.1.1.1.2 Number of primary branches per vine

The data depicted in Table 3 revealed that, in F_3 generation the growth character number of primary branches per vine was ranged from 5.33-10.66 with mean value 7.42. The close association of GCV and PCV (20.53 and 24.28 %) was observed with certain presence of environmental factors ECV (12.95 %). The high estimate of heritability (72 %) was associated with low genetic advance (3.40) and high genetic advance as per cent mean (45.82 %). Data depicted in Table 4 showed that in F_4 generation, it was ranged in between 7.33 to 9.00 with mean value 8.01. Close values were recorded for GCV (7.80 %) and PCV (11.20 %) and environmental factor ECV (8.04 %). The medium estimate of heritability (49 %) was associated with medium genetic advance as per cent of mean (14.23 %) and lower value of genetic advance (1.14).

4.1.1.2 Flowering characters

The observations on flowering characters like days required for appearance of first female flower, No. of male and female flowers per vine (sex ratio), node at which first female flower appeared and days required for first harvest of fruits were recorded for F_3 and F_4 progenies.

4.1.1.2.1 Days required for appearance of first female flower

In F_3 generation wide range of variability was observed for days required for appearance of first female flower (50.35-58 days) with mean value 54.18 days. The close values were recorded for GCV (2.27%) and PCV (3.63%) with noticeable influence of environmental factor ECV (2.83%). The medium estimate of heritability (39 %) was observed with low values of genetic advance (2.02) and genetic advance as per cent of mean (3.69%) (Table 3).

While in F₄ generation it was ranged from 52.33- 57.33 days with mean value of 54.81 days. Very close values were recorded for GCV (3.78 %) and PCV (4.24 %) with noticeable influence of environmental factor ECV (1.92 %). The high estimate of heritability (79 %) was obtained with moderate estimate of genetic advance as per cent of mean (8.74 %) and low value for genetic advance (4.79) (Table 4).

4.1.1.2.2 Number of male and female flowers per vine (sex ratio)

In case of F₃ generation the sex ratio was ranged in between 14.63 - 15.30 with an average 15.12. The close association of GCV (12.46 %) and PCV (13.13%) was observed with certain presence of environmental factor ECV (4.14%). The high estimate of heritability (90 %) was associated with lower genetic advance (1.72). The moderate value was obtained for genetic advance as per cent of mean (11.38%) (Table 3). Whereas in case of F₄ generation it was ranged in between 14.23- 15.46 with an average value of 15.04. The close association of GCV (11 %) and PCV (11.79 %) were observed with certain presence of environmental factor ECV (4.26 %). The high value was obtained for heritability (87 %) whereas low and moderate values were observed for genetic advance (1.52) and genetic advance as per cent of mean (10.10 %), respectively (Table 4).

4.1.1.2.3 Node at which first female flower appeared

In F₃ generation the node at which first female flower appeared was ranged from 8.00- 10.33 nodes with an average 8.99 nodes. The close values of GCV (9.26 %) and PCV (13.41 %) was observed with certain presence of environmental factor ECV (9.71%). The medium estimate of heritability (48%) was observed

with low values of genetic advance (1.55) and medium value of genetic advance as per cent of mean (17.24%) (Table 3). In F_4 generation it was ranged from 8.66- 10.33 nodes with an average 9.23 nodes. The close association of GCV (5.68 %) and PCV (9.01 %) was observed with certain presence of environmental factor ECV (7.00 %). The medium estimate of heritability observed (40 %) with lower genetic advance (0.89) and moderate value of genetic advance as per cent of mean (9.64 %), respectively (Table 4).

4.1.1.2.4 Days required for first harvest of fruit

In case of F_3 generation the character days required for first fruit harvest was ranged in between 60.45 - 71.25 days with an average value 64.86 days. The close association of GCV (4.47 %) and PCV (6.54 %) was observed with certain presence of environmental factor ECV (4.77 %). The medium estimate of heritability (47 %) was associated with lower genetic advance (5.47%). The moderate value was obtained for genetic advance as per cent of mean (8.43%) (Table 3). Whereas in case of F_4 generation it was ranged in between 60.69 - 71.33 with an average value of 66.15 days. The close association of GCV (3.12 %) and PCV (4.02 %) were observed with certain presence of environmental factor ECV (2.54 %). The high value was obtained for heritability (60 %) whereas low values were observed for genetic advance (4.33) and genetic advance as per cent of mean (6.46 %), respectively (Table 4).

4.1.1.3 Yield characters

A detailed study of the extent of variability associated with yield and yield contributing characters and knowledge on their heritability in relation to their contribution towards yield are the prime requisite for an efficient plant breeding programme.

Therefore genetical parameters were worked out for number of fruits per vine and fruit yield per vine which is one of the most important for crop improvement.

4.1.1.3.1 Number of fruits per vine

In case of F_3 generation the number of fruits per vine was ranged between 16-27 per vine with an average 20.62 per vine. The significant contribution of genetic variability GCV (28.12%) and PCV (30.41%) were observed with presence of environmental variability ECV (11.58%). The high estimates were observed for heritability (85%) and genetic advance as per cent of mean (64.20 %) (Table 3). Whereas in case of F_4 generation it showed wide range 16 - 25 per vine with an average value of 18.85 per vine. The significant contribution of genetic variability GCV and PCV (23.25% and 26.95% respectively) were observed with environmental variability ECV (13.63%). The high estimate of heritability (74%) with highest genetic advance as per cent of mean (49.86%) were observed which proves that yield potential can be improved during further selection cycle (Table 4).

4.1.1.3.2 Yield per vine (kg)

In F_3 generation the character fruit yield per vine showed wide range (12.06 – 19.24 kg) per vine with an average 15.77 kg per vine. The contribution of genetic variability GCV (22.78%) and PCV (23.60%) were observed with influence of environmental variability ECV (6.19%). The highest value of heritability (93%) was associated with high genetic advance as per cent of mean (55.48%) (Table 3). Whereas in F_4 generation it showed wide range of variation in between 12.38 - 18.12 kg per vine with an average value of 14.34 kg per vine. The significant contribution of genetic variability GCV (16.81%) and PCV (20.92%)

were observed with environmental variability ECV (12.45%). The high estimates of heritability (65%) and genetic advance as per cent of mean (34.37 %) were recorded (Table 4).

4.1.1.4 Fruit characters (quantitative)

4.1.1.4.1 Average weight of fruit (g)

The average weight of fruit is an important yield contributing character in bottle gourd. In case of F₃ generation it showed wide range of variation (634.66 - 772.33 g) with mean value 720.23 g. The GCV (10.70%) and PCV (11.60%) were observed with presence of environmental factor ECV (4.48%). The high values were recorded for heritability (85%), genetic advance (193.91) and per cent mean of genetic advance (26.92%) (Table 3). Whereas in case of F₄ generation it showed a wide range of variation (634.66 - 809.66 g) with mean value 721.91 g. The close association of GCV (11.20%) and PCV (12.31%) were observed with certain presence of environmental factor ECV (5.11%). The high estimates of heritability (83%), genetic advance (200.56) and genetic advance as per cent of mean (27.78%), were recorded respectively (Table 4).

4.1.1.4.2 Average length of fruit (cm)

In F₃ generation the average length of fruit was ranged in between 26.53 - 30.80 cm with an average of 28.64 cm. The close association of GCV (14.63%) and PCV (15.28%) was observed with certain presence of environmental factor ECV (3.39%). The highest value was obtained for heritability (92%) whereas lower values were recorded for genetic advance (11.16) and again high value for genetic advance as per cent of mean (38.96%) (Table 3). While in F₄ generation it was ranged in between 26.03 - 31.50 cm with an average 28.53 cm. The close association of GCV (15.58 %) and PCV (16.67%) were observed with certain presence of

environmental factor ECV (5.94%). The highest value was obtained for heritability (87%). whereas lower value was recorded for genetic advance (11.55) and again high value was recorded for genetic advance as per cent of mean (40.48%) (Table 4).

4.1.1.4.3 Fruit diameter at center (cm)

In case of F_3 generation, the average diameter of fruit at center was ranged from 4.96 - 6.06 cm with an average 5.52 cm. The genetic variability contributed as GCV (12.69%) and PCV (16.42%) with influence of environmental factor ECV (10.43%). The high heritability (60%) was associated with low value of genetic advance (1.52) and high value of genetic advance as per cent of mean (27.53%) (Table 3). While in case of F_4 generation it showed wide range of 4.73 - 6.21 cm with an average 5.55 cm. The close association of GCV (14.95%) and PCV (17.58%) were recorded with influence of environmental factor ECV (9.24%). The higher estimates of heritability (72%) was observed with low and high value for genetic advance (1.89) and genetic advance as per cent of mean (34.05%), respectively (Table 4).

4.1.1.4.4 Fruit diameter at pedicel (cm)

In case of F_3 generation, the average diameter of fruit at pedicel was ranged from 4.90 - 5.43 cm with an average 5.13 cm. The genetic variability contributed as GCV (13.30%) and PCV (15.33%) with influence of environmental factor ECV (7.62%). The high heritability (75%) was associated with low value of genetic advance (1.60) and high value of genetic advance as per cent of mean (31.18%) (Table 3). While in case of F_4 generation it showed wide range of 4.70 - 5.63 cm with an average 5.08 cm. The values of GCV (13.26%) and PCV (17.34%) were recorded with influence of environmental factor ECV (11.17%). The higher estimates of

heritability (59%) was observed with low and high value for genetic advance (1.43) and genetic advance as per cent of mean (28.14%), respectively (Table 4).

4.1.1.4.5 Fruit diameter at stylar end (cm)

In case of F_3 generation, the average diameter of fruit at stylar end was ranged from 5.06 - 6.28 cm with an average 5.75 cm. The genetic variability contributed as GCV (8.49%) and PCV (10.19%) with influence of environmental factor ECV (5.63%). The high heritability (69%) was associated with low value of genetic advance (1.04) and moderate value of genetic advance as per cent of mean (18.08%) (Table 3). While in case of F_4 generation it showed wide range of 4.83 - 6.58 cm with an average 5.77 cm. The close association of GCV (12.44%) and PCV (15.97%) were recorded with influence of environmental factor ECV (10.02%). The higher estimates of heritability (61%) was observed with low and moderate value for genetic advance (1.48) and high estimates of genetic advance as per cent of mean (25.64%), respectively (Table 4).

4.1.2 Variability, heritability and genetic advance of cross DBG-5 x Bhagirathi ($C_2 : 9 \times 10$) for F_3 and F_4 generations

Ten F_3 and F_4 progenies along with their parents were studied for growth, flowering, yield and fruit characters and are presented in Table 5 and 6.

4.1.2.1 Growth characters

4.1.2.1.1 Length of vine (m)

In case of F_3 generation, the vine length at last harvest was observed in the range of 7.91- 10.13 m with an average 9.02 m. The close value of genotypic co-efficient of variation GCV (8.00%) and phenotypic coefficient of variation PCV (13.27%) were observed

along with certain presence of environmental co-efficient of variation ECV (10.58%). The medium estimates of heritability (36.40%) and low estimates of genetic advance (1.15) and genetic advance as per cent of mean (12.75%) were observed (Table 5). Whereas in case of F_4 generation it showed wide range (7.31 - 10.05 m) with an average 8.73 m. GCV (9.56%) and PCV (15.06%) were observed with environmental co-efficient of variance ECV (11.63%). The medium estimates of heritability (40%), low estimate of genetic advance (1.41) and medium estimate of genetic advance as per cent of mean (GAM 16.15%) were observed, indicating better scope for improvement through selection (Table 6).

4.1.2.1.2 Number of primary branches per vine

In F_3 generation, the wide range of variability was observed for number of primary branches per vine (7.00 - 10.00) with mean value 8.33. Values were recorded for GCV (11.28%) and PCV (18.77%) with environmental factor ECV (15.01 %). The medium estimate of heritability (36%) was observed with medium value of genetic advance as per cent of mean (17.64 %) and low genetic advance (1.47) (Table 5). In F_4 generation it was ranged in between 7.33 - 9.00 with mean value 8.28. Close values were recorded for GCV (6.67%) and PCV (9.07%) with noticeable influence of environmental factor ECV (6.14%). The medium estimate of heritability (54%) was recorded with medium value of genetic advance as per cent of mean (12.80%) and low value for genetic advance (1.06) (Table 6).

Table 5. Mean, range, GCV, PCV, ECV, heritability, genetic advance and percent mean of genetic advance of two parents and F₃ population of cross-2 (DBG-5 x Bhagirathi)

Sr. No.	Character	Mean	Range	GCV (%)	PCV (%)	ECV (%)	h² bs (%)	GA	GAM (%)
1.	Length of vine (m)	9.02	7.91-10.13	8.00	13.27	10.58	36	1.15	12.75
2.	Number of primary branches per vine	8.33	7.00-10.00	11.28	18.77	15.01	36	1.47	17.64
3.	Days required for appearance of first female flower	53.76	51.00-55.66	2.46	3.57	2.59	47	2.39	4.45
4.	Sex ratio (M:F)	14.65	13.63-16.23	10.97	11.72	4.12	72	1.53	10.44
5.	Node at which first female flower appeared	9.27	8.00-10.34	6.41	9.64	7.20	44	1.04	11.21
6.	Days required for first harvest of fruit	63.73	59.24-68.69	3.95	5.52	3.85	51	4.99	7.83
7.	Average weight of fruit (g)	746.23	662.33-781.66	8.18	9.18	4.17	79	148.28	19.87
8.	Average length of fruit (cm)	30.60	28.83-31.73	11.07	13.21	7.21	70	7.77	25.38
9.	Fruit diameter at pedicel (cm)	5.16	4.56-5.56	13.49	16.31	9.17	68	1.58	30.62
10.	Fruit diameter at center (cm)	5.87	5.03-6.33	10.05	14.09	9.87	51	1.15	19.59
11.	Fruit diameter at stylar end (cm)	6.05	4.97-6.53	7.62	9.48	5.63	65	0.94	15.53
12.	Number of fruits per vine	20.81	15.00-26.00	24.78	28.38	13.84	76	11.18	55.40
13.	Yield per vine (kg)	16.47	12.08-20.22	20.84	23.83	11.57	88	7.56	45.90

Table 6. Mean, range, GCV, PCV, ECV, heritability, genetic advance and percent mean of genetic advance of two parents and F₄ population of cross-2 (DBG-5 x Bhagirathi)

Sr. No.	Character	Mean	Range	GCV (%)	PCV (%)	ECV (%)	h² bs (%)	GA	GAM (%)
1.	Length of vine (m)	8.73	7.31-10.05	9.56	15.06	11.63	40	1.41	16.15
2.	Number of primary branches per vine	8.28	7.33-9.00	6.67	9.07	6.14	54	1.06	12.80
3.	Days required for appearance of first female flower	54.66	49.00-57.00	3.50	3.88	1.68	81	4.47	8.17
4.	Sex ratio (M:F)	14.33	13.58-15.10	13.36	14.79	6.35	82	1.71	11.93
5.	Node at which first female flower appeared	9.33	8.33-10.66	5.95	9.96	7.98	36	0.86	9.21
6.	Days required for first harvest of fruit	62.72	57.24-67.45	2.99	4.22	2.98	50	3.75	5.97
7.	Average weight of fruit (g)	706.9	651.33-760.00	9.94	12.71	7.93	61	149.96	21.21
8.	Average length of fruit (cm)	31.47	29.26-34.20	10.11	13.28	8.61	58	6.64	21.09
9.	Fruit diameter at pedicel (cm)	4.88	4.20-5.20	16.15	17.61	7.03	84	1.99	40.77
10.	Fruit diameter at center (cm)	5.26	4.36-5.86	16.89	18.18	6.73	86	2.31	43.91
11.	Fruit diameter at stylar end (cm)	5.39	4.46-6.03	11.31	14.24	8.64	63	1.31	24.30
12.	Number of fruits per vine	19.66	17.00-27.33	25.70	28.94	13.30	79	11.05	56.20
13.	Yield per vine (kg)	14.38	12.32-17.92	14.66	21.20	15.31	48	3.68	25.59

4.1.2.2 Flowering characters

4.1.2.2.1 Days required for appearance of first female flower

In F₃ generation the wide range of variability was observed for days required for appearance of first female flower (51.00 - 55.66 days) with mean value 53.76 days. The close values were recorded for GCV (2.46%) and PCV (3.57%) with noticeable influence of environmental factor ECV (2.59%). The medium estimate of heritability (47%) was associated with low estimate of genetic advance (2.39) and genetic advance as per cent mean (4.45%) (Table 5). In F₄ generation it showed wide range of variability (49.00 - 57.00 days) with mean value 54.66 days. While very close values were recorded of GCV (3.50%) and PCV (3.88%) with noticeable influence of environmental factors ECV (1.68%). The high estimate of heritability (81%) was associated with low genetic advance (4.47) and moderate genetic advance as per cent of mean (8.17%), (Table 6).

4.1.2.2.2 Number of male and female flowers per vine (sex ratio)

In case of F₃ generation sex ratio was observed in wider range of 13.63- 16.23 with an average of 14.65. The close association of GCV (10.97%) and PCV (11.72%) was observed with certain presence of ECV (4.12%). The high estimate was obtained for heritability (72%) along with genetic advance as per cent mean of (10.44%), While low value was observed for genetic advance (1.53) (Table 5). Whereas, in F₄ generation it was ranged between 13.58 - 15.10 with an average value of 14.33 days. The close association of GCV (13.36%) and PCV (14.79%) was observed with ECV (6.35%). The high estimates were obtained for heritability (82%) and genetic advance as per cent of mean (11.93%) (Table 6).

4.1.2.2.3 Node at which first female flower appeared

In F₃ generation the wide range of variability was observed for node at which first female flower appeared (8.00 - 10.34) with mean value 9.27. The value of GCV (6.41%) and PCV (9.64%) was observed with certain influence of environmental factor ECV (7.20%). The medium heritability (44%) along with low genetic advance (1.04) and moderate genetic advance as per cent mean of (11.21%) were recorded (Table 5). In F₄ generation it was ranged from 8.33 - 10.66 with an average 9.33. The association of GCV (5.95%) and PCV (9.96%) was observed with influence ECV 7.98%). The medium value of heritability was observed (36%) with very low genetic advance (0.86) and medium genetic advance as per cent of mean (9.21%) (Table 6).

4.1.2.2.4 Days required for first harvest of fruit

In F₃ generation the wide range of variability was observed for days required for first harvest of fruit (59.24 - 68.69 days) with mean value 63.73 days. The closer value of GCV (3.95%) and PCV (5.52%) was observed with certain influence of environmental factor ECV (3.85%). The moderate heritability (51%) along with genetic advance (4.99) and moderate genetic advance as per cent mean of (7.83%) were recorded (Table 5). In F₄ generation it was ranged from 57.24 - 67.45 days with an average 62.72 days. The close association of GCV (2.99%) and PCV (4.22%) was observed with influence ECV 2.98%). The medium value of heritability was observed (50%) with low genetic advance (3.75) and genetic advance as per cent of mean (5.97%) (Table 6).

4.1.2.3 Yield characters

4.1.2.3.1 Number of fruits per vine

In case of F_3 generation the number of fruits per vine was observed in wider range of 15.00 – 26.00 with an average of 20.81. The close association of GCV (24.78%) and PCV (28.38%) was observed with certain presence of ECV (13.84%). The high estimate was obtained for heritability (76%) along with highest genetic advance as per cent mean of (55.40%) While moderate value was observed for genetic advance was (11.88) (Table 5). Whereas in F_4 generation it was ranged in between 17.00 - 27.33 with an average 19.66. The close association of GCV (25.70%) and PCV (28.94%) was observed with ECV (13.30%). The high estimates were obtained for heritability (79%) and highest genetic advance as per cent of mean (56.20%) (Table 6).

4.1.2.3.2 Yield per vine (kg)

The data presented in (Table 5) indicate that, yield per vine in F_3 generation was ranged in between 12.08 - 20.22 per vine with an average 16.47 per vine. For this most important character significant contribution of genetic variability GCV (20.84%) and PCV (23.83%) were observed with noticeable value of environmental variability ECV (11.57%). The highest estimates of heritability (88%) and high genetic advance as per cent of mean (45.90%) were observed (Table 5). While in F_4 generation (Table 6) it showed the wide range in between 12.32 - 17.92 per vine with an average 14.38 fruits per vine. The closer values of GCV (14.66%) and PCV (21.20%) were observed with environmental variability ECV (15.31%). The moderate estimates of heritability (48%) and high genetic advance as per cent of mean (25.59%) were observed.

4.1.2.4 Fruit characters (quantitative)

4.1.2.4.1 Average weight of fruit (g)

Average weight of fruit is an important yield contributing character. In F_3 generation it recorded a wide range of variation 662.33 - 781.66 g with mean of 746.23 g. The closer value of genotypic co-efficient of variation GCV (8.18%) and phenotypic co-efficient of variation PCV (9.18%) were observed with certain presence of environmental variation ECV (4.17%). The high estimates of heritability (79%), genetic advance (148.28) and per cent mean of genetic advance (19.87%) were observed (Table 5). In F_4 generation it showed a wide range of variation 651.33 - 760.00 g with mean of 706.9 g. The closer value of GCV (9.94%) and PCV (12.71%) were recorded with certain influence of ECV (7.93%). The high estimates were recorded for heritability and genetic advance as per cent of mean was (61% and 21.21% respectively) (Table 6).

4.1.2.4.2 Average length of fruit (cm)

In F_3 generation the wide range of variability was observed for average length of fruit (28.83 - 31.73 cm) with an average 30.60 cm. The close association of GCV (11.07%) and PCV (13.21%) was observed with certain presence of environmental factor ECV (7.21%). The high estimates were obtained for heritability (70%) and genetic advance as per cent of mean (25.38 %) (Table 5). In F_4 generation it was ranged in between 29.26 - 34.20 cm with an average 31.47 cm. The close association of GCV (10.11%) and PCV (13.28%) was observed with certain presence of environmental factor (ECV 8.61%). The high estimates were obtained for heritability (58%) and genetic advance as per cent of mean (21.09%) with moderate value for genetic advance (6.64) (Table 6).

4.1.2.4.3 Fruit diameter at center (cm)

In case of F_3 generation, the average diameter of fruit at center was ranged in between 5.03 - 6.33 cm with an average value of 5.87 cm. The close association of GCV (10.05%) and PCV (14.09%) was observed with some influence of environmental factor ECV (9.87%). The moderate estimates of heritability (51%), low genetic advance (1.15) and high genetic advance as per cent of mean (19.59 %) were recorded (Table 5). While in case of F_4 generation it was ranged from 4.36 - 5.86 cm with an average 5.26 cm. The close association of GCV (16.89%) and PCV (18.18%) was observed with certain influence of environmental factor ECV (6.73%). The highest value of heritability (86%) was observed with low and moderate values of genetic advance (2.31) and high genetic advance as per cent of mean (43.91%), respectively (Table 6).

4.1.2.4.4 Fruit diameter at pedicel (cm)

In case of F_3 generation, the average diameter of fruit at pedicel was ranged in between 4.56 - 5.56 cm with an average value of 5.16 cm. The close association of GCV (13.49%) and PCV (16.31%) was observed with some influence of environmental factor ECV (9.17%). The high estimates of heritability (68%), low genetic advance (1.58) and high genetic advance as per cent of mean (30.62 %) were recorded (Table 5). While in case of F_4 generation it was ranged from 4.20 - 5.20 cm with an average 4.88 cm. The close association of GCV (16.15%) and PCV (17.61%) was observed with certain influence of environmental factor ECV (7.03%). The high value of heritability (84%) was observed with low and moderate values of genetic advance (1.99) and high genetic advance as per cent of mean (40.77%), respectively (Table 6).

4.1.2.4.5 Fruit diameter at stylar end (cm)

In case of F_3 generation, the average diameter of fruit at stylar end was ranged in between 4.97 - 6.53 cm with an average value of 6.05 cm. The close association of GCV (7.62%) and PCV (9.48%) was observed with some influence of environmental factor ECV (5.63%). The high estimates of heritability (65%), low genetic advance (0.94) and moderate genetic advance as per cent of mean (15.54 %) were recorded (Table 5). While in case of F_4 generation it was ranged from 4.46 - 6.03 cm with an average 5.39 cm. The close association of GCV (11.31%) and PCV (14.24%) was observed with certain influence of environmental factor ECV (8.64%). The high value of heritability (63%) was observed with low and moderate values of genetic advance (1.31) and high genetic advance as per cent of mean (24.30%), respectively (Table 6).

4.2 Correlation coefficient between yield and yield contributing characters

The genotypic and phenotypic co-efficient of correlation for the important yield and yield contributing characters is presented in Table 7 to 10 for each two crosses in F_3 and F_4 generations respectively. The magnitude of genotypic correlation coefficient was higher than the phenotypic correlation coefficients. However, only the significant correlations of important yield contributing characters are described in foregoing paragraphs.

4.2.1 Correlation coefficient of cross Pusa Samridhi x DBG-5 (C_1 : 3 x 9) in F_3 generations

Ten F_3 progenies were studied for association of relationship between yield and yield contributing characters in F_3 generations and are presented in Table 7.

Table 7. Genotypic and Phenotypic Correlation co-efficient for yield and yield contributing characters in F₃ generation of cross Pusa Samridhi x DBG-5 (C1- 3 x 9)

Sr. No.	Character		1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Length of vine (m)	G	1.000	0.475*	0.069	-0.619**	-0.857**	-0.213	0.989**	0.985**	-0.304	-0.612**	-0.741**	-0.644**	-0.528**
		P	1.000	0.137	0.085	-0.561**	-0.256	-0.091	0.732**	0.814**	-0.297	-0.429*	-0.438*	-0.476*	-0.376
2.	Number of primary branches per vine	G	-	1.000	-0.481*	-0.064	-0.411	-0.391	0.443*	0.336	-0.227	-0.151	-0.209	-0.01	0.121
		P		1.000	-0.389	0.021	-0.338	-0.439*	0.277	0.27	-0.141	-0.094	-0.198	-0.025	0.102
3.	Days required for appearance of first female flower	G	-	-	1.000	0.156	0.752**	0.766**	-0.179	0.12	0.485*	0.166	0.427*	0.065	0.115
		P			1.000	0.128	0.261	0.618**	0.061	0.067	0.325	0.112	0.203	0.141	0.103
4.	Sex ratio (M:F)	G	-	-	-	1.000	0.760**	-0.232	-0.849	-0.731	0.751**	0.934**	0.985**	0.930**	0.980**
		P				1.000	0.459*	-0.204	-0.726**	-0.695**	0.698**	0.861**	0.758**	0.825**	0.801**
5.	Node at which first female flower appeared	G	-	-	-	-	1.000	0.419*	-0.843**	-0.739**	0.301	0.396	0.451*	0.592*	0.681*
		P					1.000	-0.016	-0.491*	-0.468*	0.296	0.347	0.471*	0.315	0.621**
6.	Days required for first harvest of fruit	G	-	-	-	-	-	1.000	-0.091	-0.052	-0.055	-0.216	0.221	-0.226	-0.346
		P						1.000	0.013	-0.027	-0.112	-0.189	-0.026	-0.124	-0.389
7.	Average weight of fruit (g)	G	-	-	-	-	-	-	1.000	0.992**	-0.515	-0.750**	-0.915**	-0.785**	-0.779**
		P							1.000	0.892**	-0.408*	-0.639**	-0.632**	-0.597**	-0.562**
8.	Yield per vine (kg)	G	-	-	-	-	-	-	-	1.000	0.275	0.607**	0.727**	0.721**	0.589**
		P								1.000	0.247	0.521**	0.603**	0.570**	0.497*
9.	Average length of fruit (cm)	G	-	-	-	-	-	-	-	-	1.000	0.926**	0.938**	0.776**	0.657**
		P									1.000	0.885**	0.703**	0.734**	0.664**
10.	Fruit diameter at pedicel (cm)	G	-	-	-	-	-	-	-	-	-	1.000	0.953**	0.980**	0.824**
		P										1.000	0.764**	0.848**	0.713
11.	Fruit diameter at center (cm)	G	-	-	-	-	-	-	-	-	-	-	1.000	0.953**	0.734**
		P											1.000	0.665**	0.705**
12.	Fruit diameter at stylar end (cm)	G	-	-	-	-	-	-	-	-	-	-	-	1.000	0.811**
		P												1.000	0.702**
13.	Number of fruits per vine	G	-	-	-	-	-	-	-	-	-	-	-	-	1.000
		P													1.000

S : Symbol

G : Genotypic

P : Phenotypic

***. ** : Significance at 5 % and 1 %, respectively**

4.2.1.1 Length of vine (m)

The length of vine had significant and positive correlation with number of fruits per vine and yield per vine at both genotypic and phenotypic levels. It had significant and positive correlation with number of primary branches at genotypic level. While, it had significant and negative correlation with sex ratio, average length of fruit and fruit diameter at center and pedicel at both genotypic and phenotypic levels.

4.2.1.2 Number of primary branches per vine

The number of primary branches per vine exhibited significant and positive correlation with length of vine and number of fruits per vine at genotypic level. Whereas significantly and negatively correlated with days required for first fruit harvest at phenotypic level. It was significantly and negatively correlated with days required for appearance of first female flower and node at which first female flower appeared at genotypic level.

4.2.1.3 Days required for appearance of first female flower

The days required for first female flower appearance were significantly and positively correlated with days required for first fruit harvest at both genotypic and phenotypic levels. It was significantly and positively correlated with average fruit weight at phenotypic and genotypic levels respectively.

4.2.1.4 Number of male and female flower (sex ratio)

Number of male and female flower (sex ratio) exhibited significant and positive correlation with node at which first female flower appeared, average weight of fruit, average length of fruit, fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels. It showed negatively and significantly correlated with number of fruits per plant and yield per plant.

4.2.1.5 Node at which first female flower appeared

Node at which first female flower appeared showed significant and positive correlation with fruit diameter at center and fruit diameter at stylar end at both genotypic and phenotypic levels. It showed significant and positive correlation with days required for first fruit harvest and fruit diameter at pedicel at genotypic levels. It showed negatively and significantly correlated with number of fruits per plant and yield per plant at genotypic and phenotypic levels.

4.2.1.6 Days required for first fruit harvest

Days required for first fruit harvest was significantly and positively correlated with days required for appearance of first female flower at both genotypic and phenotypic levels.

4.2.1.7 Number of fruits per vine (g)

Number of fruits per vine showed significant and positive correlation with yield per plant at both genotypic and phenotypic levels. Significant and negative correlation was observed at genotypic and phenotypic levels with average weight of fruit, average length of fruit, fruit diameter at center, pedicel and stylar end.

4.2.1.8 Average weight of fruit (g)

The average weight of fruit had significant and positive correlation with average length of fruit, fruit diameter at center pedicel and stylar end at both genotypic and phenotypic levels.

4.2.1.9 Average length of fruit (cm)

The average length of fruit was positively and significantly correlated with fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels.

4.2.1.10 Fruit diameter at center (cm)

Fruit diameter at center was positively and significantly correlated with fruit diameter at pedicel and stylar end at both genotypic and phenotypic levels.

4.2.1.11 Fruit diameter at pedicel (cm)

Fruit diameter at pedicel was positively and significantly correlated with fruit diameter at stylar end at both genotypic and phenotypic levels.

4.2.1.12 Fruit diameter at stylar end (cm)

Fruit diameter at stylar end was positively and significantly correlated with fruit diameter at center and pedicel at both genotypic and phenotypic levels.

4.2.2 Correlation coefficient of cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) in F₄ generations

Ten F₄ progenies were studied for association of relationship between yield and yield contributing characters F₄ generations and are presented in Table 8.

4.2.2.1 Length of vine (m)

The length of vine had significant and positive correlation with number of fruits per vine and yield per vine at both genotypic and phenotypic levels. It had significant and positive correlation with number of primary branches and days required for first fruit harvest at genotypic level. While, it had significant and negative correlation with days to sex ratio, average weight and average length of fruit at genotypic level. It had significant and negative correlation with fruit diameter at center and stylar end both genotypic and phenotypic levels. It had significant and negative correlation with fruit diameter at pedicel at phenotypic level.

Table 8. Genotypic and Phenotypic Correlation co-efficient for yield and yield contributing characters in F₄ generation of cross Pusa Samridhi x DBG-5 (C1- 3 x 9)

Sr. No.	Character		1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Length of vine (m)	G	1.000	0.683**	0.397	-0.499*	-0.378	0.651**	0.891**	0.858**	-0.472*	-0.655*	-0.878**	-0.374	-0.849**
		P	1.000	0.376	-0.328	-0.314	-0.104	0.155	0.625**	0.670**	-0.311	-0.31	-0.503*	-0.447*	-0.648**
2.	Number of primary branches per vine	G	-	1.000	-0.115	-0.512*	-0.3	0.671**	0.691**	0.805**	-0.152	-0.36	-0.580**	-0.138	-0.188
		P		1.000	0.246	-0.597**	-0.143	0.346	0.576**	0.467*	-0.285	-0.29	-0.484*	-0.487*	-0.36
3.	Days required for appearance of first female flower	G	-	-	1.000	0.141	0.211	0.545**	0.145	0.025	-0.086	-0.215	-0.224	-0.168	-0.558**
		P			1.000	0.03	0.293	0.495*	-0.291	-0.345	0.322	0.426*	0.27	0.266	0.498*
4.	Sex ratio (M:F)	G	-	-	-	1.000	0.878**	-0.553**	-0.817**	-0.706**	0.746**	0.886**	0.982**	0.935**	0.498*
		P				1.000	0.542**	-0.486*	-0.658**	-0.554**	0.693**	0.649**	0.769**	0.783**	0.527**
5.	Node at which first female flower appeared	G	-	-	-	-	1.000	-0.254	-0.47	-0.441	0.237	0.401*	0.670**	0.576**	0.154
		P					1.000	-0.194	-3080	-0.14	0.635**	0.602**	0.623**	0.579**	0.540**
6.	Days required for first harvest of fruit	G	-	-	-	-	-	1.000	0.453*	0.379	-0.309	-0.547**	-0.594**	-0.492*	-0.105
		P						1.000	0.32	0.197	-0.218	-0.075	-0.285	-0.217	-0.065
7.	Average weight of fruit (g)	G	-	-	-	-	-	-	1.000	0.964**	-0.630**	-0.865**	-0.910**	-0.935**	-0.854**
		P							1.000	0.907**	-0.673**	-0.584**	-0.808**	-0.738**	-0.751**
8.	Yield per vine (kg)	G	-	-	-	-	-	-	-	1.000	0.416*	0.694**	0.910**	0.686**	0.734**
		P								1.000	0.399	0.335	0.586**	0.557**	0.567**
9.	Average length of fruit (cm)	G	-	-	-	-	-	-	-	-	1.000	0.924**	0.790**	0.944**	0.678**
		P									1.000	0.940**	0.936**	0.854**	0.835**
10.	Fruit diameter at pedicel (cm)	G	-	-	-	-	-	-	-	-	-	1.000	0.968**	0.933**	0.746**
		P										1.000	0.874**	0.828**	0.786**
11.	Fruit diameter at center (cm)	G	-	-	-	-	-	-	-	-	-	-	1.000	0.905**	0.920**
		P											1.000	0.728**	0.901**
12.	Fruit diameter at stylar end (cm)	G	-	-	-	-	-	-	-	-	-	-	-	1.000	1.110**
		P												1.000	0.820**
13.	Number of fruits per vine	G	-	-	-	-	-	-	-	-	-	-	-	-	1.000
		P													1.000

S : Symbol

G : Genotypic

P : Phenotypic

***, ** : Significance at 5 % and 1 %, respectively**

4.2.2.2 Number of primary branches per vine

The number of primary branches per vine exhibited significant and positive correlation with number of fruits per vine and yield per vine at both genotypic and phenotypic levels and days required for first fruit harvest at genotypic level. Whereas significantly and negatively correlated with sex ratio and average fruit diameter at center at both genotypic and phenotypic level.

4.2.2.3 Days required for appearance of first female flower

The days required for first female flower appearance were significantly and positively correlated with days required for first fruit harvest at both genotypic and phenotypic levels and with average length of fruit, fruit diameter at stylar end at phenotypic level. It was significantly and negatively correlated with and fruit diameter at stylar end at genotypic level.

4.2.2.4 Number of male and female flowers per vine (sex ratio)

Number of male and female flower (sex ratio) exhibited significant and positive correlation with node at which first female flower appeared, average weight of fruit, average length of fruit, fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels. It showed negatively and significantly correlated with days to first fruit harvest, number of fruits per plant and yield per plant at both genotypic and phenotypic levels.

4.2.2.5 Node at which first female flower appeared

Node at which first female flower appeared exhibited significant and positive correlation with average length of fruit and fruit diameter at center, pedicel at both genotypic and phenotypic levels. It showed significant and positive correlation with average fruit weight and fruit diameter at stylar end at phenotypic levels. It

was negatively and significantly correlated with sex ratio at both genotypic and phenotypic levels.

4.2.2.6.1 Days required for first fruit harvest

Days required for first fruit harvest was significantly and positively correlated with number of fruits per vine at genotypic level. It was significantly and negatively correlated with average length of fruit, fruit diameter at center and pedicel at genotypic level.

4.2.2.7 Number of fruits per vine

Number of fruits per vine showed significant and positive correlation with yield per plant at both genotypic and phenotypic levels. Significant and negative correlation was observed at genotypic and phenotypic levels with average weight of fruit, average length of fruit, fruit diameter at center, pedicel and stylar end.

4.2.2.8 Average weight of fruit (g)

The average weight of fruit had significant and positive correlation with yield per vine at genotypic level and with average length of fruit, fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels.

4.2.2.9 Average length of fruit (cm)

The average length of fruit was positively and significantly correlated with yield per vine, fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels.

4.2.2.10 Fruit diameter at center (cm)

The Fruit diameter at center was positively and significantly correlated with yield per vine, fruit diameter at pedicel and stylar end at both genotypic and phenotypic levels.

4.2.2.11 Fruit diameter at pedicel (cm)

The Fruit diameter at pedicel was positively and significantly correlated with yield per vine, fruit diameter at stylar end at both genotypic and phenotypic levels.

4.2.2.12 Fruit diameter at stylar end (cm)

Fruit diameter at stylar end was positively and significantly correlated with yield per vine, fruit diameter at center and pedicel at both genotypic and phenotypic levels.

4.2.3 Correlation coefficient of cross DBG-5 x Bhagirathi (C₂ : 9 x 10) in F₃ generations

Ten F₃ and F₄ progenies were studied for association of relationship between yield and yield contributing characters in F₃ and F₄ generations, respectively and are presented in Table 9.

4.2.3.1 Length of vine (m)

The length of vine had significant and positive correlation with number of fruits per vine and yield per vine at both genotypic and phenotypic levels. It had significant and positive correlation with number of primary branches at genotypic level. It had significant and negative correlation with sex ratio, average length of fruit and fruit diameter at center and stylar at both genotypic and phenotypic levels.

4.2.3.2 Number of primary branches per vine

The number of primary branches per vine exhibited significant and positive correlation with length of vine, number of fruits per vine and yield per vine at both genotypic and phenotypic level. Whereas significantly and negatively correlated with sex ratio, node at which first female flower appeared, days required for first fruit harvest, average fruit length at genotypic level.

Table 9. Genotypic and Phenotypic Correlation co-efficient for yield and yield contributing characters in F₃ generation of cross DBG-5 x Bhagirathi (C2- 9 x 10)

Sr. No.	Character		1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Length of vine (m)	G	1.000	0.515**	-0.002	-0.786**	-0.392	0.147	0.930**	0.926**	0.326	0.663**	-0.570**	-0.285	-0.583**
		P	1.000	0.154	-0.106	-0.377	-0.192	-0.087	0.628**	0.594**	-0.309	-0.430*	-0.431*	-0.235	-0.481*
2.	Number of primary branches per vine	G	-	1.000	-0.053	-0.454*	-0.460*	-0.433*	0.979**	0.859**	-0.213	-0.537**	-0.355	0.236	-0.185
		P		1.000	0.097	-0.333	-0.385	-0.043	0.448*	0.461*	-0.032	-0.214	-0.122	0.049	-0.057
3.	Days required for appearance of first female flower	G	-	-	1.000	0.454*	0.520**	0.797**	0.111	0.249	0.689**	0.326	0.715**	0.285	0.901**
		P			1.000	0.221	0.319	0.264	0.137	0.274	0.564**	0.401	0.471*	0.289	0.439*
4.	Sex ratio (M:F)	G	-	-	-	1.000	0.798**	-0.044	-0.841**	-0.698**	0.975**	0.989**	0.828	0.909**	0.899**
		P				1.000	0.462*	-0.122	-0.677**	-0.594**	0.790**	0.814**	0.691**	0.662**	0.625**
5.	Node at which first female flower appeared	G	-	-	-	-	1.000	-0.191	-0.608**	-0.523**	0.733**	0.807**	0.819**	0.473*	0.581**
		P					1.000	-0.119	-0.143	-0.074	0.542**	0.513*	0.529**	0.381	0.411*
6.	Days required for first harvest of fruit	G	-	-	-	-	-	1.000	0.159	0.113	0.100	-0.169	-0.059	-0.345	0.084
		P						1.000	0.066	0.079	0.113	-0.073	0.156	-0.142	0.256
7.	Average weight of fruit (g)	G	-	-	-	-	-	-	1.000	0.990**	-0.500**	-0.820**	-0.644**	-0.459*	-0.448
		P							1.000	0.963**	-0.398	-0.650**	-0.452*	-0.319	-0.339
8.	Yield per vine (kg)	G	-	-	-	-	-	-	-	1.000	0.366	0.717**	0.547**	0.358	0.337
		P								1.000	0.223	0.472*	0.253	0.137	0.171
9.	Average length of fruit (cm)	G	-	-	-	-	-	-	-	-	1.000	0.905**	0.925**	0.884**	0.911**
		P									1.000	0.906**	0.820**	0.832**	0.836**
10.	Fruit diameter at pedicel (cm)	G	-	-	-	-	-	-	-	-	-	1.000	0.952**	0.817**	0.782**
		P										1.000	0.890**	0.798**	0.718**
11.	Fruit diameter at center (cm)	G	-	-	-	-	-	-	-	-	-	-	1.000	0.869**	0.970**
		P											1.000	0.853**	0.903**
12.	Fruit diameter at stylar end (cm)	G	-	-	-	-	-	-	-	-	-	-	-	1.000	0.801**
		P												1.000	0.776**
13.	Number of fruits per vine	G	-	-	-	-	-	-	-	-	-	-	-	-	1.000
		P													1.000

S : Symbol

G : Genotypic

P : Phenotypic

***, ** : Significance at 5 % and 1 %, respectively**

4.2.3.3 Days required for appearance of first female flower

The days required for first female flower appearance were significantly and positively correlated with average fruit weight, fruit diameter at center and stylar end at both genotypic and phenotypic levels. It was significantly and positively correlated with sex ratio, node at which first female flower appeared, days required for first fruit harvest at genotypic level.

4.2.3.4 Number of male and female flowers per vine (sex ratio)

Number of male and female flower (sex ratio) exhibited significant and positive correlation with node at which first female flower appeared, average weight of fruit, average length of fruit, fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels. It showed negatively and significantly correlated with number of fruits per plant and yield per plant.

4.2.3.5 Node at which first female flower appeared

Node at which first female flower appeared showed significant and positive correlation with average weight of fruit, average length of fruit and fruit diameter at center at both genotypic and phenotypic levels. It showed significant and positive correlation with fruit diameter at pedicel and stylar end at genotypic levels. It was negatively and significantly correlated with number of fruits per plant and yield per plant at genotypic level.

4.2.3.6 Days required for first fruit harvest

Days required for first fruit harvest was significantly and positively correlated with length of vine and number of primary branches at both genotypic and phenotypic levels.

4.2.3.7 Number of fruits per vine

Number of fruits per vine showed significant and positive correlation with yield per plant at both genotypic and phenotypic levels. Significant and negative correlation was observed at genotypic and phenotypic levels with average weight of fruit, average length of fruit, fruit diameter at center, pedicel and stylar end.

4.2.3.8 Average weight of fruit (g)

The average weight of fruit had significant and positive correlation with average length of fruit, fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels.

4.2.3.9 Average length of fruit (cm)

The average length of fruit was positively and significantly correlated with yield per vine, fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels.

4.2.3.10 Fruit diameter at center (cm)

Fruit diameter at center was positively and significantly correlated with yield per vine, fruit diameter at pedicel and stylar end at both genotypic and phenotypic levels.

4.2.3.11 Fruit diameter at pedicel (cm)

Fruit diameter at pedicel was positively and significantly correlated with yield per vine, fruit diameter at stylar end at both genotypic and phenotypic levels.

4.2.3.12 Fruit diameter at stylar end (cm)

Fruit diameter at stylar end was positively and significantly correlated with yield per vine, fruit diameter at center and pedicel at both genotypic and phenotypic levels.

4.2.4 Correlation coefficient of cross DBG-5 x Bhagirathi (C₂ : 9 x 10) in F₄ generations

Ten F₄ progenies were studied for association of relationship between yield and yield contributing characters in F₄ generations and are presented in Table 10.

4.2.4.1 Length of vine (m)

The length of vine had significant and positive correlation with number of fruits per vine and yield per vine at both genotypic and phenotypic levels. It had significant and positive correlation with number of primary branches and days required for first fruit harvest at genotypic level. While, it had significant and negative correlation with days to sex ratio, average weight and average length of fruit at genotypic level. It had significant and negative correlation with fruit diameter at center and stylar end both genotypic and phenotypic levels. It had significant and negative correlation with fruit diameter at pedicel at phenotypic level.

4.2.4.2 Number of primary branches per vine

The number of primary branches per vine exhibited significant and positive correlation with number of fruits per vine and yield per vine at both genotypic and phenotypic levels and days required for first fruit harvest at genotypic level. Whereas significantly and negatively correlated with sex ratio and average fruit diameter at center at both genotypic and phenotypic level, and with average fruit weight, average length of fruit, fruit diameter at stylar end at genotypic level.

Table 10. Genotypic and Phenotypic Correlation co-efficient for yield and yield contributing characters in F₄ generation of cross DBG-5 x Bhagirathi (C2- 9 x 10)

Sr. No.	Character		1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Length of vine (m)	G	1.000	0.374	-0.388	-0.465*	-0.909**	0.664**	0.853**	0.963**	-0.797**	-0.619**	-0.837**	-0.804**	-9.935**
		P	1.000	0.376	-0.328	-0.314	-0.104	0.155	0.625**	0.670**	-0.311	-0.31	-0.505*	-0.447*	-0.648**
2.	Number of primary branches per vine	G	-	1.000	0.372	-0.773	-0.076	0.842**	0.940**	0.972**	-0.702**	-0.473*	-0.733**	-0.670**	-0.606**
		P		1.000	0.246	-0.597**	-0.143	0.346	0.576**	0.467*	-0.285	-0.29	-0.483*	-0.486*	-0.36
3.	Days required for appearance of first female flower	G	-	-	1.000	0.024	0.494*	0.617**	-0.226	-0.363	0.331	0.508**	0.275	0.375	0.539**
		P			1.000	0.03	0.293	0.493*	-0.291	-0.345	0.322	0.426*	0.269	0.266	0.498*
4.	Sex ratio (M:F)	G	-	-	-	1.000	0.768**	-0.530**	-0.854**	-0.794**	0.970**	0.786**	0.968**	0.987**	0.826**
		P				1.000	0.541**	-0.486*	-0.659**	-0.554**	0.693**	0.649**	0.769**	0.783**	0.526**
5.	Node at which first female flower appeared	G	-	-	-	-	1.000	-0.401*	-0.793**	-0.844**	0.936**	0.928**	0.929**	0.945**	0.934**
		P					1.000	-0.194	-0.308	-0.14	0.634**	0.602**	0.622**	0.579**	0.540**
6.	Days required for first harvest of fruit	G	-	-	-	-	-	1.000	0.571**	0.462*	-0.435*	-0.138	-0.533**	-0.385	-0.413*
		P						1.000	0.32	0.197	-0.218	-0.075	-0.284	-0.216	-0.065
7.	Average weight of fruit (g)	G	-	-	-	-	-	-	1.000	0.940**	-0.946**	-0.878**	-0.983**	-0.948**	0.926**
		P							1.000	0.907**	-0.673**	-0.584**	-0.808**	-0.738**	-0.751**
8.	Yield per vine (kg)	G	-	-	-	-	-	-	-	1.000	0.902**	0.962**	0.998**	0.972**	0.259
		P								1.000	0.398	0.334	0.586**	0.557**	0.567**
9.	Average length of fruit (cm)	G	-	-	-	-	-	-	-	-	1.000	0.997**	0.912**	0.960**	0.910**
		P									1.000	0.940**	0.935**	0.853**	0.835**
10.	Fruit diameter at pedicel (cm)	G	-	-	-	-	-	-	-	-	-	1.000	0.961**	0.942**	0.900**
		P										1.000	0.873**	0.828**	0.786**
11.	Fruit diameter at center (cm)	G	-	-	-	-	-	-	-	-	-	-	1.000	0.902**	0.949**
		P											1.000	0.928**	0.901**
12.	Fruit diameter at stylar end (cm)	G	-	-	-	-	-	-	-	-	-	-	-	1.000	0.981**
		P												1.000	0.820**
13.	Number of fruits per vine	G	-	-	-	-	-	-	-	-	-	-	-	-	1.000
		P													1.000

S : Symbol

G : Genotypic

P : Phenotypic

***, ** : Significance at 5 % and 1 %, respectively**

4.2.4.3 Days required for appearance of first female flower

The days required for first female flower appearance were significantly and positively correlated with days to days required for first fruit harvest, average length of vine, fruit diameter at stylar end at both genotypic and phenotypic levels and with node at which first female flower appeared at genotypic level.

4.2.4.4 Number of male and female flowers per vine (sex ratio)

Number of male and female flower (sex ratio) exhibited significant and positive correlation with node at which first female flower appeared, average weight of fruit, average length of fruit, fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels. It showed negatively and significantly correlated with days to first fruit harvest, number of fruits per plant and yield per plant at both genotypic and phenotypic levels.

4.2.4.5 Node at which first female flower appeared

Node at which first female flower appeared exhibited significant and positive correlation with average weight of fruit, average length of fruit and fruit diameter at center, pedicel, stylar end at both genotypic and phenotypic levels. It showed significant and negative correlation with days required for first harvest of fruit, number of fruits per plant and yield per plant at genotypic level.

4.2.4.6 Days required for first harvest of fruit

Days required for first fruit harvest was significantly and positively correlated with number of fruits per vine and yield per vine at genotypic level. It was significantly and negatively correlated with average weight of fruit, fruit diameter at center and stylar end at genotypic level.

4.2.4.7 Number of fruits per vine

Number of fruits per vine showed significant and positive correlation with yield per plant at both genotypic and phenotypic levels. Significant and negative correlation was observed at genotypic and phenotypic levels with average weight of fruit, average length of fruit, fruit diameter at center, pedicel and stylar end.

4.2.4.8 Average weight of fruit (g)

The average weight of fruit had significant and positive correlation with yield per vine at genotypic level and with average length of fruit, fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels.

4.2.4.9 Average length of fruit (g)

The average length of fruit was positively and significantly correlated with yield per vine, fruit diameter at center, pedicel and stylar end at both genotypic and phenotypic levels.

4.2.4.10 Fruit diameter at center (cm)

Fruit diameter at center was positively and significantly correlated with yield per vine, fruit diameter at pedicel and stylar end at both genotypic and phenotypic levels.

4.2.4.11 Fruit diameter at pedicel (cm)

Fruit diameter at pedicel was positively and significantly correlated with yield per vine, fruit diameter at stylar end at both genotypic and phenotypic levels.

4.2.4.12 Fruit diameter at stylar end (cm)

The Fruit diameter at stylar end was positively and significantly correlated with yield per vine, fruit diameter at center and pedicel at both genotypic and phenotypic levels.

4.3 Fruit characters (Qualitative)

F₃ and F₄ progenies of crosses Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) along with their parents were studied for the different fruit characters (qualitative) such as shape of fruit, colour of fruit and presence of pubescence were presented in Table 11, 12.

4.3.1 Fruit shape (cylindrical, bottle-neck)

As per features of genotypes presented in Table 11 the parents Pusa samridhi (3), DBG-5 (9) and Bhagirathi (10) had Cylindrical fruit shape.

In case of F₃ and F₄ generations, in the segregating progenies of two crosses *viz.*, Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) the medium and cylindrical fruit shape was observed (Table 11, 12).

Table 11. Fruit character (Qualitative/morphological in F₃ generation of bottle gourd

Parent/crosses	Shape of fruit (Cylindrical, bottle-neck)	Colour of fruit (Light green, green)	Presence of pubescence (Present, Absent)
C ₁ : Pusa Samridhi x DBG-5	Medium, cylindrical	Light green	Present
C ₂ : DBG-5 x Bhagirathi	Medium, cylindrical	Light green	Present

Table 12. Fruit character (Qualitative/morphological in F₄ generation of bottle gourd

Parent/crosses	Shape of fruit (Cylindrical, bottle-neck)	Colour of fruit (Light green, green)	Presence of pubescence (Present, Absent)
C ₁ : Pusa Samridhi x DBG-5	Medium, cylindrical	Light green	Present
C ₂ : DBG-5 x Bhagirathi	Medium, cylindrical	Light green	Present

4.3.2 Fruit colour

From the Table 11, It was observed that the parents Pusa Samridhi, DBG-5 and Bhagirathi had light green fruit colour.

From table 12 In F_3 and F_4 segregating progenies, among the two crosses *viz.*, Pusa Samridhi x DBG-5 (C_1 : 3 x 9) and DBG-5 x Bhagirathi (C_2 : 9 x 10), both showed light green fruit colour.

4.3.3 Presence of pubescence

As per features of genotypes presented in Table 11, the parents Pusa Samridhi, DBG-5, Bhagirathi had pubescence on fruit surface.

In F_3 and F_4 generations, most of the progenies of both the crosses *viz.*, Pusa Samridhi x DBG-5 (C_1 3 x 9) and DBG-5 x Bhagirathi (C_2 : 9 x 10) showed presence of Pubescence on fruit surface (Table 12).

4.4 Per cent incidence of diseases and pests

The incidence of diseases and pests *viz.*, powdery mildew, downey mildew, fusarium wilt, gummosis and fruit fly, leaf minor of F_3 and F_4 segregating progenies are presented in Table 13 and Table 14.

4.4.1 Per cent incidence of diseases

4.4.1.1 Per cent incidence of powdery mildew

Out of three parents, the incidence of powdery mildew was found in almost all the parents. The highest incidence of powdery mildew was recorded in Bhagirathi whereas the least incidence of powdery mildew was recorded in Pusa sammridhi in both F_4 and F_3 generation respectively

In case of segregating progenies, the highest incidence of powdery mildew was recorded in most of the progenies of the

cross C₂ (DBG-5 x Bhagirati) and least incidence of powdery mildew was recorded in C₁ (Pusa Samridhi x DBG-5) in both F₃ and F₄ generation respectively (Table 13).

4.4.1.2 Per cent incidence downey mildew

Out of three parents, the incidence of downey mildew was found in almost all the parents. The highest incidence of downey mildew was recorded in Bhagirati whereas the least incidence of downey mildew was recorded in Pusa Samridhi in both F₄ and F₃ generation respectively.

Table 13. Per cent incidence of powdery mildew and downey mildew diseases in F₃ and F₄ generations of Bottle gourd

Parents/Crosses	Powdery mildew (%)		Downey mildew (%)	
	F ₃ generation	F ₄ generation	F ₃ generation	F ₄ generation
Parents				
P ₁ : Pusa Samridhi	11.55 (19.86)*	23.50 (28.99)	11.00 (19.29)	19.00 (25.81)
P ₂ : DBG-5	14.40 (22.27)	26.50 (30.97)	16.20 (23.65)	24.20 (29.43)
P ₃ : Bhagirathi	18.70 (25.58)	31.00 (33.81)	19.05 (25.87)	27.05 (31.33)
Crosses				
C ₁ : P ₁ x P ₂	13.59 (21.39)	25.23 (30.06)	15.16 (22.49)	22.85 (28.35)
C ₂ : P ₂ x P ₃	18.49 (25.20)	29.45 (32.79)	17.44 (24.51)	25.12 (29.98)

*Value in parenthesis are arc sin values

From Table 13 it was observed that in case of segregating progenies, the highest incidence of downey mildew was recorded in most of the progenies of the cross C₂ (DBG-5 x Bhagirati) and least incidence of powdery mildew was recorded in C₁ (Pusa Samridhi x DBG-5) in both F₃ and F₄ generation.

4.4.1.3 Percent incidence of fusarium wilt

Out of three parents, the incidence of Fusarium wilt was found in almost all the parents. The highest incidence of fusarium wilt was recorded in DBG-5, whereas the least incidence of fusarium wilt was recorded in Pusa Samridhi in both F₃ and F₄ generation respectively

From Table 14 it was observed that in case of segregating progenies, the highest incidence of Fusarium wilt was recorded in most of the progenies of the cross C₁ (Pusa Samridhi x DBG-5) and least incidence of Fusarium wilt was recorded in C₂ (DBG-5 x Bhagirathi) in F₃ generation.

Table 14. Percent diseases incidence of fusarium wilt and gummosis F₃ and F₄ generations of Bottle gourd

Parents/Crosses	Fusarium wilt (%)		Gummosis (%)	
	F ₃ generation	F ₄ generation	F ₃ generation	F ₄ generation
Parents				
P ₁ : Pusa Samridhi	6.20 (14.35)*	11.35 (19.64)	16.30 (23.80)	Not observed
P ₂ : DBG-5	12.90 (21.02)	19.10 (25.89)	10.50 (18.90)	Not observed
P ₃ : Bhagirathi	7.35 (15.71)	12.25 (20.46)	6.50 (14.67)	Not observed
Crosses				
C ₁ : P ₁ x P ₂	8.97 (17.26)	15.05 (22.74)	12.15 (20.27)	Not observed
C ₂ : P ₂ x P ₃	8.77 (16.94)	14.42 (22.20)	7.60 (15.79)	Not observed

*Value in parenthesis are arc sin values

4.4.1.4 Per cent incidence of Gummosis

Out of three parents, the incidence of gummosis wilt was found in almost all the parents. The highest incidence of gummosis was recorded in Pusa samridhi, whereas the least

incidence of gummosis was recorded in Bhagirathi in F₃ generation. No gummosis was recorded in F₄ generation.

From Table 14 it was observed that in case of segregating progenies, the highest incidence of gummosis was recorded in most of the progenies of the cross C₁ (Pusa Samridhi x DBG-5) and least incidence of gummosis was recorded in C₂ (DBG-5 x Bhagirathi) in both F₃ generation. No gummosis was recorded in F₄ generation.

4.4.2 Per cent incidence of pest

4.4.2.1 Per cent incidence of fruit fly

Per cent incidence of fruit fly was observed that out of three parents, the infestation of fruit fly at field condition was found in almost all the parents. The highest infestation was found in Pusa Samridhi while least infestation was observed in Bhagirathi followed by DBG-5 in both F₃ generation and DBG-5 followed by Bhagirathi in F₄ generation, respectively, (Table 15).

Table 15. Per cent incidence of fruit fly in F₃ and F₄ generations of Bottle gourd

Parents/Crosses	Fruit fly (%)	
	F₃ generation	F₄ generation
Parents		
P ₁ : Pusa Samridhi	13.20 (21.28)*	18.10 (25.15)
P ₂ : DBG-5	9.55 (17.97)	14.35 (22.24)
P ₃ : Bhagirathi	9.23 (17.66)	16.15 (23.69)
Crosses		
C ₁ : P ₁ x P ₂	10.77 (18.96)	15.59 (23.16)
C ₂ : P ₂ x P ₃	8.21 (15.28)	12.50 (20.64)

*Value in parenthesis are arc sin values

Among two crosses, the cross C_2 (DBG-5 $\times$ Bhagirati) recorded least infestation of fruit fly while the cross C_1 (Pusa Samridhi $\times$ DBG-5) recorded highest infestation of fruit fly in both F_3 and F_4 generations, respectively, (Table 15).

4.4.2.2 Per cent incidence of Leaf miner

Per cent incidence of Leaf minor was observed that out of three parents, the infestation of fruit fly at field condition was found in almost all the parents. The highest infestation was found in Pusa Samridhi, while least infestation was observed in Bhagirati followed by DBG-5 in both F_3 and F_4 generations, respectively, (Table 16).

Table 16. Per cent incidence of Leaf miner in F_3 and F_4 generations of Bottle gourd

Parents/Crosses	Leaf miner (%)	
	F_3 generation	F_4 generation
Parents		
P_1 : Pusa Samridhi	17.05 (24.38)*	20.50 (26.92)
P_2 : DBG-5	16.24 (23.75)	19.15 (25.95)
P_3 : Bhagirathi	15.35 (23.05)	18.30 (25.32)
Crosses		
C_1 : $P_1 \times P_2$	16.43 (23.89)	19.89 (26.60)
C_2 : $P_2 \times P_3$	14.78 (22.53)	17.75 (24.90)

*Value in parenthesis are arc sin values

Among the crosses, the cross C_2 (DBG-5 $\times$ Bhagirati) recorded least infestation of leaf minor while the cross C_1 (Pusa Samridhi $\times$ DBG-5) recorded highest infestation of fruit fly in both F_3 and F_4 generations respectively, (Table 16).

5. DISCUSSION

The Bottle gourd [*Lagenaria siceraria* (Molina) StandL.] is considered to be native home of tropical Africa and Asia. It is widely distributed in China, Malaysia, India and tropical Africa. It is also being grown as commercial crop near the urban areas. Although bottle gourd is a modest source of nutrients, it is very popular among a large section of people. It is easily digestible and is used extensively as vegetable. The yield is complex phenomena which depend on a number of characters. Hence, direct selection for yield will be misleading and inappropriate without any knowledge of variability, heritability and genetic advance. The knowledge of association of quantitative characters with yield and among themselves will be of great significance (Ramchandran *et al.*, 2002). Bottle gourd is a monoecious and cross pollinated crop in which large amount of variation has been observed for many economically important traits. Pollination mechanism can be exploited for development hybrid for its commercial cultivation. There is also a great scope for development of open pollinated varieties by utilizing the existing variability. Success of any breeding programme is largely dependent on the extent of genetic variability and heritability of particular character present in the population. Greater the variability in the material better are the chances for evolving promising and desired types. Maximum utilization of any ideal genotypes for increasing the genetic yield potential, disease resistance is very essential. Studies on genetic parameters of various traits provide information for selection and help in crop improvement. Variability in Bottle gourd is expected to

be immense as the fruits vary greatly in shape and size. Studies on genetic parameters of various traits provide information for selection and helps in crop improvement.

By keeping all above points in mind, present investigation was undertaken where the segregating progenies of two crosses along with their parents were evaluated for their growth, flowering, yield and qualitative characters in F₃ and F₄ generation during Summer 2014 and *kharif* 2014.

The results in respect of variability heritability, genetic advance and correlation in F₃ and F₄ progenies, in preceding chapter were discussed here under with suitable headings.

5.1 Variability, heritability and genetic advance

5.2 Correlation coefficient

5.3 Per cent incidence of diseases and pests

5.4 Fruit characters (qualitative)

5.1 Variability, heritability and genetic advance

Range of variability, genetic parameters like genotypic coefficient of variation and phenotypic coefficient of variation, environmental coefficient of variation, heritability and genetic advance with their results were discussed subsequently.

5.1.1 Range of variability

The assessment of genotypes for its nature and magnitude of genetic variability is an important prerequisite for developing any variety with high yield potential and the desired morphological characters. This helps the breeder to assess and identify superior genotypes. In the present study, among the ten progenies of all two crosses viz., Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) for F₃ and F₄ generations

respectively showed wide range of variability for most of the characters.

The wide range of variability was observed in cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) in F₃ generation for most of the characters of Bottle gourd (Table 3). The vine length at last harvest was ranged from 7.91 to 10.28 m, number of primary branches per vine from 5.33 to 10.66, days required for appearance of first female flower from 53.00 to 56.00, sex ratio from 14.63 to 15.30, node at which first female flower appeared from 8.00 to 10.33, days required for first harvest of fruit from 60.45 to 71.25, number of fruits per vine from 16 to 27, yield per vine from 12.06 to 19.24 kg, average weight of fruit from 634.66 to 772.33 g, average length of fruit from 26.53 to 30.80 cm, fruit diameter at pedicel from 4.90 to 5.43 cm, Fruit diameter at center from 4.96 to 6.06 cm and fruit diameter at stylar end from 5.06 to 6.28 cm.

In F₃ generation wide range of variability was also observed for most of the characters in cross DBG-5 x Bhagirathi (C₂: 9 x 10) (Table 5). The vine length at last harvest was ranged from 7.91 to 10.13 m, number of primary branches per vine from 7.00 to 10.00, days required for appearance of first female flower from 53.00 to 55.66, sex ratio from 13.63 to 16.23, node at which first female flower appeared from 8.00 to 10.34, days required for first harvest of fruit from 59.24 to 68.69, number of fruits per vine from 15 to 26, yield per vine from 12.08 to 20.22 kg, average weight of fruit from 662.33 to 781.66 g, average length of fruit from 28.83 to 31.73 cm, fruit diameter at pedicel from 4.56 to 5.56 cm, fruit diameter at center from 5.03 to 6.33 cm and fruit diameter at stylar end from 4.97 to 6.53 cm.

In F₄ generation of cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) also observed wide range of variability (Table 4). The vine length at last harvest was ranged from 7.45 to 10.48 m, number of primary branches per vine from 7.33 to 9.00, days required for appearance of first female flower from 52.33 to 57.33, sex ratio from 14.23 to 15.46, node at which first female flower appeared from 8.66 to 10.33, days required for first harvest of fruit from 60.69 to 71.33, number of fruits per vine from 16 to 25, yield per vine from 12.38 to 18.12 kg, average weight of fruit from 634.66 to 809.66 g, average length of fruit from 26.03 to 31.05 cm, fruit diameter at pedicel from 4.70 to 5.63 cm, Fruit diameter at center from 4.73 to 6.21 cm and fruit diameter at stylar end from 4.83 to 6.58 cm.

In the cross DBG-5 x Bhagirathi (C₂: 9 x 10) wide range of variability was recorded in F₄ generation for most of the characters (Table 6). The vine length at last harvest was ranged from 7.31 to 10.05 m, number of primary branches per vine from 7.33 to 9.00, days required for appearance of first female flower from 52.00 to 57.00, sex ratio from 13.58 to 15.10, node at which first female flower appeared from 8.33 to 10.66, days required for first harvest of fruit from 57.24 to 67.45, number of fruits per vine from 17.00 to 27.33, yield per vine from 12.32 to 17.92 kg, average weight of fruit from 651.33 to 760.00 g, average length of fruit from 29.26 to 34.20 cm, fruit diameter at pedicel from 4.20 to 5.20 cm, fruit diameter at center from 4.36 to 5.86 cm and fruit diameter at stylar end from 4.46 to 6.03 cm.

In present investigation higher mean estimates was observed for length of vine, no. of fruits per vine, fruit yield per vine, average fruit weight, average fruit length. Pandit *et al.* (2009) also

observed higher mean estimates for no. of fruits per vine, fruit yield per vine, average fruit weight and average fruit length in bottle gourd.

Pandit *et al.* (2009) evaluated fifteen genotypes of bottle gourd (*Lagenaria siceraria*) during autumn-winter season of 2003-2004 to study genetic variability, heritability and potential for screening suitable genotypes for future crop improvement. There was considerable variability in all traits except fruits per plant. Arvindkumar *et al.* (2011) studied the magnitude of genetic variability in bottle gourd. Analysis of variance revealed the adequate variability among all genotypes for all characters. Yadav *et al.* (2008) studied 18 bottle gourd (*L. siceraria*) strains/cultivars based on nine characters namely days to first male flowering, days to first female flowering, number of nodes of first male flowering, number of nodes of first female flowering. Days to edible fruit, fruit length, fruit width, number of fruits per plant and yield per plant. All the characters showed considerable amount of variability. Narayan *et al.* (1996) studied the genetic variability, heritability, genetic advance, correlation and path coefficient analysis in 25 diverse population of bottle gourd. Wide zone of variation was observed in most of the characters.

Rajput (2012) observed higher mean estimates for fruit yield per vine, average fruit weight and average fruit length in bitter gourd. Tarsem and Sanjay (1997) obtained higher mean estimates for fruit yield per vine, average fruit weight and average weight of pulp per fruit in muskmelon. Torkadi and Musmade (2007), Mehta *et al.* (2010) obtained similar findings in muskmelon. Finker *et al.* (1973) revealed that high mean values were relatively effective in identifying the superior segregants. In most of the characters viz.,

growth, yield contributing and qualitative traits wide range of variations were observed in all two crosses of F₃ and F₄ generations. Singh *et al.* (1977) reported wide range of variability for the traits viz., number of fruits per plant, fruit length and days to flowering in bitter gourd. Pathak (2014) observed wide range of variability for the traits viz., number of fruits per plant, fruit weight, fruit length and days to first male and female flower in bitter gourd. Rajput (2012) observed wide range of variability for the traits viz., average yield per vine, final vine length at last harvest and average fruit weight in bitter gourd. Mehta *et al.* (2010) found significant variation for the traits viz., average yield per vine, final vine length at last harvest and average fruit weight in muskmelon. Similar results reported by Rakhi and Rajamony (2005), Torkadi and Musmade (2007), Ibrahim (2012) and Reddy *et al.* (2013) in muskmelon. Karuppaiah *et al.* (2002), Choudhary and Kumar (2011), Rabbani *et al.* (2012) in ridge gourd. Prasad and Singh (1990), Kumar *et al.* (2013) in sponge gourd.

Thus the wide range of variation for growth, yield and fruit characteristics of bottle gourd in F₃ and F₄ generations indicated a good scope for selection of desirable genotypes in view of the objectives under investigation.

5.1.2 Genetic parameters i.e. genotypic and phenotypic co-efficient of variation

There were significant differences among the progenies of F₃ and F₄ generations of two crosses for all traits under study. In general the phenotypic coefficient of variation was slightly higher than the corresponding genotypic coefficient of variation for all the characters in both the crosses of F₃ and F₄ generation. This indicates the presence of minor role of environment in the

expression of characters (Table 3 to 9). Similar results were in agreement with the findings of Patil (2010), Arvindkumar *et al.* (2011), Yadav and Kumar (2012) in bottle gourd. Rajput (2012), Pathak (2014), Raja *et al.* (2007) in bitter gourd. Rakhi and Rajamony (2005), Torkadi and Musmade (2007), Mehta *et al.* (2010), Ibrahim (2012), Reddy *et al.* (2013) and Mali (2015) in muskmelon. Joshi *et al.* (2005), Azcon (2012) in cucumber. Khan *et al.* (2009) in pointed gourd. Chaudhary and Kumar (2011), Rabbani *et al.* (2012) in ridge gourd. Kumar *et al.* (2013) in sponge gourd. Thakur and Nandpuri (1974), Kadam (1997), Gusmini and Wehner (2007) in watermelon.

In F₃ and F₄ progenies of cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) number of primary branches per vine, number of fruits per vine, yield per vine, average weight of fruit, average length of fruit recorded high values of genotypic and phenotypic coefficients of variations. Whereas for fruit diameter at centre only in F₄ generation, fruit diameter at pedicel and stylar end exhibited moderate values of genotypic and phenotypic coefficients of variation. Rest of traits such as days required for first harvest of fruit, node at which first female flower appeared recorded low values of genotypic and phenotypic coefficients of variations in both F₃ and F₄ generation.

In F₃ and F₄ progenies of the cross DBG-5 x Bhagirathi (C₂: 9 x 10) number of fruits per vine, yield per vine, recorded high values of genotypic and phenotypic coefficients of variations. While sex ratio (only F₄), fruit diameter at pedicel and center, average length of fruit exhibited moderate values of genotypic and phenotypic coefficients of variation. The character such as vine length, days required for appeared of first female flower, days

required for first harvest of fruit, average weight of fruit, fruit diameter at stylar end only in F₃ generation recorded low values of genotypic and phenotypic coefficients of variations and in F₄ recorded low values for vine length, days required for appeared of first female flower, days required for first harvest of fruit, average weight of fruit, node at which first female flower appeared.

Characters which showed higher estimates of GCV and PCV could be fully exploited in further selection programme due to presence of large amount of variations within segregating populations i.e. scope for improvement through selection. While characters which showed lower estimates of GCV and PCV would be least exploited in further selection programme due to small amount of variations observed within segregating populations i.e. lack of scope for improvement through selection.

These findings were in conformity with Prasad *et al.* (1993) observed thirty genotypes for their variability, the studies revealed highest genotypic and phenotypic coefficient of variability for fruit yield per plant followed by number of male flowers on primary laterals and fruits per vine, GCV and PCV were high for fruit yield per plant and fruit length. Singh, *et al.* (2002) observed phenotypic coefficient of variation was higher than genotypic coefficient of variation for fruit yield per plant, fruit diameter, fruit length, fruit height, number of nodes to first male flower and vine length which were also characterized by high genetic variation. Munshi *et al.* (2005) evaluated the performance of 12 bottle gourd (*Lagenaria siceraria*) cultivars. High genotypic and phenotypic coefficient of variation were observed for vine length, number of primary branches per vine number of nodes on the main axis, peduncle length, sex ratio number of fruits per plant, fruit length,

girth and weight, crop per yield. Fruit length, number of days to first fruit harvest. Also, Patil (2010), Arvindkumar *et al.* (2011) and Yadav and Kumar (2012) reported similar findings in bottle gourd.

These findings were in conformity with Indresh (1982) recorded high estimates of GCV for fruit weight, yield per vine, fruit cavity, leaf area and fruit length in bitter gourd. Mangal *et al.* (1983) revealed high GCV average fruit yield per vine, number of branches per vine, average fruit weight and average number of fruits per vine. The least GCV was observed for number of days to first flower in bitter gourd. Raja *et al.* (2007) noticed that the highest PCV and GCV were observed for number of female flowers per plant, fruit weight and number of primary branches per plant in bitter gourd. Rajput (2012) recorded High GCV and PCV was observed for number of primary branches per vine, number of female flowers per vine, sex ratio, number of fruits per vine, fruit yield per vine, average yield per vine, average weight of fruit and fruit flesh thickness in F₂ and F₃ generations in bitter gourd. Pathak (2014) revealed high GCV and PCV was observed for number of fruits per plant, fruit weight and fruit length whereas low GCV and PCV was observed for days to first male and female flower in bitter gourd.

The other workers reported similar results *i.e.* Tarsem and Sanjay (1997), Rakhi and Rajamony (2005), Torkadi and Musmade (2007), Mehta *et al.* (2010), Reddy *et al.* (2013), Ibrahim (2012) and Mali (2015) in muskmelon. Patil (2010), Arvindkumar *et al.* (2011) and Yadav and Kumar (2012) in bottle gourd. Joshi *et al.* (2005), Gaikwad (2007), Arunkumar *et al.* (2011) and Azcon (2012) in cucumber. Chandrakumar (2006) in pointed gourd. Arora *et al.* (1983), Abusaleha and Dutta (1990) and Prasad and Singh (1990)

in spone gourd. Raju *et al.* (1998) in summer squash. Thakur and Nandpuri (1974) and Kadam (1997) in water melon.

5.1.3 Heritability and genetic advance

Heritability (broad sense) was found high for most of the traits in both the crosses of F₃ and F₄ generations. In case of F₃ generation in cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) heritability was ranged from 39 to 93 per cent. In cross DBG-5 x Bhagirathi (C₂: 9 x 10) it ranged from 36 to 88 per cent.

In case of F₄ generation in cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) heritability was ranged from 40 to 87 per cent. In cross DBG-5 x Bhagirathi (C₂: 9 x 10) it ranged from 36 to 86 per cent. Above information suggests that, selection based on phenotypic expression could be relied upon as major role of genetic constitution in the expression of these characters. Similar results were reported by Singh *et al.* (2002), Kumar *et al.* (2007), Singh *et al.* (2008), Pandit *et al.* (2009) in bottle gourd. Torkadi and Musmade (2007) and Mehta *et al.* (2010) in muskmelon. Azcon (2012) in cucumber. Mangal *et al.* (1983), Islam *et al.* (2009), Rajput (2012) and Pathak (2014) in bitter gourd.

In case of F₃ and F₄ generation, in cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) the values of genetic advance observed were low to very high and ranged from 1.04 to 193.91 and 0.89 to 200.56, in cross DBG-5 x Bhagirathi (C₂: 9 x 10) ranged from 0.94 to 148.48 and 0.86 to 149.96 in F₃ and F₄ generations, respectively. These findings are in conformity with the findings of Singh *et al.* (2002), Kumar *et al.* (2007), Singh *et al.* (2008), Pandit *et al.* (2009) in bottle gourd. Srivastava and Srivastava (1976), Singh *et al.* (1977), Lawande (1987) and Rajput (2012) in bitter gourd. Torkadi and

Musmade (2007) and Mehta *et al.* (2010) in muskmelon, Kumar *et al.* (2007) in bottle gourd and Azcon (2012) in cucumber.

Genetic advance as per cent of mean coupled with heritability provide great scope of improvement in present set of materials for the trait studied.

In case of F₃ generation in cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) the association of high estimates of heritability with high estimates of genetic advance as per cent of mean were recorded in characters like number of primary branches per vine (72 and 45.82%), average weight of fruit (85 and 26.92%), average length of fruit (92 and 38.96%), fruit diameter at pedicel (75 and 31.18%), fruit diameter at center (60 and 27.53), number of fruits per vine (85 and 64.20), yield per vine (93 and 55.48). Whereas the high estimates of heritability with moderate estimates of genetic advance as per cent of mean was observed for length of vine (59 and 17.94%), node at which first female flower appeared (48 and 17.24), sex ratio (90 and 11.38%), fruit diameter at stylar end (69 and 18.08%). The moderate estimates of heritability with lower estimates of genetic advance as per cent of mean was recorded in days required for appearance of first female flower (39.09 and 3.69%), days required for first fruit harvest (47 and 8.43%).

In F₃ generation, the cross DBG-5 x Bhagirathi (C₂: 9 x 10) the association of high estimates of heritability with high estimates of genetic advance as per cent of mean were recorded in characters like average weight of fruit (79 and 19.87%), average length of fruit (70 and 25.38%), fruit diameter at pedicel (68 and 30.62%), number of fruits per vine (76 and 55.40), yield per vine (88 and 45.90). Whereas the high estimates of heritability with moderate estimates of genetic advance as per cent of mean was

observed for sex ratio (72 and 10.44%), fruit diameter at stylar end (65 and 15.53%). The moderate estimates of heritability with lower estimates of genetic advance as per cent of mean was recorded in days required for appearance of first female flower (47 and 4.45%), days required for first fruit harvest (51 and 7.83%).

In case of F₄ generation, in cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) the association of high estimate of heritability with high estimate of genetic advance as per cent of mean were recorded in characters like yield per vine (65 and 34.37%), number of fruits per vine (74 and 49.86%), average weight of fruit (83 and 27.78%), average length of fruit (87 and 40.48), fruit diameter at pedicel (59 and 28.14), center (72 and 34.05), stylar end (61 and 25.64). Whereas the high estimate of heritability with low estimate of genetic advance as per cent of mean was observed for days required for appearance of first female flower (79 and 8.77), days required for first fruit harvest (60 and 6.46).

In cross, DBG-5 x Bhagirathi (C₂: 9 x 10) reported high estimates of heritability along with high estimates of genetic advance as per cent of mean in the characters like fruit yield per vine (48 and 25.59%), number of fruits per vine (79 and 56.20%), average weight of fruit (61 and 21.21%), average length of fruit (58 and 21.09), fruit diameter at pedicel (84 and 40.77), center (86 and 43.91), stylar end (63 and 24.30). While the characters days required for appearance of first female flower (81 and 8.17%) and sex ratio (82 and 11.93%) showed the high estimate of heritability with low estimate of genetic advance as per cent of mean in the F₄ generation.

The traits which exhibited high estimates of heritability along with high estimates of genetic advance as per cent of mean

might be due to predominance of additive gene effects. Therefore it appears that selection for characters mentioned in above crosses and their respective generation would be effective.

High heritability along with high genetic advance was recorded for male to female flower, vine length, total number of branches and fruits plants⁻¹, Sharma and Dhankar (1990). A very high broad sense heritability (>90 %) was recorded for length of main vine, number of primary branches plant⁻¹, number of nodes of first male flower, number of nodes of first female flower, fruit length, fruit weight, number of fruit plant⁻¹, fruit yield plant⁻¹. High genetic advance (percent of mean) was recorded for sex ratio, fruit length and fruit yield plant⁻¹. The sex ratio, fruit length and fruit yield plant⁻¹ showed high heritability (> 80%) coupled with high genetic advance, Prasad *et al.* (1993). Heritability in the broad sense was very high for all the 8 characters, number of male flowers, number of female flowers and fruit yield plant⁻¹ exhibited high heritability coupled with high genetic advance, Narayan *et al.* (1996). High heritability and high genetic advance were recorded for fruit yield plant⁻¹, vine length, fruit diameter, fruit length, fruit weight, number of nodes to first male and female flowers and number of primary branches plant⁻¹, Singh *et al.* (2002). High heritability coupled with high genetic advance were observed for fruit length, fruit width, days to first female flowering days to first male flowering and yield plant⁻¹, Yadav *et al.* (2008), Singh *et al.* (2008), Pandit *et al.* (2009).

High heritability coupled with high genetic advance as per cent mean was observed for the characters like number of primary branches per vine, average weight of fruit, and average yield per plant in bitter gourd (Mangal *et al.*, 1983). Rajput (2012)

observed high heritability with high genetic advance for characters number of primary branches per vine, number of female flowers per vine, sex ratio, average yield per vine and number of fruits per vine in bitter gourd. Pathak (2014) observed high heritability with high genetic advance for fruit weight, fruit length and number of fruits per plant in bitter gourd.

Similar type of results were reported by Prasad *et al.* (2004), Pandey *et al.* (2005), Singh and Lal (2005), Torkadi and Musmade (2007), Ibrahim (2012), Reddy *et al.* (2013) and Mali (2015) in muskmelon.

The higher estimate of heritability with low genetic advance as per cent mean indicates the presence of non-additive gene effect. Therefore selection may not be effective for these traits. The high heritability and low genetic advance may be attributed due to low phenotypic variation in these traits. Srivastava and Srivastava (1976) reported similar results for character days to first flower, fruit length and total fruit yield. Singh *et al.* (1977) reported high heritability with low genetic advance for character fruit diameter. Mangal *et al.* (1983) also reported similar result for character days to first flower and total fruit yield per vine in bitter gourd. Pathak (2014) reported high heritability with low genetic advance for character days to first male and female flower indicated that non-additive gene effects in bitter gourd. Similar findings were also in accordance with Prasad *et al.* (2004), Pandey *et al.* (2005), Rakhi and Rajamony (2005), Singh and Lal (2005), Torkadi and Musmade (2007), Ibrahim (2012) and Reddy *et al.* (2013) in muskmelon. Kumar *et al.* (2007), Arunkumar *et al.* (2011) in cucumber. Karuppaiah *et al.* (2002), Choudhary and Kumar (2011) in ridge gourd.

5.2 Correlation coefficient

In present study the phenotypic and the genotypic correlation co-efficient were worked out in respect of the 13 characters for each two crosses of both F₃ and F₄ generations (Table 9 to 14) and the same are discussed here below.

In case of F₃ and F₄ generation in cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) the significant and high positive correlation both at phenotypic and the genotypic level was observed between yield per vine and the yield contributing characters such as vine length, number of primary branches per vine, number of fruits per vine, average weight of fruit, average length of fruit and fruit diameter at pedicel, center and styler end. While, the characters like sex ratio and node at which first female flower appeared were significantly and negatively correlated with yield per vine, which were helpful relationships. Most of these characters were also found to be positively associated among them. Similar correlation coefficient both at phenotypic and genotypic level between fruit yield per vine and the yield contributing characters were observed in cross DBG-5 x Bhagirathi (C₂: 9 x 10) in F₃ and F₄ generations. These findings in both F₃ and F₄ generations indicate that the ideal vine should have more vine length, more number of primary branches per vine, more number of fruits per vine, more weight of fruit, more length of fruit and more diameter of fruit and less days required for first female flower appearance, lower node position at which first female flower appeared and less days required for first harvest of fruit. The selection of a better yielder should also emphasis for improvement in these components.

Prasad *et al.* (1993) also reported a significant and positive association of fruit yield with number of fruits vine⁻¹,

average weight of fruit and number of female flowers vine⁻¹. Sharma and Dhankar (1993) in bottle gourd reported the positive correlation between yield and number of fruits was mainly due to highest direct effect of number of fruits. Days to first female flowering showed negative association with vine length. Badade *et al.* (2001) reported that the yield was significantly and positively correlated with number of branches vine⁻¹, percentage of female flower and number of fruits vine⁻¹ in bottle gourd, while significantly and negatively correlated with days to first male and female flower appearance at both phenotypic and genotypic levels. Yadav *et al.* (2007) while studying 18 strains of bottle gourd revealed that yield plant⁻¹ was positively and significantly associated with the number of fruits plant⁻¹, but has a negatively significant correlation with days to first female flowering at both genotypic and phenotypic levels. Pandit *et al.* (2009) while evaluating 15 genotypes of bottle gourd revealed that the correlation between both genotypes and phenotypes indicated the over-riding importance of fruit length and fruit width in determining the average fruit weight, which in turn adequately described the increase in fruit yield plant⁻¹. Yadav *et al.* (2010), Kumar *et al.* (2012), Sharma and Sengupta (2012) also reported similar kind of report.

Khattra *et al.* (1994) reported a significant and positive correlation of total fruit yield per vine with average fruit weight and number of fruits per vine while negative correlation was recorded with days to anthesis of first female flower and days to first harvest in bitter gourd. Dey *et al.* (2005) reported that, total yield per vine showed highly significant and positive phenotypic correlations with fruit weight followed by number of fruits per vine, flesh thickness,

days from fruit set to maturity, fruit index, fruit length and fruit diameter where as other traits like number of male flowers per vine, ascorbic acid, total carotenoids content and days to first male flower exhibited negative correlation coefficient with fruit yield in bitter gourd. Botau *et al.* (2010) demonstrated that the fruit yield per vine had significant and positive correlation with number of fruits per vine, fruit weight, fruit length and fruit diameter in bitter gourd. Pathak (2014) observed the yield had significant positive correlation with number of fruits per plant and directly correlated with fruit weight, number of fruits per plant and fruit length, hence selection based on these characters would be more rewarding. Gupta *et al.* (2015) revealed that fruit yield per vine in bitter gourd had direct and indirect influence on total marketable fruit yield. Correlation of various characters with yield is useful and provides criteria for direct selection of component characters. The characters average fruit weight, marketable fruits per vine, and seeds per fruit exhibited positive phenotypic association while marketable fruits per vine, seeds per fruit, average fruit weight and node at which first female flower appears showed genotypically positive association with total marketable fruit yield per hectare.

Similar findings were also in conformity in another cucurbitaceous crops. Tarsem and Sanjay (1997), Choudhary *et al.* (2003), Chamnan and Kasem (2006), Jagtap (2010), Naroui *et al.* (2010), Cheema *et al.* (2011) in muskmelon. Dewan *et al.* (2014) in ash gourd, Singh *et al.* (2002), Rao *et al.* (2003), Joshi *et al.* (2005), Bhande *et al.* (2012) in cucumber. Khan *et al.* (2009) in pointed gourd, Choudhary and Kumar (2011), Hanumegowda *et al.* (2012), Rabbani *et al.* (2012) in ridge gourd, Khule *et al.* (2011), Kumar *et al.* (2013) in sponge gourd. Kadam (1997), Rolania *et al.* (2003) in

watermelon found that most of these characters were favourably associated with fruit yield per vine.

5.3 Fruit characters (qualitative)

F₃ and F₄ progenies of crosses Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) along with their parents were studied for the different qualitative traits such as shape of fruit, colour of fruit and presence of pubescence on fruit was presented in Table 15 and 16.

5.3.1 Shape of fruits or size of fruits

Among the F₃ and F₄ segregating progenies of the two crosses *viz* Pusa Samridhi DBG-5 x (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) observed medium and cylindrical shape of fruits. Also, few progenies produced short/long fruit shape. Thus shape of fruit was governed by additive variance (Ramaswamy *et al.*, 1977) Similar results were reported by Prasad and Prasad (1979) in bottle gourd, Rajput (2012) in bitter gourd. Jagtap (2010) and Patil (2014) in muskmelon.

5.3.2 Colour of fruits

In F₃ and F₄ segregating progenies, among the two crosses *viz.*, Pusa Samridhi DBG-5 x (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) showed light green colour of fruits. These findings were in conformity with the findings of Singh *et al.*, (2002), Bawkar Suhas (2016) in bottle gourd.

5.3.3 Presence of pubescence

In F₃ and F₄ segregating progenies, among the two crosses *viz.*, Pusa Samridhi DBG-5 x (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) showed medium to high prescence of pubescence on fruit surface (Table 15,16). Similar results were reported by Bawkar Suhas (2016) in bottle gourd.

5.4 Per cent incidence of diseases and pests

5.4.1 Per cent incidence of diseases

5.4.1.1 Per cent incidence of powdery mildew

The highest incidence of powdery mildew was recorded in Bhagirathi (18.70 and 31.00 %) whereas the least incidence of was recorded in Pusa Samridhi (11.55 and 23.50 %) in both F₃ and F₄ generation respectively. In case of segregating progenies, the highest incidence of powdery mildew (27.00 and 34.50 %) was recorded in most of the progenies of the cross DBG- 5 x Bhagirathi (C₂: P₂ x P₃) and least incidence of powdery mildew (09.05 and 20.50 %) was recorded in Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) in F₃ and F₄ generations, respectively. These results are in conformity with the findings of Bawkar *et. al.* (2015) in bottle gourd, Jagtap (2010) and Patil (2014) in muskmelon.

5.4.1.2 Per cent incidence of downey mildew

The low incidence of downey mildew at field condition was recorded in the parents Pusa Samridhi (11.00 and 19.00 %) while the highest incidence was observed in parent Bhagirathi (19.05 and 27.05 %) in both F₃ and F₄ generations respectively. In case of crosses, most of the progenies was recorded the lowest incidence of downey mildew (09.80 and 16.50 %) at field condition in cross Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) whereas, the highest incidence of downey mildew (23.10 and 31.00%) was observed in the cross DBG-5 x Bhagirati (C₂: 2 x 3) in the F₃ and F₄ generations, respectively. Similar type of finding was also reported by Bawkar *et. al.* (2015) in bottle gourd. Jagtap (2010) and Patil (2014) in muskmelon.

5.4.1.3 Percent incidence of Fusarium wilt

The highest incidence of Fusarium wilt was recorded in DBG-5 (12.90 and 19.10 %) whereas the least incidence of was recorded in Pusa Samridhi (6.20 and 11.35 %) in both F₃ and F₄ generation respectively. In case of segregating progenies, the highest incidence of fusarium wilt (11.50 and 18.05 %) was recorded in most of the progenies of the cross Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) and least incidence of fusarium wilt (4.00 and 10.00 %) was recorded in DBG-5 x Bhagirathi (C₂: P₂ x P₃) in F₃ and F₄ generations respectively.

5.4.1.4 Percent incidence of Gummosis

The highest incidence of gummosis was recorded in Pusa Samridhi (16.30 %) whereas the least incidence of was recorded in DBG-5 (6.50 %) in F₃ generation. In case of segregating progenies, the highest incidence of gummosis (16.75 %) was recorded in most of the progenies of the cross Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) and least incidence of gummosis (5.35 %) was recorded in DBG-5 x Bhagirathi (C₂: P₂ x P₃) in F₃ generations. F₄ Generations recorded nil gummosis due to *kharif* season.

5.4.2 Per cent incidence of pest

5.4.2.1 Per cent incidence of fruit fly

The highest infestation of fruit fly was found in Pusa Samridhi (13.20 and 18.10 %) while least infestation was observed in Bhagirathi and DBG-5 (9.23 and 14.35 %) in both F₃ and F₄ generations respectively. Among the two crosses, the cross DBG-5 x Bhgirathi (C₂: 2 x 3) recorded least infestation of fruit fly (5.08 and 10.70 %) while the Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) recorded highest infestation of fruit fly (18.78 and 22.70 %) in both F₃ and F₄

generations respectively. Similar type of finding was also reported by Bawkar *et. al.* (2015) in bottle gourd.

5.4.2.2 Per cent incidence of Leaf miner

The highest infestation of leaf miner was found in Pusa Samridhi (17.05 and 20.50 %) while least infestation was observed in Bhagirathi (15.35 and 18.30 %) in both F₃ and F₄ generations respectively. Among the two crosses, the cross DBG-5 x Bhgirathi (C₂: 2 x 3) recorded least infestation of leaf miner (11.69 and 17.40 %) while the Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) recorded highest infestation of leaf miner (15.36 and 18.30 %) in both F₃ and F₄ generations, respectively.

6. SUMMARY AND CONCLUSIONS

The present investigation entitled as, “Genetic studies in F₃ and F₄ generations of bottle gourd [*Lagenaria siceraria* (Mol) StandL.]” was undertaken at All India Coordinated Research Project on Vegetable Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) during the summer 2014 and *kharif* 2014.

Ten F₃ progenies of each of crosses Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) each cross with 300 plant population along with their parents, whereas ten F₄ progenies of cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) each cross with 300 plant population were evaluated along with their parents in randomized block design with three replications. Data of thirteen characters was recorded on total plant population in both generation and used for estimation of variability, heritability (broad sense), genetic advance, genetic advance as per cent of mean and correlation coefficients.

6.1 Variability, heritability and genetic advance

A good range of variability was observed for all ten traits of bottle gourd in progenies of two crosses for F₃ and F₄ generation. Genotypic coefficient of variation was lower than the phenotypic coefficient of variation in all quantitative traits which indicate role of environment in the expression of traits. In F₃ and F₄ generations of cross Pusa Samridhi x DBG-5 (C₁: 3 x 9), high values of genotypic and phenotypic coefficient of variations were recorded for traits *viz.* length of vine, number of primary branches per vine, sex ratio, number of fruits per vine, yield per vine, average weight of

fruit, average length of fruit and fruit diameter at pedicel, center and stylar end.

In F₃ and F₄ generations progenies of the cross DBG-5 x Bhagirathi (C₂: 9 x 10) length of vine, number of primary branches per vine, sex ratio, number of fruits per vine, yield per vine, average weight of fruit, average length of fruit and fruit diameter at pedicel, center and stylar end recorded high values of genotypic and phenotypic coefficients of variations in F₃ and F₄ generations.

Thus, the high amount of genotypic and phenotypic coefficients of variations indicates presence of ample amount of genetic variation for the characters which can be used effectively in crop improvement programme.

High heritability was observed in F₃ and F₄ generations of progenies of two crosses *viz.* Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10). In cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) heritability was ranged from 39 to 93 per cent. In cross DBG-5 x Bhagirathi (C₂: 9 x 10) it ranged from 36 to 88 per cent. It indicated that major role of genetic constitution in expression of characters. Also, range of genetic advance was found high for most of the characters.

Association of high heritability with high genetic advance as per cent of mean was recorded in F₃ generation of the cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) for the characters like number of primary branches per vine, yield per vine, average length of fruit, fruit diameter at pedicel, fruit diameter at center, number of fruits per vine, average weight of fruit. Whereas the high estimates of heritability with moderate estimates of genetic advance as per cent of mean was observed for length of vine, node at which first female flower appeared, sex ratio and fruit diameter at stylar

end. The characters days required for appearance of first female flower, days required for first harvest of fruit showed moderate estimates of heritability with low estimates of genetic advance as per cent of mean in F₃ generation.

In progenies of cross DBG-5 x Bhagirathi (C₂: 9 x 10) the traits like average weight of fruit, average length of fruit, fruit diameter at pedicel, number of fruits per vine, yield per vine recorded high estimates of heritability along with high estimates of genetic advance as per cent of mean in F₃ generation. Whereas the characters *viz.* fruit diameter at stylar end, sex ratio recorded high estimates of heritability with moderate estimates of genetic advance as per cent of mean. While characters *viz.* days required for appearance of first female flower, days required for first fruit harvest showed moderate estimates of heritability with low estimates of genetic advance as per cent of mean in F₃ generation.

In case of F₄ generation, progenies of cross Pusa Samridhi x DBG-5 (C₁: 3 x 9) the association of high estimate of heritability with high estimate of genetic advance as per cent of mean was recorded in characters like yield per vine, average length of fruit, fruit diameter at pedicel, fruit diameter at center, number of fruits per vine, average weight of fruit. Whereas the high estimate of heritability with low estimate of genetic advance as per cent of mean was observed for days required for appearance of first female flower and days required for first harvest.

In cross DBG-5 x Bhagirathi (C₂: 9 x 10) reported that high estimates of heritability along with high estimates of genetic advance as per cent of mean in the characters like yield per vine, average length of fruit, fruit diameter at pedicel, center and stylar end, number of fruits per vine and average weight of fruit. Whereas,

the characters, days required for appearance of first female flower and sex ratio recorded high estimate of heritability with low estimate of genetic advance as per cent of mean.

Hence, the presence of high heritability along with high genetic advance as per cent of mean might be attributed due to the dominance of additive gene effect. Therefore phenotypic selection will be effective in further breeding programme.

High heritability with low genetic advance as per cent of mean indicates non-additive gene effect. Thus, selection for such characters will not be effective in further breeding programme.

6.2 Correlation coefficient

In case of F₃ and F₄ generations of both the crosses the significant and high positive correlation both at phenotypic and the genotypic level was observed between yield per vine and the yield contributing characters such as length of vine, number of primary branches, number of fruits per vine, average weight of fruit, average length of fruit and fruit diameter at pedicel, center and stylar end. While, the characters like sex ratio, days required for appearance of first female flower were significantly and negatively correlated with yield per vine, which were helpful relationships. Most of these characters were also found to be positively associated among themselves.

6.3 Fruit characters (Qualitative)

In case of fruit shape, the F₃ and F₄ segregating progenies of crosses Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) observed medium and cylindrical shape of fruits. In case of fruit colour, light green colour of fruits was observed in crosses Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) in the F₃ and F₄ generations. In case of

presence of pubescence on fruit surface, Pusa Samridhi x DBG-5 (C₁: 3 x 9) and DBG-5 x Bhagirathi (C₂: 9 x 10) showed presence of pubescence on fruit surface.

6.4 Per cent incidence of diseases and pests

The highest incidence of powdery mildew was recorded in parent Bhagirathi (18.70 and 31.00 %), whereas the least incidence was recorded in Pusa Samridhi (11.55 and 23.50 %) in both F₃ and F₄ generation respectively. In case of segregating progenies, the highest incidence of powdery mildew (27.00 and 34.50 %) was recorded in most of the progenies of the cross DBG- 5 x Bhagirathi (C₂: P₂ x P₃) and least incidence of powdery mildew (09.05 and 20.50 %) was recorded in Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) in F₃ and F₄ generations respectively.

The low incidence of downey mildew at field condition was recorded in the parent Pusa Samridhi (11.00 and 19.00 %) while the highest incidence was observed in parent Bhagirathi (19.05 and 27.05 %) in both F₃ and F₄ generations respectively. In case of crosses, most of the progenies was recorded the lowest incidence of downey mildew (09.80 and 16.50 %) at field condition in cross Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) whereas, the highest incidence of downey mildew (23.10 and 31.00%) was observed in the cross DBG-5 x Bhagirathi (C₂: P₂ x P₃) in the F₃ and F₄ generations respectively.

The highest incidence of fusarium wilt was recorded in DBG-5 (12.90 and 19.10 %) whereas the least incidence of was recorded in Pusa Samridhi (6.20 and 11.35 %) in both F₃ and F₄ generation respectively. In case of segregating progenies, the highest incidence of fusarium wilt (11.50 and 18.05 %) was recorded in most of the progenies of the cross Pusa Samridhi x

DBG-5 (C₁: P₁ x P₂) and least incidence of fusarium wilt (4.00 and 10.00 %) was recorded in DBG-5 x Bhagirathi (C₂: P₂ x P₃) in F₃ and F₄ generations respectively.

The highest incidence of gummosis was recorded in parent Pusa Samridhi (16.30 %) whereas the least incidence of was recorded in parent DBG-5 (6.50 %) in F₃ generation. In case of segregating progenies, the highest incidence of gummosis (16.75 %) was recorded in most of the progenies of the cross Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) and least incidence of gummosis (5.35 %) was recorded in DBG-5 x Bhagirathi (C₂: P₂ x P₃) in progenies of F₃ generations. No gummosis symptom was observed in progenies of F₄ generations in both the crosses.

The highest infestation of fruit fly was found in Pusa Samridhi (13.20 and 18.10 %) while least infestation was observed in Bhagirathi and DBG-5 (9.23 and 14.35 %) in both F₃ and F₄ generations respectively. Among the two crosses, the cross DBG-5 x Bhagirathi (C₂: P₂ x P₃) recorded least infestation of fruit fly (5.08 and 10.70 %) while the Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) recorded highest infestation of fruit fly (18.78 and 22.70 %) in both F₃ and F₄ generations respectively.

The highest infestation of leaf miner was found in Pusa Samridhi (17.05 and 20.50 %) while least infestation was observed in Bhagirathi (15.35 and 18.30 %) in both F₃ and F₄ generations respectively. Among the two crosses, the cross DBG-5 x Bhagirathi (C₂: P₂ x P₃) recorded least infestation of leaf miner (11.69 and 17.40 %) while the Pusa Samridhi x DBG-5 (C₁: P₁ x P₂) recorded highest infestation of leaf miner (15.36 and 18.30 %) in both F₃ and F₄ generations respectively.

6.5 Conclusion

1. The maximum phenotypic and genotypic coefficient of variation was observed for characters *viz.* Length of vine, number of primary branches per vine, sex ratio, number of fruits per vine, yield per vine, average weight of fruit, average length of fruit, fruit diameter at pedicel, center and styler end in bottle gourd and remaining characters shows moderate PCV and GCV in two crosses *viz.* C₁ (Pusa Samridhi x DBG-5), C₂ (DBG-5 x Bhagirathi) in F₃ and F₄ generations. The characters showing wide range of variation provide ample scope for selecting the desirable plant types.
2. Phenotypic coefficient of variation (PCV) was higher than the respective genotypic coefficient of variation (GCV) for all the characters of F₃ and F₄ generations of both the crosses denoting environmental factors influencing their expression to some degree. Wide difference between PCV and GCV indicates the role of environmental factors where as narrow difference between PCV and GCV suggested that these characters are least influenced by environment.
3. High estimates of heritability for all characters of both the crosses of F₃ and F₄ generations indicating that they were least affected by environment and selection based on phenotypic performance would be reliable.
4. High estimates of genetic gain was observed for most of the yield and yield contributing characters in both the crosses of F₃ and F₄ generations thus they could be improved to a large extent through selection.
5. High heritability with high genetic advance as per cent of mean was observed for the characters length of vine, number

of primary branches, number of fruits per vine, yield per vine, average weight of fruit, average length of fruit, fruit diameter at center, pedicel and stylar end in two crosses of F₃ and F₄ generations and phenotypic selection for their improvement could be achieved by simple selection.

6. High heritability with low genetic advance as per cent of mean was observed for sex ratio, days required for appearance of first female flower and days required for first harvest of fruit in different crosses for which selection would not be rewarding, in such cases selection should be delayed.
7. In both the crosses of F₃ and F₄ generations the significant and positive correlation both at phenotypic and the genotypic level was observed between yield per vine and the yield contributing characters. Thus association of characters should be considered for improvement.
8. Out of 300 plant population in each cross, the four superior progenies were identified for future crop improvement *i.e.* raising of F₅ generation based on more fruit yield per vine with light green colour, medium cylindrical shape and presence of pubescence on fruit. The progenies *viz.* Cross-1 (Pusa Samridhi x DBG-5), (progeny 2, 3) and Cross-2 (DBG-5 x Bhagirathi), (progeny 1, 2) are important for further studies. Such types of progenies are extremely helpful in crop improvement programme for development of cultivar or variety with maximum fruit yield per vine by simple selection method.
9. For improvement of bottle gourd the characters such as vine length, number of primary branches, days required for first female flower appearance, node at which first female flower

appeared, days required for first harvest of fruit, number of fruits per vine, average fruit weight, average length of fruit, fruit diameter at pedicel, center and styler end should be considered for development of ideal genotypes.

Future line of work

In present investigation, both the crosses of bottle gourd studied for F₃ and F₄ progenies showed certain difference of variability, heritability and genetic advance which can be exploited in future crop improvement work. The PCV was higher than GCV for almost all the characters studied. For development of superior genotypes in bottle gourd, the yield contributing and qualitative characters should be considered. The heritability and genetic advance was high for most of the characters. The selection based on high heritability and genetic advance for different characters should be kept in mind while selecting better genotypes. The yield per vine has positive and significant association with almost all yield contributing characters, which should be considered positively, while selecting the ideal genotypes in bottle gourd. The progenies of cross-1 (Pusa Samridhi x DBG-5), (progeny 2, 3) and cross-2 (DBG-5 x Bhagirathi), (progeny 1, 2) should be exploited for F₅ generation to obtain high yield with better quality fruit in bottle gourd.

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8. VITA

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in

HORTICULTURE

(VEGETABLE SCIENCE)

2018

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