# “STUDIES ON GENETIC DIVERSITY IN BOTTLE GOURD [*Lagenaria siceraria* (Mol.) Standl.]”


## SNEHA RATHORE


**Thesis**

**MASTER OF SCIENCE IN HORTICULTURE**

**(VEGETABLE SCIENCE)**


**DEPARTMENT OF VEGETABLE SCIENCE**

**COLLEGE OF HORTICULTURE AND FORESTRY**

**RANI LAKSHMI BAI CENTRAL AGRICULTURAL UNIVERSITY**

**JHANSI – 284003 (UTTAR PRADESH)**


**JULY 2023**

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**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF**

**RANI LAKSHMI BAI CENTRAL AGRICULTURE UNIVERSITY**
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**RANI LAKSHMI BAI CENTRAL AGRICULTURE UNIVERSITY**
**JHANSI- 284003, UTTER PRADESH, INDIA**

**(Vegetable Science)**

# CERTIFICATE-I

Certified that **Ms. Sneha Rathore,** Id. No. **H/PG/012/21** has satisfactorily pursued her course of research for not less than IV semesters and that the thesis entitled **"Studies on genetic diversity in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" s**ubmitted by her to the Rani Lakshmi Bai Central Agricultural University, Jhansi 284003 (U.P.) in partial fulfilment of the requirements for the award of the degree of **Master of Science in Horticulture** in the subject of **Vegetable Science** is the result of original research work conducted by her under my supervision and is sufficiently of a high standard to warrant its presentation to the examination.

I also certify that the thesis or part thereof has not been previously submitted by her for a degree/diploma of any University.

Date 19/07/2023

Chairperson

(Arjun Lal Ola)

## COLLEGE OF HORTICULTURE AND FORSTRY

## Rani Lakshmi Bai Central Agricultural University Jhansi – 284003

## (Vegetable Science)

### CERTIFICATE-II

This is to certify that the thesis entitled **"Studies on genetic diversity in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]"** submitted by **Ms. Sneha Rathore,** ID. No. **H/PG/012/21** submitted to the Rani Lakshmi Bai Central Agricultural University, Jhansi 284003 (U.P.) for partial fulfilment of the requirements for the award of the degree of **Master of Science in Horticulture** in the subject of **Vegetable Science** has been **approved** by the Student's Advisory Committee after the *viva voce* examination.

Date 01/08/2023

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# LIST OF CONTENTS


| S.No. | CHAPTERS NAME | PAGE NO. |
|---|---|---|
| 1 | INTRODUCTION | 1 |
| 2 | REVIEW OF LITERATURE | 5 |
| 3 | MATERIALS AND METHODS | 18 |
| 4 | RESULTS AND DISCUSSION | 34 |
| 5 | SUMMARY AND CONCLUSIONS | 67 |
| | BIBLIOGRAPHY | 70 |
| | APPENDIX I | 78 |
| | APPENDIX II | 79 |
| | ABSTRACT (ENGLISH) | 81 |
| | ABSTRACT (HINDI) | 82 |
| | CURRICULUM VITAE | 83 |

# LIST OF TABLES


| S.No. | Table Name | Page no. |
|---|---|---|
| **3.2.1** | Meteorological data weekly average for the crop period (*kharif 2022*) | 18 |
| **3.4.1** | Genotypes of bottle gourd and their sources of collections | 19 |
| **3.4.2** | Experimental Design | 20 |
| **4.1.1** | ANOVA analysis of bottle gourd genotypes for different characters | 35 |
| **4.2.1** | Mean performance of bottle gourd genotypes | 39 |
| **4.2.2** | Fruit quality parameters of bottle gourd | 43 |
| **4.3.1** | Mean, Range, Coefficient of variations (GCV and PCV), Genetic Advance, Genetic Advance as Per cent of mean and Heritability, for 21 Characters of bottle gourd genotypes. | 48 |
| **4.4.1** | Estimation of genotypic correlation coefficients for different characters of Bottle gourd | 55 |
| **4.4.2** | Estimation of phenotypic correlation coefficients for different characters of Bottle gourd | 56 |
| **4.5.1** | Direct (diagonal) and indirect diagonal (above and below diagonal) genotypic path effects of different characters towards yield in Bottle gourd | 62 |
| **4.5.2** | Direct (diagonal) and indirect (above and below diagonal) phenotypic path effects of different characters towards yield in bottle gourd | 63 |
| **4.6.1** | Inter and Intra Cluster Distance: Tocher's Method | 64 |
| **4.6.2** | Percentage contribution of different characters towards diversity in bottle gourd genotypes | 65 |
| **4.6.3** | Clustering pattern of 30 bottle gourd genotypes by Tocher's method | 66 |

# LIST OF FIGURES


| S. No. | Figure Name | Page no. |
|---|---|---|
| **3.5** | Layout of experimental plot | 21 |
| **4.1** | Mean performance of different bottle gourd genotype for days to first fruit bud, node number to first male flower appearance, node number to first female flower appearance | 41 |
| **4.2** | Mean performance of different bottle gourd genotype for fruit length (cm), fruit width (cm) and average fruit weight (g) | 41 |
| **4.3** | Mean performance of different bottle gourd genotype for first fruit picking, number of fruits per plant and yield per plant (Kg) | 42 |
| **4.4** | Mean performance of different bottle gourd genotype for total soluble solids protein content ($^{o}$Brix), (mg/100g) and ascorbic acid content (mg/100g) | 42 |
| **4.5** | Genetic variability for different characters in bottle gourd genotypes | 49 |
| **4.6** | Percentage contribution of different characters towards diversity in bottle gourd genotypes | 65 |

# LIST OF SYMBOLS AND ABBREVIATIONS

| S. NO. | Symbol | Abbreviation |
|---|---|---|
| **1.** | % | Percentage |
| **2.** | m | Meter |
| **3.** | $2_n$ | Diploid chromosome |
| **4.** | R.H. | Relative humidity |
| **5.** | *etc*. | and so on; and other people/thing |
| **6.** | $F_1$ | First filial generation |
| **7.** | cm | Centimeter |
| **8.** | g | Gram |
| **9.** | mg | Milligram |
| **10.** | pH | Hydrogen ion concentration |
| **11.** | mm | Millimeter |
| **12.** | ml | Milliliter |
| **13.** | No. | Number |
| **14.** | d.f | Degree of freedom |
| **15.** | SEm (+) | Standard error of mean |
| **16.** | CD | at 5% Critical difference with significance level of 5% and 1% |
| **17.** | ANOVA | Analysis of Variance |
| **18.** | CV | Coefficient of variation |
| **19.** | GV | Genotypic variance |
| **20.** | PV | Phenotypic variance |
| **21.** | GCV | Genotypic coefficient of variation |
| **22.** | PCV | Phenotypic coefficient of variation |

| | | |
|---|---|---|
| **23.** | GA | Genetic advance |
| **24.** | / | Per |
| **25.** | < | Less than |
| **26.** | > | More than |
| **27.** | $H^2$ | Heritability |
| **28.** | GMS | Genotypic mean sum of square |
| **29.** | EMS | Error mean sum of square |
| **30.** | RMS | Replication mean sum of square |
| **31.** | IC | Indigenous collection |
| **32.** | *i.e.,* | That is |
| **33.** | Fig. | Figure |
| **34.** | *et al.* | and co-workers |
| **35.** | @ | at the rate of |
| **36.** | °C | Degree Celsius |
| **38.** | Kg | Kilogram |
| **39.** | Kg/ha | Kilogram per hectare |
| **40.** | max. | Maximum |
| **41.** | Min. | Minimum |
| **42.** | *viz.,* | Namely |
| **43.** | q | Quintals |

# LIST OF ABBREVIATION AND ACRONYMS

| S. N. | Trait Abbreviation | Trait Acronyms |
|---|---|---|
| **1.** | Vine length (cm) | VL |
| **2.** | Days to first flowering bud | DFFB |
| **3.** | Node number to first male flower appearance | FMFEN |
| **4.** | Node number to first female flower appearance | FFFEN |
| **5.** | Days to first fruit setting | DFS |
| **6.** | Days to first fruit picking | DFP |
| **7.** | Number of fruits per plant | NFPP |
| **8.** | Fruit length | FL |
| **9.** | Fruit width (cm) | FW |
| **10.** | Average fruit weight (g) | FWt |
| **11.** | Yield per plant | YPP |
| **12.** | Yield | YPH |
| **13.** | Total soluble solids (°Brix) | TSS |
| **14.** | Protein content (mg/100g) | PC |
| **15.** | Ascorbic acid content (mg/100g) | ACC |

# 1. INTRODUCTION

Bottle gourd (*Lagenaria siceraria,* 2n= 2x=22) belonging the family *Cucurbitaceae* is one of the most significant cucurbitaceous vegetable in India. It is widely grown in the tropics and sub-tropics, primarily for its fruit, which can be globular, cylindrical, bottle-shaped, or even club-shaped. In different regions of India, it is also known by the names Calabash, Doodhi, and Lauki (Gurcan *et al.*, 2015). Bottle gourd is a monoecious, diploid, annual and climbing or prostrate plant with delicate pubescence. The leaves are cordate-ovate to reniform-ovate, 15–30 cm broad and non-lobed. The flowers are white, lone, showy and open at night time. It is also known as white flowering gourd. The flowers have five petals. On lengthy pedicels that extend above the leaves are the staminate blooms. The pistillate blooms contain a single, short peduncle and a hairy ovary (Dubey *et al*., 2022). It is a cross pollinated crop with large amount of variation for many economically important traits at maturity such as yield, shape and size. Cross pollination rates range from 60 to 80% ( Tomar and Abhishek, 2020).

The fruit length depends on varietal characters and varies from 150 to 1000 mm. With respect to fruit and seed traits, wide variability is present among bottle gourd germplasms. The flat, roughly rectangular or trapezoidal seeds are yellowish to dark brown at the ends (Ahmad *et al.*, 2021). The immature fruit has light green to yellowish green or cream-colored skin and relatively soft in texture with white pulp and large white seeds. After peeling of bark, it is used as vegetable and for making sweets like halwa, kheer, petha and barfi. It is also used for preparing various other dishes like curry, raita, pickles, kofta and lauki ka paratha. The seeds are utilized for oil extraction and are abundant in lipids, fatty acids, minerals, and vital amino acids (Minocha *et al.,* 2015).

The bottle gourd requires 24-27 °C temperature for its growth and development. It is typically cultivated twice a year, from February to March and June to July. It can be grown in warm and humid and slightly cool climate. Its healthy development requires a temperature range of 30°C to 35°C during the day and 18°C to 22°C at night. Temperatures <10°C limit the metabolic activity of seeds for germination, whereas day time temperatures >40°C may induce burning of leaves. It is vulnerable to frost and extremely low temperatures. It thrives better on loam and sandy loam soils that are well drained, rich in organic materials. It is susceptible to waterlogging conditions. The optimum soil pH is 6.0-7.0 (Parle & Kaur, 2011).

It is one of the earliest vegetable crop that was cultivated for human consumption. In additionto offering food and medicine, bottle gourds are also used to make a wide range of tools and instruments including bowls, bottles, containers, floats for fishing nets. The bottle gourd is found in South Africa and India in its wild form and is said to have originated in Africa and America (Srivastava *et al.*, 2014).

As per Ayurveda and Unani, it has anti-periodic, antipyretic, laxative, cooling, diuretic,antebellum whole and liver tonic properties. Bottle gourd can help in reducing stress, heart diseases, weight loose and in treating sleeping disorders. Prevents premature greying of hair and helps in digestion. For every 100 g of fresh fruit pulp, the edible fraction of the fruit comprises 96.3% moisture, 2.9% carbohydrates, 0.2% protein, 0.1% fat, 0.5% mineral matter and 11 mg of vitamin C. Additionally, it contains a variety of minerals, including Ca (12 mg), P (37 mg), Na (1.7 mg), K (87 mg), Cr (0.05 mg) and Fe (0.8 mg) (Rehan *et al*., 2020).

India holds a prominent position and is the world's second-largest producer of vegetable after China. Bottle gourd has covered an area of 1.93 lakh hectares with the production of 31.71 lakh MT in India (Anonymous NHB 2021-22). However, there is a need to evaluate the present status of productivity due to increasing population pressure. Recently, vegetable production is increased due to high yielding varieties/hybrids, better management practices and adoption of improved technology.

The critical and initial steps in any crop development programme are the collection, preservation, and evaluation of germplasm. An effective breeding programme must be created with a better understanding of the type and degree of genetic diversity contained in the breeding material(Engels and Ebert, 2021).

Comprehensive biological knowledge and a grasp of genetic diversity for yield and its constituent parts are required for the implementation of an intense breeding and improvement programme ( Damor *et al.,* 2017). The existence of genetic variability, the way in which economic traits are passed down through the generations, heritability, the type of gene action, and the relative magnitude of additive and dominance as well as the overall genotypic and phenotypic variance of the population must all be thoroughly understood. Considering the availability of genetic variability, there is scope of yield and quality improvement and there by develop export potential of bottle gourd (Dubey *et al*., 2022).

Genetic variability is pre requisite for effective improvement programme of any crop. Yield being the end product of many correlated characters, the selection of such characters which are highly heritable and positively correlated is more desirable. Amongst major constraints, lack of varieties with high and stable productivity, losses from several biotic factors are common. Hence, there is a need to explore genetic variability which is considered as an important factor for crop improvement program for obtaining high yielding progenies (Ahmad *et al.*, 2021).

Knowing the role and relationships between various yield and yield attributing components is essential for a successful breeding programme. The correlation coefficient would indicate the relationship among independent and dependent variables without specifying cause and effect (Akinnola, 2012). A positive association between desirable traits is favorable to plant breeder because it is useful simultaneous improvement of both the parameters and a negative correlation will hinder the simultaneous expression of both the characters with high values. The genetic improvement in dependent parameters can be achieved by applying strong selection to a character which is genetically correlated with dependent parameters. This is called as correlated response (Al-Jibouri *et al*., 1958).

Selection for yield and quality traits can be achieved to best possible extent if information about correlation between such traits is available followed by better understanding of the association between the relevant characters provided by path coefficient analysis (Muralidharan *et al.,* 2017).

According to Samadia (2002) the yield potential of bottle gourd is low in hot and arid climate and there is a scope for its improvement. The quantity and quality traits of bottle gourd is directly influenced by the fruit characters. The traits such as a large number of fruits per vine with soft flesh and soft seed are taken account since they are expected to produce high yield with excellent quality fruit.

Genetic diversity among germplasm is important for genetic development of any crop since it makes it allows to detect the most divergent parents based on the contribution of various qualitative and quantitative parameters. Which can be used in any hybridization programme. In order to select the best genotypes in a breeding programme, genetic diversity in the germplasm must be evaluated. (Goyal and Bisen, 2017).

A high frequency and high heterotic of suitable segregants may always be produced by genetically varied parents in succeeding generations. As it is crucial to a successful

breeding programme, genetic diversity and variability are of utmost importance to plant breeders. As preceding generations have already discovered, the ability of genetically varied parents to create a high frequency and number of attractive segregants in subsequent generations is constant (Kumar and Nadarajan, 1994). Mahalanobis's (1936) development of the $D^2$ statistic makes it a useful tool for estimating genetic divergence among crop varieties. Keeping above facts in the view, the present investigation entitled "Studies on genetic diversity in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was under taken during *kharif* 2022, with the following objectives.

- To assess the genetic variability, heritability and genetic advance in bottle gourd.
- To estimate the correlation coefficient among the yield and yield components.
- Path coefficient analysis for yield and yield components.
- To study the genetic divergence in bottle gourd for growth, yield and quality attributes.

# 2. REVIEW OF LITERATURE

A brief review of available literature in consonance with the objectives of the present investigation in respect of bottle gourd crop are reviewed and presented under the following heads.

2.1 Genetic parameters

2.2 Coefficient correlation

2.3 Path analysis

2.4 Genetic divergence

## 2.1. Genetic parameters

Improvement in any crop is based on the level of genetic variation and the degree of improvement depends upon the magnitude of available useful genetic variability. The knowledge of genetic variability with respect to yield and yield attributing traits in the germplasm of a crop is the basic requirement in order to select the desirable types (Ghorpade *et al.,* 2019). The variability observed for any character is due to differences in the genetic constitution of the populations as well as variation arising due to environmental conditions. The coefficients of genotypic variability and phenotypic variability are used as an aid in the plant breeding work. However, the proportion of heritable variance of a character is of much importance. For the any breeding program initiation, it is necessary to assess the genetic variability present in the indigenous genotypes for yield and its components. Parameter of phenotypic and genotypic coefficient of variations is helpful in detecting the amount of variability present in the germplasm (Datta and Das, 2013).

Heritability shows the proportion of phenotypic variance that is due to genotype which is heritable (Hanson *et al*., 1956). Selection of a trait should fairly be easy if heritability of that trait is very high. This is because there would be a close correspondence between phenotype and genotype due to a relatively smaller contribution of environment to the phenotype. High heritability shows the existence of additive genes in the expression of traits that could be easily exploited (Bharadwaj *et al.,* 2007) and high broad sense heritability estimate indicate genetic variances with less influence of the environment and the potential effectiveness of selection of the hybrids for traits of interest (Allard, 1960). The estimates of heritability are influenced by various factors, such as type of genetic material, sample size, sampling method, conduct of

experiment, method of calculation and effect of linkage (Fehr, 1987). It is necessary to split the overall variability into heritable and nonheritable components.

Bhatt *et al.,* (2022) studied genetic variability in eight parents with their twenty-eight cross combinations and two checks of bottle gourd. The estimations of the coefficients of variation showed that for all the traits, the magnitude of the phenotypic coefficients of variation (PCV) was larger than the genotypic coefficients of variation (GCV). The lowest GCV and highest PCV are indicating as the traits are influenced by environment because of higher PCV than GCV. Presence of high variability indicates possibility of effective selection for the character improvement. Yet Fruit yield, fruit dimension, fruit grith, number of fruits per plant, and average fruit weight have all exhibited great heritability and high genetic progress.

Dubey *et al.,* (2022) carried out experiment for 30 diverse genotypes of bottle gourd for different genetic parameters. stated that the intensity of phenotypic coefficients of variation (PCV) was greater than the genotypic coefficient of variation (GCV) for all the studied trait of bottle gourd. Fruit yield and the number of fruits produced by each plant showed high estimates of phenotypic and genotypic coefficients of variation, whereas average fruit weight, vine length, node number to first staminate flowers, fruit circumference (cm), fruit length, and minimum days to first pistilate flower anthesis and days of first fruit showed moderate variation. On the other hand, fruit yield per plant, average fruit weight, number of fruits per plant, node number to first pistillate flower, node number to first staminate flower and vine length all had high heritability. The number of fruits per plant, fruit yield per plant (Kg), node number to first pistillate flower, average fruit weight per fruit (g), vine length (m), node number to first staminate flowers, and fruit circumference revealed the greatest value of genetic progress.

Kumar *et al.,* (2021) studied on genetic variability, heritability and genetic advance in thirty-one diverse genotypes in bottle gourd. He demonstrated that the phenotypic coefficient of variance (PCV) was marginally larger than the matching genetic coefficient of variance (GCV). Fruit yield per plant was shown to have a high genotypic and phenotypic coefficient of variation, followed by fruit length. At the same time plant germination, vine length, internode length, days to first flower commencement, days to first fruit set, days to first fruit picking, fruit length, fruit girth, number of fruits per plant, fruit weight and fruit yield per plant show high heritability along with high genetic advance which let out the majority of additive gene action of these traits.

Singh *et al.,* (2021) conducted an experiment on 20 genotypes of bottle gourd for evaluation of genetic variability and heritability. The findings demonstrated that the phenotypic

coefficients of variation were greater than the corresponding genotypic coefficients of variation. Fruit length was shown to have the greatest phenotypic and genotypic coefficients of variation, followed by the number of fruits per plant and fruit diameter.

Venkatraman and Haripriya, (2021) studied genetic variability for yield and its contributing characters in bottle gourd genotypes. Results showed that PCV and GCV were high (more than 20%) for the sex ratios PCV and GCV were 34.19% and 24.79%, respectively. Primary branches and vine length both had moderate PCV (14.28, 16.10) and GCV (13.78, 13.43) values. Also, high heritability and high genetic advance as a percentage of mean were found for the following traits: vine length (0.93%), fruit length (0.87%), fruit width (0.76%), fruits per vine (0.59%), fruit yield (0.44%), node at first female flower appears (0.41%), days to first harvest (0.40%) and fruit thickness (0.37%).

Rashid *et al.,* (2020) studied genetic variability in bottle gourd and found that fruit diameter (35.65 and 34.62) and total chlorophyll (30.08 and 20.02) and fruit length had the highest phenotypic and genotypic coefficients of variation (23.70 and 23.44). As well as fruit length (0.97 and 47.74), fruit diameter (0.94 and 71.73) and total sugars (0.74 and 24.05) all showed strong heritability along with high genetic progress (0.84 and 25.42).

Rehan *et al.,* (2020) recorded fruit girth and fruit length had the highest genotypic and phenotypic coefficient of variation among different bottle gourd genotypes, indicating a significant degree of variability in those characteristics and suggesting the prospect of improving production by selection of these features. Besides fruit length, fruit girth, days to first fruit harvest, and vine length show strong heritability and high genetic progress.

Sailaja *et al.,* (2020) was shown to have high GCV and PCV values for fruit diameter (39.26 and 39.65), fruit length (38.04 and 38.82), fruit girth (33.55 and 32.48), yield per plant (21.33 and 22.98), and plant height (20.71 and 21.38). These traits show great diversity in the various bottle gourd germplasm, which can be enhanced. Additionally, fruit diameter, followed by fruit length, plant height and yield showed high heritability along with high genetic advance as a percentage of mean.

Tomar and Abhishek, (2020) demonstrated strong heritability and high genetic progress as measured by the percentage of mean observed for the days of male and female blooming, length of the vine, fruit yield per plot, number of fruits per plot and the fruit yield per plant (Kg).

Ahmad *et al.,* (2019) Studied the genetic variability, heritability and genetic advance in bottle gourd. The results revealed strong genotypic co-efficient of variation for traits like fruit yield per plant and high phenotypic co-efficient of variation for traits like number of fruits per plot. Also, high genetic progress measured as a percentage of the mean for days of male blooming, days of female flowering, vine length, fruit yield per plot, number of fruits per plot, and fruit yield per plant is seen along with high heritability.

Ghorpade *et al.,* (2019) conducted an experiment to calculate the bottle gourd phenotypic and genotypic coefficient of variation. The PCV and GCV values for proteins, and T.S.S. were high. Characters including ascorbic acid, protein, and T.S.S. were found to have high heritability and high genetic progress.

Kandasamy *et al.,* (2019) revealed Moderate discrepancies between genotypic and phenotypic coefficients of variation (PCV and GCV) in bottle gourd genotypes, indicating that the environment has a little influence on these variables. Vine length, fruit girth, days to fruit harvest and node number of first female flower all showed considerable genotypic diversity among these traits, indicating selection-driven improvement.

Chandrashekhar *et al.,* (2018) studied the genetic parameters for yield and yield attributing characters in bottle gourd genotypes. Results indicated that node at which the first female flowers appear, average weight of fruit (g), fruit length (cm), fruit diameter (cm), yield per plant (Kg) and total yield per hectare were all estimated to having high estimations of PCV and GCV and a large range of variability, indicating that there is a lot of variation in the germplasm for these characters that can be improved. On the other hand, high heritability along with high genetic advance as a percentage of mean was observed for total vine length (m), node at which first male flower appearance, node at which first female flower appears, number of fruits per plant, average fruit weight (g), fruit length (cm), fruit diameter (cm), flesh thickness (mm), rind thickness (mm), yield per plant (Kg), total yield per hectare, total soluble solids.

Chikkeri *et al.,* (2018) studied genetic variability and heritability in 31 genotypes of bottle gourd for various traits. Results revealed maximum phenotypic and genotypic coefficients (PCV and GCV) were observed for fruit diameter (26.06 and 27.10cm) and nodes to first male flower (22.77 and 24.87). Moderate values were predicted for fruit yield per vine (14.56 a) and number of fruits per vine (19.21 and 20.82). (15.51 and 16.55). moreover, the diameter of the fruit, length of the fruit, nodes to the first male flower and weight of 100 seeds were all found to have estimated high heritability along with high genetic advance as a percentage of the mean,

indicating that these traits were strongly influenced by additive gene action. Days to first male flower anthesis, days to first female flower anthesis, days to first fruit picking and days to 50% blooming were observed to have moderate heritability and low genetic advance values.

Varalakshmi *et al.,* (2018) reported that vine length, branch number, fruit length, fruit breadth, fruit yield per vine, and yield per ha all showed high heritability (in the broad sense) together with significant genetic progress, showing the presence of additive gene effects, and selection may be used to increase these characteristics.

Rambabu *et al.,* (2017) indicated that among the bottle gourd genotypes there are many features tested in which fruit characters, particularly fruit form and fruit colour, showed the most variety. Results of the analysis of variance showed that all of the characters' genotypes differed significantly. Moreover, high genetic progress and heritability as a proportion of mean was observed for total vine length, days to first male flower appearance at early node, days to first female flower appearance at early node, days to first picking, number of fruits per plant, average fruit weight, fruit length, fruit diameter, fruit yield per plant, total soluble solids of the pulp and ascorbic acid content of the pulp.

Deepthi *et al.,* (2016) undertook a bottle gourd experiment to investigate genetic diversity, heritability and to identify viable genotypes for future development projects. The results showed that there was a wide range of variability along with high estimates of PCV and GCV for the number of primary branches per vine, node at which the first male flower appeared, number of fruits per vine, weight (g) and length (cm) and diameter (cm) of the fruits, yield per vine (Kg), total yield (t/ha), indicating that there was a high degree of variability. Also, high heritability along with high genetic advance, as observed by the percentage of mean for days until first male flower appearance, node at first male appeared, number of fruits per vine, fruit weight (g), fruit length (cm), fruit diameter (cm), yield per vine (Kg) and total yield per hectare, this suggested that these traits had an additive genetic influence and were hence more trustworthy for efficient selection.

Khan *et al.,* (2016) revealed extremely significant differences for all the examined features of bottle gourd genotypes, showing strong genetic variability. For fruit output (Kg/plant), the greatest GCV (63.07%) and PCV (63.75%) were noted. Furthermore, the broad sense heritability was high for all characters and that the genetic advance expressed as a percent of mean was also moderate to high for all economic traits, including the node to first staminate flower anthesis, node to first pistillate flower anthesis, days to first male flower anthesis, days

to first female flower anthesis, days to first picking, number of fruits per plant, fruit weight (Kg), fruit length (cm), fruit circumference (cm), vine length at the time of last harvest (m), fruit yield (Kg per plant).

Husna *et al.,* (2011) studied Variability, correlation and path analysis among different characters of thirty-one bottle gourd genotypes. The large genotypic coefficients of variation (GCV) were found for yield per plant and fruit weight, however low GCV was found for fruit width. Also, days of first male blooming and female flower pedicel length showed high heritability and strong genetic progress in percent of mean, indicating that this characteristic was under additive gene control and that selection for genetic improvement for this trait would be successful.

## 2.2 Coefficient correlation

The term correlation coefficient was given by Karl Pearson in 1902 and denoted by "r". It is used to measure the association between yield and it's contributing traits to determine the component trait on which selection can be based for genetic improvement in yield. For a plant breeder, it is essential to know the degree of relationship between yield and its contributing traits to facilitate the improvement in desirable traits. Correlation coefficient provides information on inter-character association of various yield components but when more characters are involved in the association analysis it becomes challenging to ascertain which trait actually contributes more towards yield.

Panigrahi *et al.,* (2018) revealed that the vine length, number of fruits per vine and length of fruit all exhibited positive and significant correlations with the fruit yield per vine. There was also a positive correlation between fruit yield per vine and yield per hectare at both the genotypic and phenotypic levels.

Varalakshmi *et al.,* (2018) found a substantial and positive relationship between fruit yield per hectare, fruit number per vine and fruit yield per vine at both the genotypic and phenotypic levels. Fruit weight (0.407), fruit length (0.339), fruit width (0.310), fruit yield per vine (0.249), days needed for first female flower emergence (0.224) and vine length had the most direct effects on fruit yield per hectare. Fruit quantity had the smallest direct effects on fruit yield per hectare (0.173).

Muralidharan *et al.,* (2017) undertook a study to analyse the quantitative and qualitative characteristics of bottle gourds. The bottle gourd's fruit output per plant was shown to be

significantly associated with both fruit weight and fruit flesh thickness (r = 0.522 and 0.644, respectively).

Mashilo *et al*., (2016) studied the genetic diversity of bottle gourd. Results showed significant and positive correlations between the number of fruits per plant with number of male flowers, number of female flowers, plant height and number of branches.

Janaranjani and Kanthaswamy, (2015) carried out an experiment with eighteen different characters in bottle gourd. Results showed positive correlation between fruit output and fruit pickings, fruit flesh thickness, and fruit per vine.

Mandal *et al*., (2015) showed a positive and substantial correlation between fruit yield per plant and fruit length and number per plant at both the genotypic and phenotypic levels. Negative associations of fruit yield per plant were noted with node number of first female flower and days to first harvest.

Husna *et al.,* (2014) studied variability, correlation and path analysis among different characters of thirty-one bottle gourd genotypes. Correlation studies revealed the significant association of yield per plant with vegetative characters number of branches per vine followed by leaf breadth at genotypic and phenotypic level.

Varpe *et al*., (2014) indicated that fruit yield and its entrails indicated a positive and significant correlation of fruit yield with fruit length, number of fruits per plant. Although first male flower appearance and first female flower appearance showed significant and negative correlation with fruit yield.

Raut *et al*., (2013) showed significant and positive correlation between fruit yield per plant and days until the first male flower appears (0.117), the number of male flowers per plant (0.192), the number of female flowers per plant (0.405), fruit length (0.369), fruit weight (0.157) and the number of fruits per plant (0.766) was found. which indicate that effective improvement in yield through these components could be achieved.

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

Husna *et al.,* (2011) studied Variability, correlation and path analysis among different characters of thirty-one bottle gourd genotypes. Results showed that at the most significant

correlation of yield per plant with reproductive features was the number of fruits per plant, followed by fruit weight.

Yadav *et al*., (2010) investigated 15 diverse genotypes of bottle gourd and reported a significant and positive correlation of fruit yield per plant with days to first female flower anthesis, vine length, number of primary branches per plant, length of fruit, fruit weight and number of fruits per plant.

Alok *et al*., (2007) Reported that yield per plant has positive and significant association with the number of fruits per plant yet has a negative significant correlation with days to first female flower anthesis at both genotypic and phenotypic levels.

Parvathi and Reddy, (2006) studied correlation between fruit yield per vine and 14 yield components were assessed in 5 parental genotypes of bottle gourd. Fruit yield per vine demonstrated a strong positive association with fruit weight, girth, fruit per vine, suggesting that bottle gourd fruit output may be improved by selection for these features.

Singh *et al.,* (2006) reported that yield per vine display positive and significant correlation with fruit diameter, fruit length, fruit weight and number of fruits per vine. Negative correlation of sex ratio (M/F) with yield per vine indicated that an increase in the number of female flowers per vine results in a corresponding decrease in sex ratio but increase in yield.

## 2.3 Path Analysis

Path coefficient, which allows the division of the correlation coefficient into the components of direct and indirect effects, is an evaluation of the direct influence of one variable on another. The path coefficient term was coined by Wright, (1921). In plant breeding this technique was first introduced by Dewey and Lu, (1959). The use of path coefficient analysis requires a cause-and-effect situation among variables. The direct and indirect impacts of the component characteristics on the yield are divided into separate correlation coefficients using path analysis. Wright, (1921) provides a useful method for determining both direct and indirect reasons of association. It also allows for a rigorous investigation of the 16 distinct factors that contributed to a particular correlation and, using a route analysis tool, assesses the relative weight of each accidental element.

Muralidharan *et al.,* (2017) undertook a study to analyse the quantitative and qualitative characteristics of bottle gourd genotypes. The findings of the path analysis study showed that the traits like vine length, number of primary branches, seeds per fruit, and pickings were the

most significant yield determinants due to their high direct effects and high indirect effects via many other yield-improving traits. This implies that in order to increase the production of bottle gourds, focus must be placed on these features during selection.

Mashilo *et al*., (2016) revealed high direct path coefficient value (0.96) between fruit weight and number of seeds per fruit. Also, positive direct path coefficient value (0.92) was exhibited between number of female flowers per plant and number of fruits per plant.

Janaranjani and Kanthaswamy, (2015) conducted correlation analyses and path analyses using 36 hybrid bottle gourds representing 18 distinct traits. According to the path analysis, fruit production was positively affected directly by the quantity of fruits per vine, days till the first female flower opened (0.800), fruit cavity (0.38096), and fruit weight (0.3738). However, fruit length (-0.37031) had a strong negative direct impact on fruit output per vine (-0.37031). Negative low direct effects on fruit yield per vine were noted for the number of primary branches (-0.1898), days to first male flower opening (- 1.10344), sex ratio (-0.14104), and number of pickings (-0.12244). The residual effect observed in the present study was 0.2976. The fruit weight exhibited positive direct effect on yield and indirectly influence through days to first male flower opening and number of seeds per fruit.

Husna *et al.,* (2014) studied variability, correlation and path analysis among different characters of thirty-one bottle gourd genotypes. Path co-efficient analysis indicated that vegetative features, specifically the number of branches per vine and leaf breadth, had the greatest direct impact on yield per plant.

Husna *et al.,* (2011) studied on variability, correlation and path analysis among different characters of 31 bottle gourd genotypes. based on Path co-efficient analysis found that fruit number per plant, followed by fruit weight had the greatest direct impact on yield per plant.

Alok *et al*., (2007) demonstrated that the biggest positive direct influence on production was caused by fruit diameter, number of fruits per plant, and yield per plant, with days to first male flower appearance, days to first female flower appearance, and days to first fruit harvest following. All the variables, with the exception of the number of initial male flowering nodes, fruit length, and days before the first female blooming, directly affected the yield. For indirect impacts, the days to the first male flowering, the number of nodes of the first female blooming, the days to edible fruit, the breadth of the fruit, and the number of fruits per plant all exhibited extremely significant and positive associations with yield per plant.

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

Dwivedi, (2000) In these trials, a path coefficient analysis on bottle gourds showed a significant direct positive influence of fruit production per plant on the number of fruits per plant, average green fruit weight, vine length, node number to first male flower, and fruit length. This indicated that the direct selection for these traits would result in an appreciable improvement of yield per plant.

## 2.4 Genetic Divergence

To identify the source of genes for a certain characteristic within the germplasm, evaluation of genetic diversity is important (Farhad *et al.,* 2010). The plant breeders always want to know the genetic divergence among the available varieties due to reasons that crosses between genetically diverse parents are likely to produce high heterotic effect (Ramanujam *et al*., 1974)

Ahmad *et al.,* (2021) assess the genetic diversity among fifteen genotypes of bottle gourd. Five clusters formed in the examination of genetic diversity, which indicated a high level of genetic variety. The clustering pattern demonstrated that genetic diversity and spatial diversity were unrelated. The analysis of the characters' percentage contributions to the expression of total genetic divergence revealed that the Days to 50% flowering (14.48%), Days of fruit set (12.95%), Vine length (m) (11.67%), Number of fruits per plant (10.93%), Days to first fruit (10.16%), Average fruit weight (g) (9.44%), and Fruit diameter (cm) (6.63%) made the largest contributions to the expression of total genetic divergence. The genotype from cluster II (GP7) should be crossed with the genotypes of cluster I (GP-5), cluster IV (GP-2), and cluster III (GP-1), as this may result in the development of a wide range of advantageous genetic diversity for the improvement of yield in bottle gourd.

Rambabu *et al.,* (2020) assessed genetic divergence among twenty-one genotypes of bottle gourd for sixteen quantitative characters using Mahalanobis' $D^2$ statistics. Six clusters of genotypes were created. The highest contribution to divergence came from fruit production per plant (53.81%), then pulp ascorbic acid content (28.10%), fruit seed density (4.29%), and pulp TSS (4.29%). Cluster I and Cluster VI had the greatest intercluster distance, which was followed by Cluster VI and Cluster V. Most of the attributes associated with genotypes in cluster I had the highest cluster mean values. Six promising and diverse inbred lines or varieties of bottle

gourd, including RJBGC-140, RJBGC-118, BOGVAR-2, Pusa Samridhi (from cluster I), Arka Bahar (from cluster VI), and Pusa Sandesh (from cluster V), were chosen as parents for the exploitation of bottle gourds based on superior mean performance for fruit yield per plant, genetic distances, and clustering pattern.

Rehan *et al.,* (2020) evaluated the genetic diversity and genetic variability of 24 genotypes of bottle gourd. A significant amount of genetic variety was discovered among genotypes, according to Mahalanobis $D^2$ analysis. Twenty-four bottle gourd genotypes were studied in all, and they were divided into five clusters. The two clusters with the most genotypes were I (19 genotypes) and III (2 genotypes). Cluster V and Cluster I had the highest inter-cluster $D^2$ value, and Cluster V and III had the lowest inter-cluster $D^2$ value. The genotypes of Cluster V and Cluster I are not closely connected, according to the greatest inter-cluster $D^2$ values, however the genotypes of Cluster II, Cluster III, and Cluster IV are, according to the minimum inter-cluster $D^2$ value.

Quamruzzaman *et al.,* (2020) germplasm was constellated into five separate groups, ranging from three genomes in cluster III to six genomes in clusters II and IV. In every instance, the intra-cluster distance was smaller than the inter-cluster distance. Cluster IV contained the greatest intra-cluster value (2.65). Cluster I and V's germplasm had the greatest inter-cluster distance (12.24), followed by cluster I and III (12.05), while cluster I and IV's germplasm had the smallest (12.04). (3.46). Cluster I, Cluster IV, and Cluster III did well in terms of the cluster means values and yield contributing performance. Inbreeds are found in clusters I, IV, and III, which are determined by group distance, inter-genotypic crossings, and cluster means.

Chetariya and vaddoria, (2017) stated that the clustering pattern suggested that genetic diversity and spatial diversity were not related. In the analysis of the percent contribution of various characters towards the expression of total genetic divergence, the number of fruits per vine (22.45%) was followed by primary branches per vine (13.80%), average fruit weight (11.51%), vine length (11.18%), fruit yield per vine (10.61%), number of male flowers (7.84%), fruit length (6.45%), ratio of male to female flowers (4.82%), days to first picking (4.49%), and days to opening of first male flower (3.84%). according to the greatest genetic distance. It is recommended that genotypes from cluster XII (GP-14) be mated with genotypes from clusters IV (GP-25) and XI (GP-53), as this may result in the development of a wide range of advantageous genetic diversity for bottle gourd yield improvement.

Damor *et al.,* (2017) carried out an experiment to analyse the genetic diversity, for the yield and its contributing traits in bottle gourd. Through the use of Mahalanobis $D^2$ statistics, seven clusters were formed among the forty bottle gourd genotypes. It was clear from the clustering pattern that there was no connection between spatial and genetic diversity. Clusters II and IV showed the greatest genetic difference, followed by clusters III and VII. Fruit weight, followed by total sugar content, pedicel length, antioxidant activity, fruit length, fruit girth, number of fruits per plant, and the number of initial female blooming nodes, all played major roles in the genetic divergence. Based on intercluster distances, combining genotypes from clusters II and IV can provide a wide range of diversity in segregating generations, allowing for the use of selection to increase yield.

Damor *et al.*, (2017) studied 40 bottle gourd genotypes, at main vegetable research station, Anand Agricultural University, Anand, during Kharif, 2015. 40 genotypes of bottle gourds were grouped into seven clusters, through Mahalanobis $D^2$ Statistics. The clustering pattern indicated the absence of, relationship between geographical diversity and genetic diversity.

Visen *et al.*, (2015) studied 31 genotypes of bottle gourd for genetic divergence. Based on $D^2$ values, the cluster analysis put all 34 genotypes of 31-bottle gourds into 5 primary clusters. Extreme genetic diversity was estimated among the cluster.

Ara *et al.*, (2014) studied genetic diversity of 28 bottle gourd genotypes. On the basis of $D^2$ values, twenty-eight genotypes were grouped into five different clusters. This indicated the existence of genetic diversity among the genotypes. Maximum genotypes were in cluster I involving 10 genotypes, followed by cluster II with 9 genotypes. Cluster III, cluster IV and cluster V had 4, 3 and 2 genotypes, respectively. The genotypes from different origins (districts) assembled into a cluster with plants of close affinity. These results showed that geographic diversity may not necessarily be related with genetic diversity. Therefore, the selection of genotypes for hybridization should be based.

Devi *et al.*, (2013) studied genetic diversity among 50 genotypes of snake gourd using Mahalanobis $D^2$ statistic. Based on D analysis, the genotypes were grouped into four different clusters, where the cluster 33 possessed higher number (32) of genotypes followed by the cluster II (2), III (15) and IV (1). The maximum inter-cluster distance was observed between the clusters III and cluster IV and that of minimum in between the Clusters I and Cluster II. In case of intra-

cluster distance, the maximum distance was observed in the cluster III and that of minimum was observed in the cluster IV.

Laxuman *et al.,* (2012) studied genetic diversity of 28 bitter gourd genotypes. The genotypes were grouped into four clusters. All clusters were having two parental genotypes. Cluster I and cluster III were nearest to each other with inter cluster distance of 268.648 and cluster III and cluster IV were most diverse as they had maximum distance of 298.173. Cluster I was in close proximity to cluster III (268.648) as compared to cluster II (276.223) and cluster IV (283.403). Cluster II was nearest to cluster IV (278.048) and farthest from cluster III (288.998). The intra cluster distance was also estimated for all the four clusters. Intra cluster distance was highest in cluster IV (246.729) followed by cluster III (230.862), cluster II (213.822) and cluster I (209.090).

Choudhary *et al*., (2011) conducted research on the genetic diversity of 35 bottle gourd varieties. Four groups were formed from the genotypes. While cluster III was represented by three genotypes, cluster IV was very large and contained 16 genotypes. Clusters II and IV had the greatest intercluster distance, whereas clusters I and II had the minimum distance.

# 3. MATERIALS AND METHOD

The present investigation on the "Studies on genetic diversity in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was implemented during the *kharif* 2022. The details of the experimental materials, observations and methods or techniques adopted during the course of the investigation are presented in this chapter.

## 3.1 Site of the experiment

Rani Lakshmi Bai Central Agricultural University (RLBCAU) is situated in the Bundelkhand agro-climatic zone (6) of Uttar Pradesh. The experiment was conducted in the Vegetable Research Farm (Block- B) of RLBCAU, Jhansi. The experimental site is situated at 25.30° N latitude and 78.32° E longitude at an altitude of 227 m above mean sea level.

## 3.2 Climate and weather

Bundelkhand is a sub-tropical and semi-arid place subjected to the severe warm summer season and cold wintry weather. The average annual rainfall of this region varies from 867-1062 mm. The metrological data for the cropping season during *kharif 2022* is presented in table: -

**3.2.1 Meteorological data weekly average for the crop period (*kharif 2022*)**

| Month | Max. Temp. | Min. Temp. | Max. R.H. | Min. R.H. | Max. Rainfall mm | Min. Rainfall mm |
|---|---|---|---|---|---|---|
| **July 2022** | 34.2 | 27.0 | 84.60 | 58.50 | 21.95 | 0.01 |
| **Aug 2022** | 32.99 | 26.22 | 85.04 | 62.06 | 15.05 | 0.75 |
| **Sep 2022** | 33.96 | 25.97 | 85.46 | 57.00 | 18.67 | 0.04 |
| **Oct 2022** | 33.13 | 20.70 | 102.97 | 39.53 | 3.95 | 0.31 |
| **Nov 2022** | 33.91 | 18.21 | 82.24 | 28.38 | 0 | 0 |

## 3.3 Soil condition of the experimental field

A soil sample was taken from a depth of 15 cm below the surface of the experimental field, before seed sowing the crop for experiment. The sample was placed to laboratory analysis to determine the physical and chemical compositions by using various standard methods. It was observed that soil of the experimental plot was sandy loam having pH 6.8 which show the neutral nature of experimental soil. The electrical conductivity was 0.4dS/m and organic carbon content of soil was 2.04g/Kg of soil.

## 3.4 Experimental material

The experimental material comprises 30 bottle gourd genotypes collected from different sources like CAUs, SAUs, ICAR-Institutions, local collections and private companies. The experimental genotypes were grown in the Vegetable Research Farm near the College of Horticultural and Forestry RLBCAU, Jhansi which are shown in Table (3.4.1)

**Table (3.4.1): - Genotypes of bottle gourd and their sources of collections**

| Treatment | Name of genotypes | Sources |
|---|---|---|
| T1 | Sharada | Monsanto Holdings Pvt. Ltd. |
| T2 | Pusa Santushti | IARI, New Delhi |
| T3 | Amrit $F_1$ | HM. Clause India Pvt. Ltd. |
| T4 | Narendra Shishir | NDUAT, Faizabad, Uttar Prades |
| T5 | Surag | Tropical Seeds Pvt. Ltd. |
| T6 | Madhu Sree | NDUAT, Faizabad, Uttar Pradesh |
| T7 | Pusa Samrudhi | IARI, New Delhi |
| T8 | IC-594545 | MPUAT, Udaipur, Rajasthan |
| T9 | RBG-1 | Local collection, Lalitpur, Uttar Pradesh |
| T10 | RBG-2 | Local collection, Udaipur, Rajasthan |
| T11 | RBG-3 | Local collection, Kota, Rajasthan |
| T12 | RBG-4 | Local collection, Udaipur, Rajasthan |
| T13 | RBG-5 | Local collection, Jhalawar, Rajasthan |
| T14 | RBG-6 | Local collection, Jobner, Rajasthan |
| T15 | RBG-7 | Local collection, Udaipur, Rajasthan |
| T16 | Pusa Naveen | IARI, New Delhi |
| T17 | Hybrid Green Gold | Speciality Seeds Pvt. Ltd. |
| T18 | MAHY 8 | MAHYCO |

| | | |
|---|---|---|
| T19 | Muskan | Pahuja Seeds Pvt. Ltd. |
| T20 | Mahi | VNR Seed Pvt. Ltd. |
| T21 | Narendra Madhuri | NDUAT, Faizabad, Uttar Pradesh |
| T22 | Arka Bahar | IIHR, Bangalore |
| T23 | RBG-8 | Local collection, Kota, Rajasthan |
| T24 | RBG-9 | Local collection, Jhalawar, Rajasthan |
| T25 | RBG-10 | Local collection, Kota, Rajasthan |
| T26 | RBG-11 | Local collection, Jobner, Rajasthan |
| T27 | RBG-12 | Local collection, Jhalawar, Rajasthan |
| T28 | RBG-13 | Local collection, Kota, Rajasthan |
| T29 | RBG-14 | Local collection, Jhalawar, Rajasthan |
| T30 | RBG-16 | Local collection, Jobner, Rajasthan |

**Table (3.4.2) Experimental Design:**

| | | |
|---|---|---|
| **1.** | **Title of the Experiment** | **Studies on genetic diversity in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]** |
| **2.** | **Location** | College of Horticulture and Forestry, RLBCAU, Jhansi |
| **3.** | **Year of commencement** | *Kharif* 2022 |
| **4.** | **Experimental design** | RBD |
| **5.** | **Sowing date** | 17 July 2022 |
| **6.** | **Spacing** | 3 x 3 m |
| **7.** | **Number of replications** | 3 |
| **8.** | **Number of genotypes** | 30 |
| **9.** | **Number of plots** | 90 |

## 3.5 Layout of experimental field

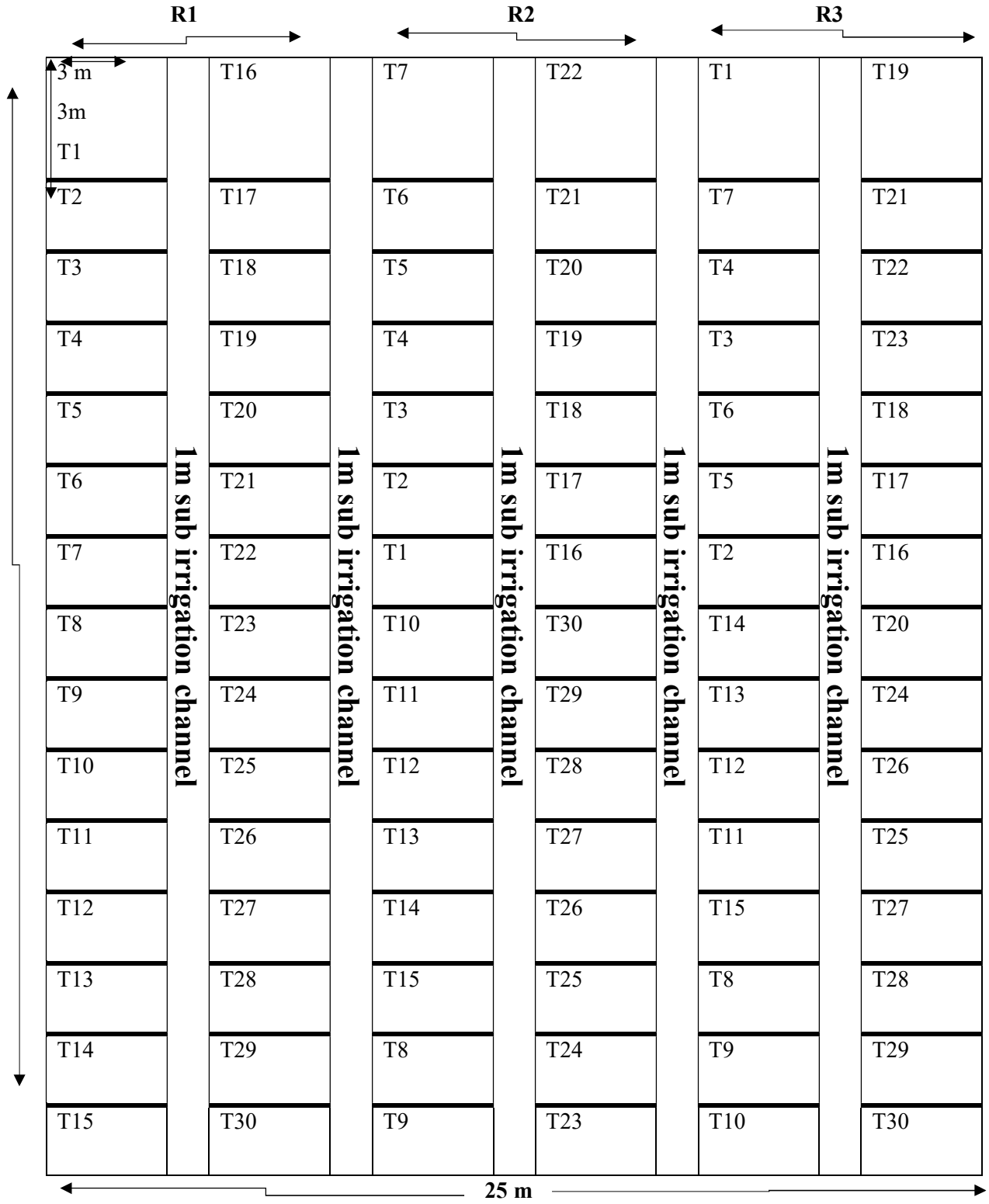


Fig 3.1 Layout of experimental field

## 3.6 Observations recorded

Observation for all the characters were recorded in three selected plants of each treatment. Detailed procedure followed to record in each character is given below.

## A. Growth and flowering parameters: -

**1. Vine length (cm)**

The length of vine was measured in three randomly selected plants with help of measuring tape from base of the vine to the growing tip of main shoot at final harvest.

**2. Days to first flowering bud**

Number of days taken from sowing to the appearance of first flower bud on three selected plants in each plot was noted and average days to first flowering were calculated.

**3. Node number to first male flower appearance**

Node number at which first male flower appeared in three selected plants of a plot was recorded and average was calculated.

**4. Node number to first female flower appearance**

Node number at which first female flower opened in three selected plants of a plot was recorded as node number to first female flower and average was calculated.

## B. yield parameters: -

**1. Days to first fruit setting**

The number of days taken from sowing of seeds to the first fruit set of the three selected plants in each experimental plot was recorded and average was calculated.

**2. Days to first fruit picking**

The number of days taken from the date of sowing to the date of first harvest of the edible green tender fruits in three selected plants was recorded as days to first harvest for a particular genotype and average was calculated.

**3. Number of fruits per plant**

Total number of fruits per plant from three selected plants of each genotype were counted and average number of fruits was calculated.

**4. Fruit length (cm)**

A random sample of five fruits were taken from each plot to record fruit characteristics *viz.,* fruit length and fruit circumference, fruit length was measured from the peduncle end of the fruit up to the blossom scar point with the help of measuring tape. Total length of the five fruits was divided by five to obtain average length of fruit of the genotype.

**5. Fruit width (cm)**

Circumference of fruits was measured on the same random sample of ten fruits on which fruit length was recorded. It was measured in the middle of the fruit with the help of Digimatic venires caliper. Average circumference was calculated as arithmetic mean.

**6. Average fruit weight (g)**

Weight of fruits was measured on the same random sample of ten fruits on which fruit length and width was recorded.

**8. Yield per plant (Kg)**

The weight of harvested fruits of all picking from each observational plant were summed up after the last picking and the average fruit yield per plant in kilogram was calculated.

**9. Yield per ha (q)**

The weight of fruits obtained at all pickings was recorded and average yield per hectare was calculated by multiplication of the weight of fruit per plot and per hectare.

## C. Qualitative parameters: -

1. **Fruit shape:** Long, round, oval
2. **Surface:** glossy green or hairy surface
3. **Protein Content (mg/100g)**

**Method**: Kjeldahl method

**Procedure**:

0.2 g samples of dry bottle gourd were taken for weighed then transfer them into the digestion tube of the Gerhardt digestor in the duplicated sample and two spatulas from each sodium and copper sulphate were added to each tube. Then 10 ml of sulphuric acid was also added with sample digested until the tubes were seen in green colour and each the digested materials were dissolved into distilled water then transfers into a 100 ml of volumetrics flaked then made the mark. Each sample (10 ml) was transferred into the distillation tube then 20 ml of 4% of boric acid to added into 3-4 drops of mixed for the indicator. The indicator was placed in the collected conical flask to trap the safe rate of ammonium. The unit was equipped with 31-40% of NaOH then the facilitated operation for distilled water. Distillation was done only for 5 minutes the ammonium was collected with captured by the boric acid. The unit of distillation unit was rinsed with distilled water for 3 minutes. The boric acid turned from reddish to pink with green during the collection of the ammonium. The green colour was titrated against the HCl until the appearance of the colour turned to pink colour and blank sample run

simultaneously. The titrate values obtain put on the formula the multiply the factor 6.25 for get to protein percentage.

$$\text{Total Protein} = \frac{A}{AS} \times \text{Concentration of standard}$$

Where,

A = absorbance of sample,

As = absorbance of standard

**4.Total Soluble Solid ($^{o}$Brix)**

**Method:** Hand Refractometer

**Procedure** –

- firstly, clean the prism with tissue paper.
- The fresh bottle gourd crush by mottle and pestle for the extract of juice.
- The juice is squeezed with the help of a muslin cloth and drop on the one place prism.
- Thereafter the value direct by the eye piece of refractometer towards the light at room temperature.

**5. Ascorbic acid content (mg/100g)**

Ascorbic acid otherwise known as Vitamin C is antiscorbutic. It is present in citrus fruits, gooseberry, bitter gourd etc. in high amount. Generally, it is present in all fresh vegetables and fruits. It is water soluble and heat-labile vitamin. The method described below is easy, rapid and a large number of samples can be analysed in a short time.

**Materials**

1. Oxalic Acid (4%)

2. Dye Solution: Weigh 42mg sodium bicarbonate into a small volume of distilled water. Dissolve 52mg 2,6-dichlorophenol indophenol in it and make up to 200ml with distilled water.

3. Stock Standard Solution: Dissolve 100mg ascorbic acid in 100ml of 4% oxalic acid solution in a standard flask (1mg/ml).

4. Working Standard: Dilute 10ml of stock solution to 100ml with 4% oxalic acid. The concentration of working standard is 100ug/ml

**Principle**

Ascorbic acid reduces the 2, 6-dichlorophenol indophenol dye to a colourless leuco-base. The ascorbic acid gets oxidized to dehydroascorbic acid. Though the dye is a blue coloured

compound, the end point is the appearance of pink colour. The dye is pink colour in acidic medium. Oxalic acid is used as the titrating medium.

**Procedure**

1. Pipette out 5ml of the working standard solution into a 100ml of conical flask.
2. Add 10ml of 4% oxalic acid and titrate against the dye (V1 ml). End point is the appearance of pink colour which persists for a few minutes. The amount of dye consumed is equivalent to the amount of ascorbic acid.
3. Extract the sample (0.5-5g depending on the sample) in 4% oxalic acid and make up to a known volume (100ml) and centrifuge.
4. Pipette out 5ml of this supernatant, add 10ml of 4% oxalic acid and titrate against the dye (V2 ml).

**Calculations**

Amount of ascorbic acid mg/100ml sample

$$\frac{0.5\text{mg}}{\text{V1ml}} \times \frac{\text{V2ml}}{5\text{ml}} \times \frac{100\text{ML}}{\text{Wt. of the sample}} \times 100$$

## 3.7 Statistical Analysis:

1. Analysis of Variance (Panse and Shukhatme, 1967)
2. Coefficient of Variation (Burton and De Vane, 1953)
3. Heritability Broad Sense (Burton and De Vane, 1953)
4. Correlation Coefficient Analysis (Al-Jibouri *et al.*, 1958)
5. Path coefficient analysis (Dewey and Lu, 1959)
6. Mahalanobis $D^2$ analysis (Mahalanobis, P.C.,1936)

### 3.7.1 Analysis of Variance

Analysis of variance was done to estimate total variance into total variation due to the treatments and replications according to procedure described by Panse and Sukhatme (1957). Structure of analysis of variance is given below:

**Table (3.6) ANOVA table for randomized block design**

| Source of variation | Degree of freedom | Mean sum of square | F ratio |
|---|---|---|---|
| Replication | r-1 | MSR | MSR/MSE |
| Treatments | t-1 | MST | MST/MSE |
| Error | (r-1) (t-1) | MSE | |
| Total | rt-1 | | |

Where,

r = Number of replications

t=Number of treatments/genotypes

MSR = Mean square due to replications

MST = Mean square due to treatments

MSE = Mean square due to error

**Standard Error of Mean (SEm)**

Standard error of mean was calculated by formula

SEm = √EMS/r

**Critical difference**

Critical difference was calculated by the following formula

Critical difference = √2 x SEm/r x t value at 5% level of significance

Where,

SEm = Standard error of mean

r = Number of replications

t = Table value of 't' distribution at error d. f. on $P<0.05$ and 0.01.

**Test of significance**

If the variance of F-calculated value of (MSS (T)/ EMS) for treatment was greater than the F-table value at 5% and 1% level of significance, the variance between treatments was considered to be significant. If the F-calculated value is less than F-tabulated value, the differences between treatments were considered to be non-significant. Statistical significance of variation due to genotype was tested by comparing calculated values to Table F values at the one per cent and five per cent level of probability.

**Mean**

Mean value of each character was worked out by dividing the totals by the corresponding number of observations.

Mean = ⍰X/N

Where,

⍰X = Sum of all the observations for each character in each replication.N

= Corresponding number of observations.

**Range**

Lower and upper limits of mean values for each character was arrange to measure the range of variation for the character.

Range = R2 - R1

Where,

R2 = Highest mean

R1= Lowest mean

**3.7.2 Coefficient of variation**

Genotypic and phenotypic coefficients of variation were computed according to Burton and De Vane (1953) based on the estimate of genotypic and phenotypic variance as follows:

$$GCV = \sqrt{GV} / \bar{x} \times 100$$

$$PCV = \sqrt{PV} / \bar{x} \times 100$$

Where,

GV = Genotypic variance

PV = Phenotypic variance

$\bar{X}$ = Grand mean

PCV and GCV were classified as suggested by Robinson *et al*. (1949)

Less than 10%: Low

10 to 20%: Moderate

More than 20%: High

Phenotypic variance (σ2 p) Phenotypic variance (σ2 p) denotes the total variance present in a population for particular character and is calculated by following formula

σ 2 p = σ 2 g + σ2 e

Where,

σ 2 g = Genotypic variance

σ 2 e = Error variance

**3.7.3 Heritability ($h^2$)**

Heritability in broad sense is the ratio of genotypic variance to total or phenotypic variance. It is that portion of total variability or phenotypic variability which is heritable and due to the genotype. It was calculated by the formula given by Lush (1949) and Burton and De Vane (1953).

$$h^2(bs) = \frac{\sigma_g^2}{\sigma_p^2} X\ 100$$

Where,

σ 2 g = genotypic variance

σ 2 p = phenotypic variance

$h^2$ (bs) = Heritability in broad sense

Heritability- The higher the value of heritability more is the genetic advance.

As suggested by Johnson *et al*. (1955), heritability values are categorized as follows:

Less than 30%: Low

30 to 60%: Moderate

More than 60%: High

The heritability percentage is observed as high then it indicates that characters are least influenced by the environment and selection for this type of characters are fruitful for improvement purpose. If the heritability percentage is found to be low indicates that characters are highly influenced by the environment and genetic improvement through selection is difficult for these characters.

**Genetic Advance**

The genetic advance that is, expected genetic gain was worked out by using the formula suggested by Lush (1949) and Johnson *et al*. (1955). Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection that heritability estimates alone.

$GA = K. h^2. \sigma_p$

Where, GA = Genetic advance

K= Selection coefficient, which assumes the value of 2.06 for 50% selection intensity.

$h^2$ = Heritability

σp = Phenotypic standard deviation

**Genetic advance as % of mean**

It was calculated by the following formula:

Genetic advance as % mean = Genetic advance / General mean X 100

The range of genetic advance as percent of mean is classified as suggested by Johnson *et al.* (1955)

Less than 10 percent = Low

10-20 percent = Moderate

More than 20 percent = High

**3.7.4 Correlation coefficient analysis**

Correlation coefficient analysis reveals the association of characters *i.e.*, a change in one character brought about by a change in the other character. Phenotypic and genotypic correlation coefficients between different variables were calculated by using the covariance technique (Al-

Jibouri *et al.* 1958). The correlation coefficients among all possible traits combinations at genotypic (rg) and phenotypic (rp) level were estimated using formula by Johnson *et al.* (1955).

$$r_{xy} = \frac{\sqrt{\Sigma (Xi - \bar{X})(Y_i - \bar{Y})}}{\sqrt{\sum (Xi - \bar{X})^2 \sum (Yi - \bar{Y})^2}}$$

Rxy – the correlation coefficient of the linear relationship among the variables x and y

$\bar{x}$ – the mean of the values of x-variable

$\bar{y}$ – the mean of the values of y-variable

xi – the values of the x-variable in sample

yi – the values of the y-variable in sample

$$\text{Correlation} = \frac{\text{Cov}(x,y)}{\sigma x . \sigma y}$$

rg = Covg(xy) / □□ 2rg 1 x □ 2 rg 2 rp

= Covp (xy) / □□ 2 rp 1 x □ 2 rp 2

Where,

rp (xy)= phenotypic correlation coefficient

rg (xy)= genotypic correlation coefficient

Covp, Covg are the phenotypic and genotypic covariance of y and x, respectively

σ 2p and σ 2g are the phenotypic and genotypic variance of y and x, respectively.

**Test of significance**

To test the significance of correlation coefficient, the estimated values were compared with table value of correlation coefficient prescribed by Fisher and Yates (1938) at (n-2) treatment degree of freedom at 5% and 1% level of significant. If the calculated value of correlation coefficient is greater than tabulated value, it is considered to be significant and vice-versa.

### 3.7.5 Path Coefficient Analysis

Path coefficient analysis term coined by Wright (1921) and explained by Dewey and Lu (1959) was executed separately to know the direct and indirect effects of the important component traits on yield per plant. Standard path coefficients which are the standardized partial regression coefficient were obtained by solving the following set of "P" simultaneous equations through the use of Do-little technique as given by Goulden (1959).

$P_{01} + P_{02}r_{12} + \ldots \ldots + P_{op}r_{1p} = r_{01}$

$P_{01}r_{12} + P_{02} + \ldots \ldots + P_{op}r_{2p} = r_{02}$

$P_{0p}r_{1p} + P_{02}r_{2p} + \ldots \ldots + P_{op} = r_{op}$

Where $P_{01}$, $P_{02}$, … are the direct path effects of 1, 2, ……, P variables on zero variables $r_{12}$, $r_{13}$, ……$r_{1p}r_p$, (p-1) are the possible coefficients between dependent variable and independent variables and $r_{01}$, $r_{02}$, ……$r_{op}$ are the correlation coefficients between dependent variable and independent variables.

The indirect effect of ith variable through jth variable was worked out as (Poj x rij).

The contribution of the remaining unknown was measured as the residual factor and was calculated as:

$P\ 2\ ox = 1 - (P^{\ 2}{}_{01} + 2P_{01}P_{02}r_{12} + 2P_{01}P_{03}r_{13} + \ldots \ldots + P^{\ 2}{}_{02} + 2P_{02}P_{03}r_{23} + P^{\ 2}{}_{op})$

Residual factor = $P^2_{ox}$

Later the path coefficients were rated based on the scales given below (Lenka and Mishra, 1973).

More than 1.00 = Very high

0.3-0.99 = High

0.2-0.29 = Moderate

0.1-0.19 = Low

0.0-0.09 = Negligible

### 3.7.6 Genetic Divergence

Mahalanobis $D^2$ analysis

Mahalanobis (1936) the generalized distance between two populations is calculated by formula.

$D^2 = \Sigma\Sigma\lambda ij SiSj$

Where, $D^2$ = Square of generalized distance

$\lambda ij$= Reciprocal of the common dispersal matrix

Si = ($\mu i$ 1 – $\mu i$ 2)

Sj = ($\mu j$ 1 – $\mu j$ 2)

$\mu$ = General mean

**Transformation of correlated variables**

The original means were subjected to get the un-correlated transformed variable with the standard deviation unity. The correlated values (Xs) were first transformed to uncorrelated ones (Ys), following the pivotal condensation method (Rao 1952). The Yi was then transformed to Yjs by division of the corresponding standard deviation with relation.

$Yi = Yj/Y_{ar}(y_j)0.5$

So, as to make the variance of Yi =1

**Calculation of $D^2$ values**

$D^2$ between any two populations or genotypes was calculated as the sum of squares of differences in the values between pairs of corresponding mean values of the transformed characters.

$\sum(Yi^2 - Yj^2)^2 = D^2$

Where, i=1,2, 3...p

**Contribution of individual characters towards divergence**

In the combinations each character was ranked on the basis of $di = yi^j - yi^k$ values. Rank 1 was given to highest mean difference and ranked p to the lowest mean differences, where P is the total number of characters.

**Testing the significance of $D^2$ values**

The $D^2$ value obtained for a pair of population is taken as the calculated value of $X^2$ and is tested against the tested value $D^2$ for 'p' degrees of freedom, where p is number of characters considered.

**Group constellation**

The $D^2$ values were arranged in increasing order of magnitude. Tocher's method of clustering was used for clustering of genotypes (Rao, 1952). The 2 most closely associated genotypes were chosen and then a 3 genotype was found which had the smaller average $D^2$ from the first three and so on.

**Cluster mean**

The cluster mean for a particular trait is the summation of mean values of the genotypes included in a cluster divided by number of genotypes in the cluster.

**Intra and inter-cluster distances**

The intra cluster $D^2$ was calculated by the formula $\sum Di^2/n$, where $Di^2$ is the sum of the distances between all possible combinations [n = i (i-1)/2] of the genotypes (i) includes in a cluster. All possible $D^2$ values between the genotypes of two clusters were added then divided by $n_1 \times n_2$ for computing inter -cluster distance.

Where, $n_1$ and $n_2$ = the number of genotypes in 2 clusters.

The square root of average $D^2$ value was used to calculate the average intra and inter-cluster D values. Average intra and inter cluster (D) = $\sqrt{D^2}$ value.

**Cluster diagram**

Using intra (D) and inter cluster ($D^2$) values between and within clusters, cluster diagram showing the relationship between different populations was drawn.

# 4. RESULTS AND DISCUSSION

The experimental findings of the present investigation entitled "Studies on genetic diversity in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was carried out with thirty bottle gourd genotypes. These genotypes of bottle gourd were grown in three replications in Randomized Block Design. The results obtained for genotypic and phenotypic coefficient of variation, heritability in broad sense, genetic advance and genetic advance as percent of mean, correlation coefficient analysis, path coefficient analysis have been discussed under the following sub-heads:

4.1 Analysis of variance,

4.2 Mean performance of genotypes,

4.3 Genetic variability, heritability, genetic advance,

4.4 Correlation coefficient analysis,

4.5 Path coefficient analysis

4.6 Genetic divergence

## 4.1 Analysis of variance

Analysis of variance showed significant differences among all the 30 genotypes for the 15 characters studied. Analysis of variance showed significant differences among the genotypes both at 1% and 5% level of significance. The mean sum squares are given in table (4.1.1) for different studied characters. The highly significant mean sum of squares was recorded for the traits *viz*., vine length, days to first flowering bud, node number to first male flower appearance, node number to first female flower appearance, days to first fruit setting, days to first fruit picking, number of fruits per plant, fruit length, fruit width, average fruit weight, yield per plant, yield per hectare, total soluble solid, protein content and ascorbic acid content, revealed significant difference for all the parameters, indicating sufficient amount of variation among all the germplasm for all parameters under the study. Bhatt *et al.,* (2022), Dubey *et al.,* (2022), Kumar *et al.,* (2021), Singh *et al.,* (2021), Venkatraman, (2021), Rashid *et al.,* (2020), Ahmad *et al.,* (2019) and Chikkeri *et al.,* (2018) also recorded highly significant differences among the bottle gourd genotypes with respect to most of the characters under their studies.

**Table 4.1.1 ANOVA analysis of bottle gourd genotypes for different characters**

| S. No. | Characters | Source of variation | | |
|---|---|---|---|---|
| | | Replications Mean sum of squares | Treatments Mean sum of squares | Error |
| 1. | d.f | 2 | 29 | 58 |
| 2 | Vine length | 567.8 | 17813.2** | 1286.2 |
| 3 | Days to first flowering bud | 4.011 | 39.815** | 1.448 |
| 4 | Node number to first male flower appearance | 0.433 | 5.848** | 0.881 |
| 5 | Node number to first female flower appearance | 0.300 | 5.572** | 1.334 |
| 6 | Days to first fruit setting | 6.933 | 62.974** | 2.807 |
| 7 | Days to first fruit picking | 5.633 | 66.460** | 3.955 |
| 8 | Number of fruits per plant | 0.344 | 4.470** | 0.298 |
| 9 | Fruit length | 4.633 | 281.641** | 5.116 |
| 10 | Fruit width | 0.446 | 20.031** | 0.732 |
| 11 | Average fruit weight | 0.004 | 0.082** | 0.009 |
| 12 | Yield per plant | 0.505 | 8.688** | 0.656 |
| 13 | Yield per ha | 1559.2 | 26816.3** | 2025.2 |
| 14 | Total Soluble Solid | 0.007 | 0.908** | 0.009 |
| 15 | Protein Content | 210.6 | 3949.1** | 77.4 |
| 16 | Ascorbic acid content | 0.040 | 9.287** | 0.136 |

***Significant at 5% level of probability, ** Significant at 1% level of probability**

## 4.2 Mean performance of genotypes

The wide range of genetic variability inherent in the experimental materials allows superior genotypes to be selected based on many characters. Mean values and ranges for 15 characters of different genotypes are shown in table (4.2.1) and fig. (4.1), (4.2), (4.3), (4.4)

## A. Growth and flowering parameters: -

### 4.2.1 Vine length

The vine length ranged from 570 cm to 800 cm with mean of 697.4 cm. The maximum vine length 800cm was recorded in RBG 9 (800.0) followed by IC-594545 (786.7cm) and RBG 4 (786.7cm). Whereas, the minimum vine length was statistically observed in Pusa Santushti (570cm) followed by Sharada (593.3cm) and Surag (613.3cm).

### 4.2.2 Days to first flowering bud

Days to first flowering bud ranged from 26.0 days to 39.3 days with mean of 32.2 days. Out of 30 genotypes the earlier flower bud was appeared for the variety Pusa Samrudhi (26.0 days) followed by Pusa Naveen (27.0 days), MAHY 8 (27.0 days) and Mahi (27.0 days). However, maximum days to first flower bud appearance takes place in Narendra Shishir (39.3 days) and RBG 10 (39.3 days) followed by RBG 2 (36.6 days) and Narendra Madhuri (36.0 days).

### 4.2.3 Node number to first male flower appearance

The node number to first male flower appearance ranged from 8.67 to 13.0 with mean of 10.9. The lowest node number to first staminate flower appearance was observed in case of IC-594545 (8.67) followed by RBG 5 (9.0) and RBG 12 (9.0). While, the highest was recorded in RBG 1 (13.0) and RBG 6 (13.0) followed by Narendra Madhuri (12.6) and Pusa Samrudhi (12.3).

### 4.2.4 Node number to first female flower appearance

The node number to first female flower appearance ranged from 10.6 to 15.3 with mean of 12.9. The earliest node number to first female flower appearance was observed in Pusa Samrudhi (10.6) followed by IC-594545 (11.0), RBG 3 (11.0) and RBG 13 (11.0). Whereas, the maximum was recorded for RBG 6 (15.3) and Mahi (15.0) followed by Narendra Madhuri (14.6), RBG 9 (14.6) and RBG 16 (14.6).

## B. Yield parameters: -

### 4.2.5 Days to first fruit set

Days to first fruit set ranged from 37.3 to 57.3 days with the mean of 46.9 days. The minimum days to first fruit set was recorded for MAHY 8 (37.3 days) followed by Mahi (40.0 days) and Pusa Samrudhi (42.0 days). However, maximum days to first fruit setting was noticed in Narendra Shishir (57.3 days) and RBG 10 (57.3 days) followed by RBG 2 (54.3 days).

### 4.2.6 Days to first fruit picking

Days to first fruit picking ranged from 46.0 to 66.3 days with mean of 55.6 days. The minimum days to fruit picking was recorded for MAHY 8 (46.0 days) followed by Mahi (48.0 days) and RBG 5 (50.6 days). However, maximum days to first fruit picking was observed in RBG 10 (66.3 days) followed by Narendra Shishir (65.6 days) and RBG 2 (65.3 days).

### 4.2.7 Number of fruits per plant

Number of fruits per plant ranged from 4.6 to 8.0 with mean of 6.4. The maximum number of fruits per plant observed in Hybrid Green Gold (8.0) followed by MAHY 8 (7.6), Amrit $F_1$ (7.6). Whereas, minimum number of fruits per plant recorded in RBG 5 (4.6) followed by RBG 1(5.0), RBG 2 (5.3) and RBG 3(5.3).

### 4.2.8 Fruit length (cm)

The average fruit length per plant ranged from 10.0cm to 46.6cm with mean of 30.7cm. The maximum fruit length was recorded in Muskan (46.6cm) followed by MAHY 8 (45.0cm) and RBG 2 (42.3cm). Whereas, the minimum fruit length was observed in IC-594545 (10.0cm) followed by RBG 4 (12.3cm) and Narendra Madhuri (15.0cm).

### 4.2.9 Fruit width (cm)

The average fruit width per plant ranged from 4.3cm to 12.6cm with mean of 6.9cm. The highest fruit width was recorded in Narendra Shishir (12.6cm) followed by IC-594545 (12.0cm), RBG 4 (11.7cm) and Narendra Madhuri (11.7cm). Whereas, the minimum fruit width was recorded in Muskan (4.3cm) followed by RBG 12 (4.3cm) and RBG 10 (4.8cm).

### 4.2.10 Average fruit weight (g)

The average fruit weight per plant ranged from 0.633g to 0.867g with mean of 0.750g. The highest fruit weight was recorded in Pusa Santushti (0.867g), IC-594545 (0.867g) and Pusa

Samrudhi (0.867g). Whereas, the lowest fruit weight was recorded in RBG 4 (0.667g) followed by RBG 9 (0.667g) and RBG 13 (0.667g).

### 4.2.11 Yield per plant (Kg)

Fruit yield per plant (Kg/plant) ranged from 3.43Kg to 6.60Kg with mean of 4.82Kg. The highest fruit yield per plant was recorded in Hybrid Green Gold (6.60Kg) followed by MAHY 8 (6.40Kg) and Pusa Samrudhi (6.30Kg). Whereas, the minimum fruit yield per plant was recorded in RBG 5 (3.43Kg) followed by RBG 9 (3.6 Kg), RBG 2(3.7 Kg) and RBG 3 (3.7Kg).

### 4.2.12 Yield per ha (q)

Fruit yield ranged from 193.6q to 344.8q with mean of 260.0 quintal per hectare. The maximum fruit yield was recorded in Hybrid Green Gold (344.8q) followed by MAHY 8 (339.9q) and Pusa Samrudhi (333.6q). Whereas, the minimum fruit yield (q/ha) was recorded in RBG 5 (193.6q) followed by RBG 3 (199.2q) and RBG 2 (201.0q).

## C. Qualitative parameters: -

### 4.2.13 Protein Content (mg/100g)

Protein content ranged from 138.1mg to 219.6mg with mean of 182.0mg. The high protein content observed in MAHY 8 (219.6mg) followed by Pusa Samrudhi (218.6mg) and Narendra Madhuri (213.3mg). Whereas, lowest protein content observed in Muskan (138.1mg) followed by RBG 3(145.9mg) and Pusa Santushti (155,1mg).

### 4.2.14 Total Soluble Solid (ºBrix)

The total soluble solid ranged from 1.67 ºBrix to 2.93 ºBrix with a general mean of 2.29 ºBrix. The highest value for total soluble solid was shown in RBG 9 (2.93 ºBrix) followed by RBG 4 (2.8 ºBrix) and RBG 16 (2.7 ºBrix). Whereas, lowest value was observed in the RBG 11 (1.67 ºBrix) followed by Pusa Naveen (1.70 ºBrix) and RBG 2 (1.83 ºBrix).

### 4.2.15 Ascorbic acid content (mg/100g)

The ascorbic acid content (mg/100g) ranged from 11.23mg to 16.97mg with mean of 14.61mg. The highest value for ascorbic acid content was observed in RBG 9 (16.97mg) and RBG 12 (16.97mg) followed by IC-594545 (16.67mg). however, lowest value was recorded in RBG 1(11.23mg) followed by Surag (11.90mg) and RBG 4 (12.37mg).

**Table 4.2.1 Mean performance of bottle gourd genotypes**

| S. No. | Genotypes | DFFB | FMFEN | FFFEN | FFS | FFP | FL | FW | F Wt | NFPP | YPP | YPH | VL | T.S. S | PC | AAC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | **Sharada** | 27.67 | 12.00 | 13.67 | 43.00 | 51.67 | 37.67 | 6.23 | 0.800 | 6.67 | 5.33 | 281.43 | 593.3 | 2.03 | 203.93 | 13.33 |
| **2.** | **Pusa Santushti** | 31.00 | 9.33 | 10.67 | 46.33 | 55.00 | 19.33 | 9.90 | 0.867 | 6.00 | 5.17 | 293.70 | 570.0 | 2.17 | 155.13 | 13.83 |
| **3.** | **Amrit $F_1$** | 34.00 | 10.33 | 13.33 | 48.00 | 56.67 | 38.33 | 6.20 | 0.767 | 7.67 | 5.87 | 325.13 | 696.7 | 2.20 | 170.50 | 15.63 |
| **4.** | **Narendra Shishir** | 39.33 | 11.67 | 14.00 | 57.33 | 65.67 | 20.00 | 12.67 | 0.833 | 6.33 | 5.30 | 281.43 | 706.7 | 2.07 | 159.33 | 16.40 |
| **5.** | **Surag** | 33.33 | 10.33 | 12.67 | 47.00 | 55.00 | 38.33 | 6.00 | 0.867 | 7.00 | 6.07 | 327.73 | 613.3 | 2.53 | 196.33 | 11.90 |
| **6** | **Madhu Sree** | 33.33 | 12.00 | 13.33 | 47.00 | 56.00 | 19.00 | 10.80 | 0.767 | 7.00 | 5.37 | 326.23 | 676.7 | 2.47 | 200.33 | 12.60 |
| **7.** | **Pusa Samrudhi** | 26.00 | 12.33 | 13.67 | 42.00 | 51.00 | 37.00 | 6.87 | 0.867 | 7.33 | 6.30 | 333.67 | 620.0 | 2.73 | 218.67 | 15.17 |
| **8.** | **IC-594545** | 31.67 | 8.67 | 11.00 | 45.33 | 54.00 | 10.00 | 12.07 | 0.867 | 6.67 | 5.83 | 287.00 | 786.7 | 2.37 | 165.13 | 16.67 |
| **9.** | **RBG-1** | 31.33 | 13.00 | 14.33 | 45.67 | 53.67 | 33.33 | 6.13 | 0.800 | 5.00 | 3.93 | 207.03 | 680.0 | 2.53 | 195.33 | 11.23 |
| **10.** | **RBG-2** | 36.67 | 9.67 | 11.67 | 54.33 | 65.33 | 42.33 | 5.33 | 0.700 | 5.33 | 3.70 | 201.07 | 733.3 | 1.83 | 182.67 | 16.40 |
| **11.** | **RBG-3** | 30.67 | 9.33 | 11.00 | 46.67 | 55.33 | 32.33 | 5.77 | 0.700 | 5.33 | 3.73 | 199.20 | 730.0 | 2.03 | 145.93 | 16.60 |
| **12.** | **RBG-4** | 30.00 | 9.33 | 11.33 | 46.00 | 54.00 | 12.33 | 11.70 | 0.667 | 6.67 | 4.57 | 241.43 | 786.7 | 2.83 | 182.33 | 12.37 |
| **13.** | **RBG-5** | 32.67 | 9.00 | 11.33 | 45.33 | 50.67 | 19.00 | 6.50 | 0.733 | 4.67 | 3.43 | 193.67 | 623.3 | 2.33 | 173.67 | 14.23 |
| **14.** | **RBG-6** | 32.33 | 13.00 | 15.33 | 43.67 | 52.00 | 20.00 | 11.10 | 0.633 | 7.00 | 4.33 | 244.03 | 706.7 | 2.13 | 178.40 | 13.87 |
| **15.** | **RBG-7** | 27.33 | 10.67 | 13.00 | 45.67 | 52.33 | 31.67 | 5.20 | 0.767 | 6.67 | 5.10 | 285.13 | 650.0 | 1.80 | 181.30 | 13.50 |
| **16.** | **Pusa Naveen** | 27.00 | 11.67 | 13.67 | 44.00 | 51.00 | 30.67 | 5.80 | 0.733 | 5.67 | 4.13 | 218.47 | 673.3 | 1.70 | 185.77 | 14.33 |
| **17.** | **Hybrid Green Gold** | 27.33 | 11.67 | 13.67 | 45.67 | 53.00 | 38.33 | 6.43 | 0.833 | 8.00 | 6.60 | 344.80 | 723.3 | 2.33 | 181.65 | 14.03 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **18.** | **MAHY 8** | 27.00 | 10.33 | 11.33 | 37.33 | 46.00 | 45.00 | 5.27 | 0.833 | 7.67 | 6.40 | 339.97 | 736.7 | 2.20 | 219.67 | 14.10 |
| **19.** | **Muskan** | 30.00 | 10.00 | 11.33 | 44.67 | 52.33 | 46.67 | 4.37 | 0.733 | 6.33 | 4.63 | 246.97 | 776.7 | 2.40 | 138.13 | 16.00 |
| **20.** | **Mahi** | 27.00 | 12.67 | 15.00 | 40.00 | 48.00 | 41.67 | 6.40 | 0.667 | 6.67 | 4.43 | 228.87 | 640.0 | 2.63 | 184.20 | 14.57 |
| **21.** | **Narendra Madhuri** | 36.00 | 12.67 | 14.67 | 47.00 | 60.67 | 15.00 | 11.70 | 0.767 | 5.33 | 4.10 | 219.20 | 686.7 | 2.37 | 213.33 | 14.60 |
| **22.** | **Arka Bahar** | 35.00 | 10.00 | 12.00 | 49.00 | 64.00 | 34.00 | 5.67 | 0.800 | 6.00 | 4.77 | 238.87 | 650.0 | 2.73 | 176.20 | 16.00 |
| **23.** | **RBG-8** | 30.67 | 12.00 | 13.67 | 43.33 | 56.67 | 30.67 | 5.67 | 0.740 | 5.67 | 4.18 | 212.93 | 683.3 | 2.23 | 174.33 | 15.17 |
| **24.** | **RBG-9** | 33.67 | 12.00 | 14.67 | 49.33 | 56.67 | 35.67 | 5.00 | 0.667 | 5.33 | 3.67 | 221.80 | 800.0 | 2.93 | 208.67 | 16.97 |
| **25.** | **RBG-10** | 39.33 | 10.33 | 13.00 | 57.33 | 66.33 | 30.67 | 4.83 | 0.767 | 7.67 | 5.90 | 321.03 | 740.0 | 2.03 | 182.67 | 16.13 |
| **26.** | **RBG-11** | 36.00 | 12.33 | 14.33 | 48.00 | 55.67 | 34.00 | 5.40 | 0.633 | 6.33 | 4.07 | 224.80 | 716.7 | 1.67 | 156.67 | 14.33 |
| **27.** | **RBG-12** | 33.33 | 9.00 | 11.67 | 49.67 | 56.67 | 33.00 | 4.30 | 0.633 | 6.67 | 4.20 | 229.23 | 773.3 | 2.10 | 202.67 | 16.97 |
| **28.** | **RBG-13** | 35.00 | 9.67 | 11.00 | 46.67 | 54.33 | 36.67 | 5.50 | 0.667 | 7.33 | 4.93 | 262.90 | 693.3 | 2.07 | 185.00 | 13.93 |
| **29.** | **RBG-14** | 36.67 | 10.00 | 13.00 | 50.67 | 58.67 | 33.33 | 5.53 | 0.700 | 6.67 | 4.70 | 247.37 | 750.0 | 2.60 | 182.67 | 14.40 |
| **30.** | **RBG-16** | 35.00 | 12.00 | 14.67 | 51.67 | 60.33 | 26.67 | 5.37 | 0.667 | 6.00 | 4.00 | 214.80 | 706.7 | 2.77 | 160.70 | 13.03 |
| | **Mean** | 32.21 | 10.90 | 12.93 | 46.92 | 55.62 | 30.76 | 6.99 | 0.75 | 6.42 | 4.82 | 260.00 | 697.44 | 2.29 | 182.04 | 14.61 |
| | **C.V** | 3.73 | 8.58 | 8.93 | 3.56 | 3.59 | 7.35 | 12.24 | 11.75 | 8.18 | 14.32 | 14.32 | 5.00 | 3.80 | 4.35 | 2.5666 |
| | **SEm ±** | 0.69 | 0.54 | 0.66 | 0.96 | 1.14 | 1.30 | 0.49 | 0.05 | 0.31 | 0.46 | 25.98 | 20.70 | 0.05 | 5.07 | 0.2132 |
| | **C.D. 5%** | 1.96 | 1.53 | 1.88 | 2.73 | 3.25 | 3.69 | 1.39 | 0.16 | 0.89 | 1.32 | 73.55 | 58.61 | 0.15 | 14.37 | 0.6034 |
| | **Lowest value** | 39.33 | 13.00 | 15.33 | 57.33 | 66.33 | 46.67 | 12.67 | 0.87 | 8.00 | 6.60 | 344.80 | 800.00 | 2.93 | 219.67 | 16.97 |
| | **Highest value** | 26.00 | 8.67 | 10.67 | 37.33 | 46.00 | 10.00 | 4.30 | 0.63 | 4.67 | 3.43 | 193.67 | 570.00 | 1.67 | 138.13 | 11.23 |

DFFB- days to first flowering bud, FMFEN- first male flower at early node, FFFEN- first female flower at early node, FFS- days to first fruit setting, FFP- days to first fruit picking, FL- fruit length (cm), FW- fruit width (cm), F Wt- average fruit weight (g), NFPP- number of fruits per plant, YPP- yield per plant (Kg), YPH- yield per ha (q), VL- vine length (cm), T.S.S- total Soluble Solid ($^{o}$Brix), PC- protein Content (mg/100g), ACC- ascorbic acid content (mg/100g)

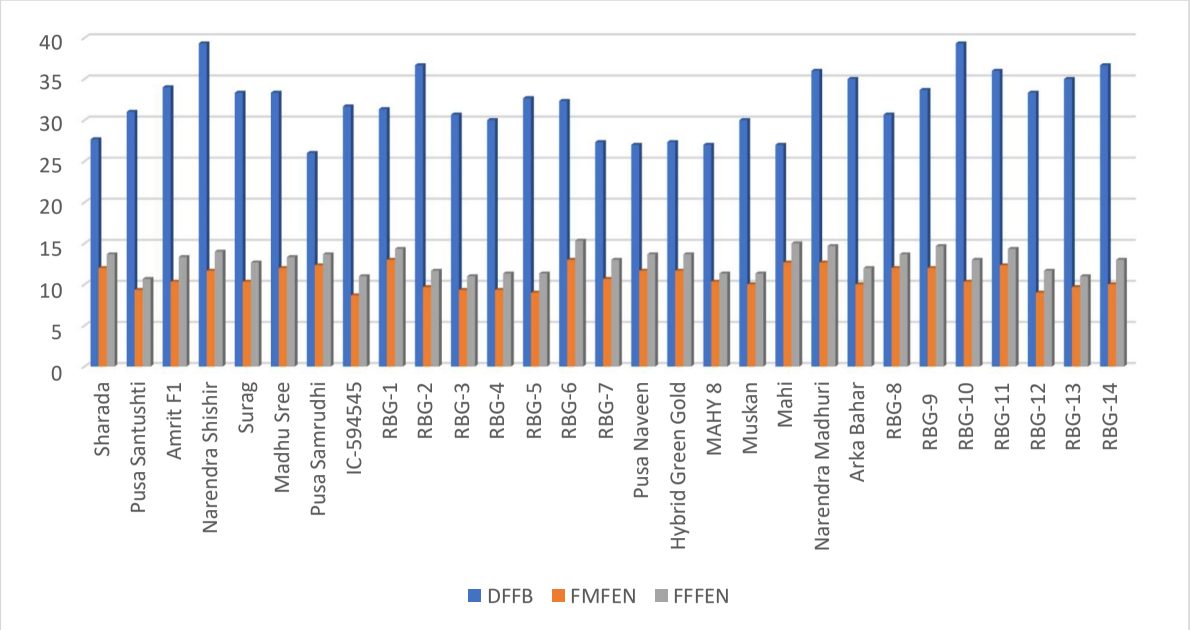


Fig. 4.1 Mean performance of different bottle gourd genotype for days to first fruit bud, node number to first male flower appearance, node number to first female flower appearance

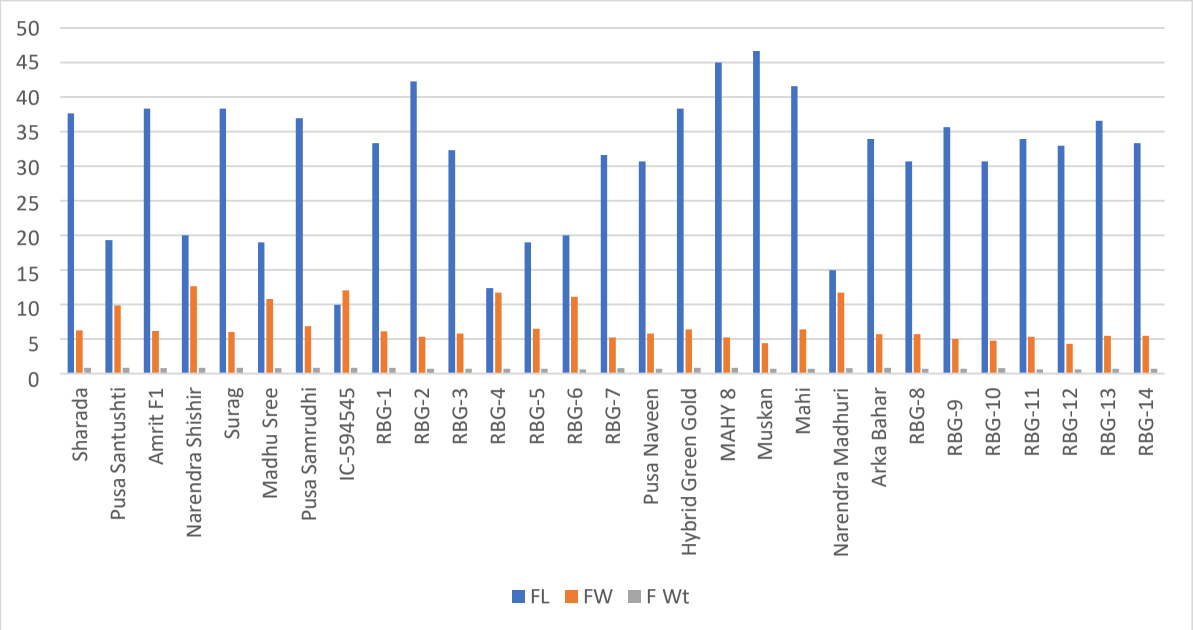


Fig. 4.2 Mean performance of different bottle gourd genotype for fruit length (cm), fruit width (cm) and average fruit weight (g)

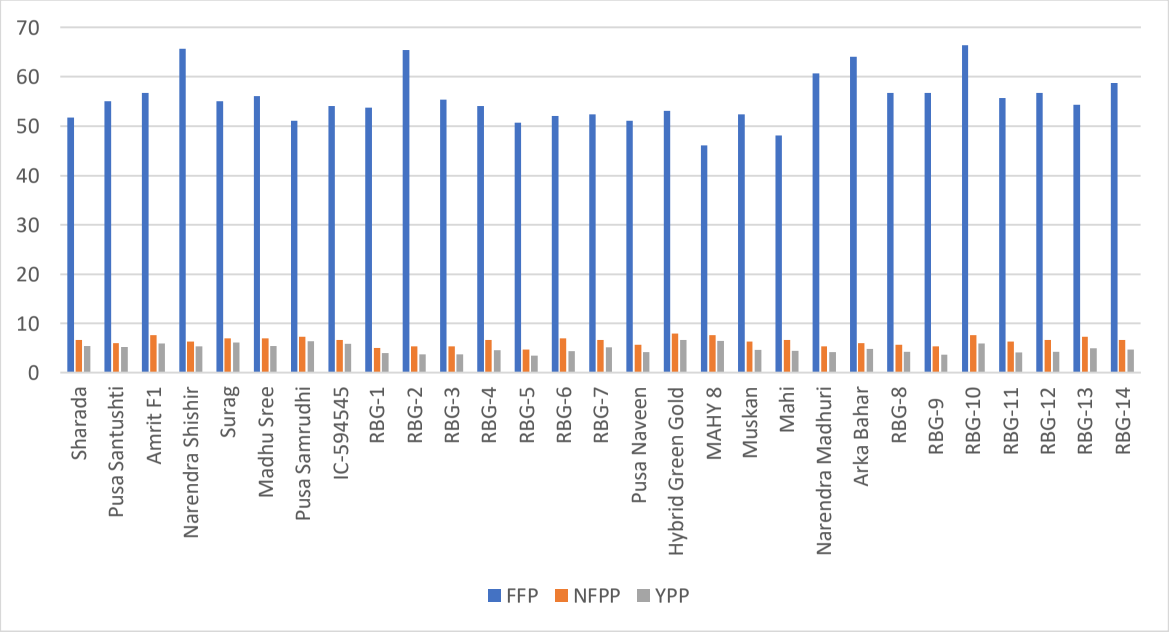


Fig. 4.3 Mean performance of different bottle gourd genotype for first fruit picking, number of fruits per plant and yield per plant (Kg)

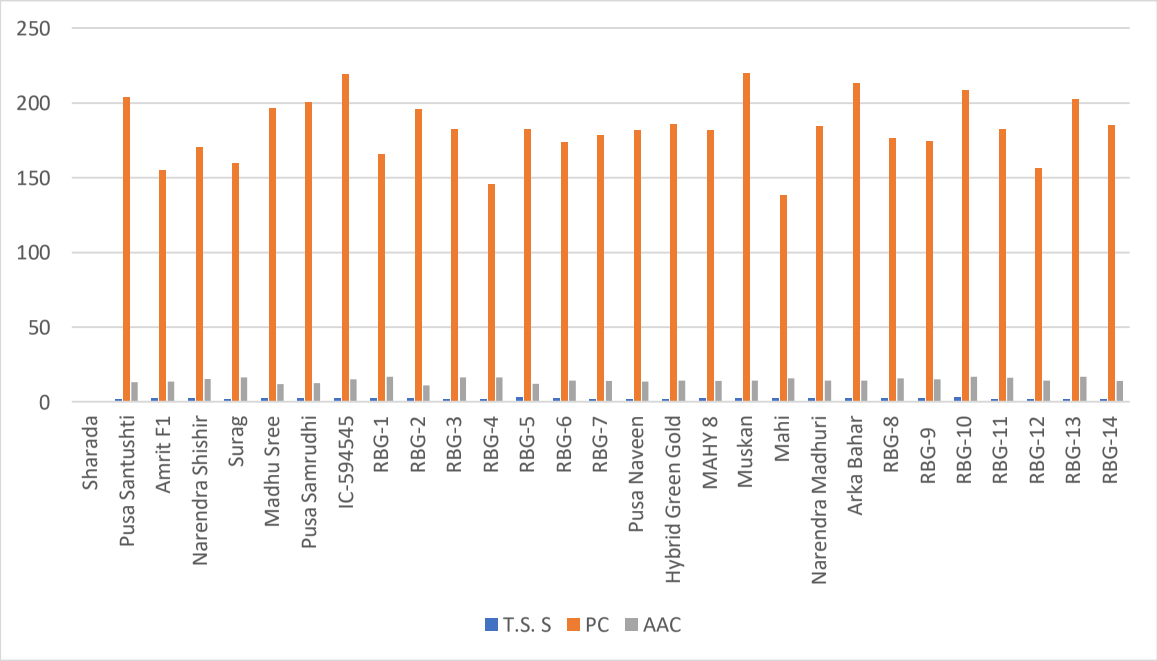


Fig. 4.4 Mean performance of different bottle gourd genotype for total soluble solids protein content (°Brix), (mg/100g) and ascorbic acid content (mg/100g)

**Table: - 4.2.2 Fruit quality parameters of bottle gourd**

| S. No. | Genotypes | Fruit shape | Fruit colour | Fruit surface |
|---|---|---|---|---|
| **1.** | **Sharada** | Cylindrical | light green | smooth |
| **2.** | **Pusa Santushti** | Pear | light green | fine hairy |
| **3.** | **Amrit $F_1$** | Cylindrical | light green | smooth |
| **4.** | **Narendra Shishir** | Round | light green | smooth |
| **5.** | **Surag** | Cylindrical | light green | smooth |
| **6** | **Madhu Sree** | Round | light green | fine hairy |
| **7.** | **Pusa Samrudhi** | Cylindrical | light green | smooth |
| **8.** | **IC-594545** | Round | whitish green | smooth |
| **9.** | **RBG-1** | Cylindrical | dark patchy green | smooth |
| **10.** | **RBG-2** | Cylindrical | whitish green | smooth |
| **11.** | **RBG-3** | Bottle | light patchy green | smooth |
| **12.** | **RBG-4** | Round | light green | smooth |
| **13.** | **RBG-5** | Cylindrical | whitish green | smooth |
| **14.** | **RBG-6** | Pear | whitish green | fine hairy |
| **15.** | **RBG-7** | Bottle | light patchy green | fine hairy |
| **16.** | **Pusa Naveen** | Bottle | light green | fine hairy |
| **17.** | **Hybrid Green Gold** | Cylindrical | light green | smooth |
| **18.** | **MAHY 8** | Cylindrical | light green | fine hairy |
| **19.** | **Muskan** | Cylindrical | light green | fine hairy |
| **20.** | **Mahi** | Cylindrical | light green | smooth |
| **21.** | **Narendra Madhuri** | Flat round | light green | fine hairy |
| **22.** | **Arka Bahar** | Cylindrical | light green | fine hairy |
| **23.** | **RBG-8** | Crooked | dark patchy green | smooth |
| **24.** | **RBG-9** | Bottle | dark patchy green | smooth |
| **25.** | **RBG-10** | Crooked | dark patchy green | smooth |
| **26.** | **RBG-11** | Crooked | dark patchy green | smooth |
| **27.** | **RBG-12** | Bottle | light green | fine hairy |
| **28.** | **RBG-13** | Crooked | whitish green | smooth |
| **29.** | **RBG-14** | Crooked | light patchy green | smooth |
| **30.** | **RBG-16** | Cylindrical | whitish green | smooth |

## 4.3 Genetic parameters

All the characters under study were analyzed for genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), genetic advance as percent of mean and heritability (broad sense). In the present study, it was found that magnitude of phenotypic coefficient of variation (PCV) were higher than genotypic coefficient of variation (GCV) for all the characters. Which indicates high influence of environment in the inheritance of these traits. The fruit yield is the key objective in bottle gourd improvement. Absolute variability of different characters does not reveal which of the particular character were showing the highest variability. This could only be accessed through standardizing the phenotypic and genotypic variances and by obtaining coefficient of variability. The genotypic coefficient of variation does not fully provide the measurement of heritable or environmental variation and thus evaluation of heritability becomes necessary. The estimate of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability ($h^2$) in broad sense, genetic advances and genetic advances as per cent of mean were estimated for 15 characters and are presented in table (4.3.1**)** and fig (4.5).

The results (Table 4.3) indicated moderate level of PCV and GCV for majority of vegetative and qualitative traits such as vine length (cm), days to first flowering bud, node number to first male flower appearance, node number to first male flower appearance, days to first fruit setting, number of fruits per plant, protein content (mg/100g) and ascorbic acid content (mg/100g). whereas, high magnitude of GCV as well as PCV was recorded for fruit length (cm), fruit width (cm), average fruit weight (g), yield per plant (Kg) and total soluble solids ($^o$Brix).

## A. Growth and flowering parameters: -

### 4.3.1 Vine length (cm)

The value of $V_p$ and $V_g$ for vine length was 6795.17 and 5509.0 respectively. The moderate value of phenotypic coefficient of variation (11.50%) and genotypic coefficient of variation (10.36%) was recorded for vine length. It exhibited high broad sense heritability (81.07%) coupled with moderate genetic advance as percent of mean (19.22%).

### 4.3.2 Days to first flowering bud

The value of $V_p$ and $V_g$ for days to first flowering bud was recorded 14.23 and 12.78 respectively. The moderate value of phenotypic coefficient of variation was 11.70% and

genotypic coefficient of variation was 11.09%. It exhibited high broad sense heritability (89.83%) coupled with high genetic advance as percent of mean (21.65%).

### 4.3.3 Node number to first male flower appearance

In respect to this trait, the observed values of genotypic variance and phenotypic variance was 1.65 and 2.53 each. It expressed moderate phenotypic coefficient of variation (14.56%) and genotypic coefficient of variation (11.76%) and high broad-sense heritability (65.25%) combined with moderate genetic advance as percent of mean (19.58%).

### 4.3.4 Node number to first female flower appearance

Node number to first female flower appearance showed genotypic variance and phenotypic variance 1.41 and 2.74 respectively. It expressed moderate phenotypic coefficient of variation (12.81%) and low level of genotypic coefficient of variation (9.18%) and moderate broad-sense heritability (51.42%) combined with moderate genetic advance as percent of mean (13.57%).

The moderate level of PCV and GCV for vine length (cm), days to first flowering bud, node number to first male flower appearance and node number to first female flower appearance indicated moderate range of variability among the studied genotypes for these vegetative traits in bottle gourd. In addition, the very low or insignificant difference between GCV and PCV for these traits indicated that the selection based on phenotypic performance will be trustworthy since the investigated traits were less impacted by environment. The high heritability coupled with moderate to high genetic advance was recorded for these traits which indicated that selection based on these traits would be effective. The results are in conformity with the findings of Dubey *et al.,* (2022), Chikkeri *et al.,* (2018), Ahmad *et al.,* (2019), Rashid *et al.,* (2020) and Venkatraman and Haripriya, (2021) in bottle gourd.

## B. Yield parameters: -

### 4.3.5 Days to first fruit setting

The value of $V_{\mathrm{p}}$ and $V_{\mathrm{g}}$ for days to first fruit setting ranged from 22.86 and 20.05 respectively. It expressed moderate phenotypic coefficient of variation (10.16%) and low-level genotypic coefficient of variation (9.52%). It exhibited high broad sense heritability (87.72%) combined with moderate genetic advance as percent of mean (18.37%).

### 4.3.6 Days to first fruit picking

The value of $V_p$ for days to first fruit picking was 24.79 and $V_g$ 20.83. It expressed low level of phenotypic coefficient of variation (8.99%) and genotypic coefficient of variation (8.24%). It exhibited high broad sense heritability (84.05%) combined with moderate genetic advance as percent of mean (15.57%).

### 4.3.7 Number of fruits per plant

Number of fruits per plant under study exhibited phenotypic variance and genotypic variance values as 1.68 and 1.39 respectively. The assessed moderate value for phenotypic coefficient of variation was (19.46%) and genotypic coefficient of variation (17.66%). High broad sense heritability (82.33%) coupled with high genetic advance as percent of mean (33.00%).

### 4.3.8 Fruit length (cm)

The value of $V_p$ and $V_g$ for fruit length was 97.29 and 92.17 each. It expressed high phenotypic coefficient of variation (32.09%) and genotypic coefficient of variation (31.23%) and high broad-sense heritability (94.74%) combined with high genetic advance as percent of mean (62.63%).

### 4.3.9 Fruit width (cm)

The value of $V_p$ and $V_g$ for fruit width was 7.16 and 6.43 respectively. It expressed high phenotypic coefficient of variation (38.29%) and genotypic coefficient of variation (36.28%) and high broad-sense heritability (89.78%) combined with high genetic advance as percent of mean (70.82%).

### 4.3.10 Average fruit weight (g)

In respect to this trait, the observed values of genotypic variance and phenotypic variance 0.02 and 0.03 respectively. It expressed high phenotypic coefficient of variation (22.01%) and moderate genotypic coefficient of variation (18.62%) and high broad-sense heritability (71.55%) combined with high genetic advance as percent of mean (32.45%).

### 4.3.11 Yield per plant (Kg)

Yield per plant under study exhibited phenotypic variance and genotypic variance values as 3.33 and 2.67 respectively. The assessed high value for phenotypic coefficient of variation was (32.29%) and genotypic coefficient of variation (28.94%). High broad sense heritability (80.32%) coupled with high genetic advance as percent of mean (53.42%).

Higher magnitude of GCV and PCV was recorded for fruit length (cm), fruit width (cm) and yield per plant (Kg), which demonstrating the presence of a broad range of genetic variability for these traits in the germplasm. Additionally, research showed that these features have a wide genetic base, little environmental effect, and are governed by additive genes, indicating that there is considerable potential for further evolution of these traits through selection. The Moderate to low level of GCV and PCV was recorded for average fruit weight (g), Number of fruits per plant and days to first fruit picking indicated moderate range of variability among the studied genotypes for these vegetative traits in bottle gourd. The high heritability coupled with high genetic advance was recorded for number of fruits per plant, Fruit length (cm), Fruit width (cm), average fruit weight (g) and Yield per plant (Kg), which indicated that selection based on these traits would be effective. Similar findings were also reported by Dubey *et al.,* (2022), Kumar *et al.,* (2021), Kumar *et al.,* (2021), Singh *et al.,* (2021), Rashid *et al.,* (2020), Ahmad *et al.,* (2019), Chikkeri *et al.,* (2018), Khan *et al.,* (2016) and Ghorpade *et al.,* (2019) in bottle gourd.

## C. Quality parameters: -

### 4.3.12 Protein Content (mg/100g)

In respect to Protein Content, the observed values of genotypic variance and phenotypic variance 1290.5 and 1367.97 respectively. It expressed moderate phenotypic coefficient of variation (18.30%) and genotypic coefficient of variation (17.78%) and high broad-sense heritability (94.34%) combined with high genetic advance as percent of mean (35.57%).

### 4.3.13 Total Soluble Solid ($^{o}$Brix)

In respect to Total Soluble Solids, the observed values of genotypic variance and phenotypic variance 0.29 and 0.30 respectively. It expressed high phenotypic coefficient of variation (22.05%) and genotypic coefficient of variation (21.72%) and high broad-sense heritability (97.02%) combined with high genetic advance as percent of mean (44.07%).

### 4.3.14 Ascorbic acid content (mg/100g)

Ascorbic acid content showed phenotypic variance 3.18 and genotypic variance 3.05. It expressed moderate phenotypic coefficient of variation (12.41%) and genotypic coefficient of variation (12.14%) and high broad-sense heritability (95.72%) combined with high genetic advance as percent of mean (24.47%).

The quality parameters such as protein content (mg/100g), total soluble solid (°Brix) and ascorbic acid content (mg/100g) showed moderate to high level of GCV and PCV indicated moderate range of variability among the studied genotypes for these qualitative traits in bottle gourd. additionally, the very little difference between GVV and PCV for these traits indicated that the selection based on phenotypic performance will be trustworthy since the investigated traits were less impacted by environment. The high heritability coupled with high genetic advance was recorded for these qualitative traits indicated that selection based on these traits would be effective. Dubey *et al.,* (2022), Chandrashekhar *et al.,* (2018), Rehan *et al.,* (2020), Ahmad *et al.,* (2019) and Rambabu *et al.,* (2017) also reported similar findings in bottle gourd.

**Table 4.3.1: Mean, Range, Coefficient of variations (GCV and PCV), Genetic Advance, Genetic Advance as Per cent of mean and Heritability, for 21 Characters of bottle gourd genotypes.**

| Characters | Range | Mean | $V_p$ | $V_g$ | PCV (%) | GCV (%) | Genetic Advance | Genetic Advance as % of mean | Broad sense heritability (%) |
|---|---|---|---|---|---|---|---|---|---|
| **DFFB** | 39.3-26.0 | 32.21 | 14.23 | 12.78 | 11.70 | 11.09 | 6.98 | 21.65 | 89.83 |
| **FMFEN** | 13.0-8.67 | 10.90 | 2.53 | 1.65 | 14.56 | 11.76 | 2.14 | 19.58 | 65.25 |
| **FFFEN** | 15.3-10.6 | 12.93 | 2.74 | 1.41 | 12.81 | 9.18 | 1.75 | 13.57 | 51.42 |
| **FFS** | 57.3-37.3 | 46.92 | 22.86 | 20.05 | 10.16 | 9.52 | 8.64 | 18.37 | 87.72 |
| **FFP** | 66.3-46.0 | 55.62 | 24.79 | 20.83 | 8.99 | 8.24 | 8.62 | 15.57 | 84.05 |
| **FL** | 46.6-10.0 | 30.76 | 97.29 | 92.17 | 32.09 | 31.23 | 19.25 | 62.63 | 94.74 |
| **FW** | 12.6-4.30 | 6.99 | 7.16 | 6.43 | 38.29 | 36.28 | 4.95 | 70.82 | 89.78 |
| **F Wt** | 0.87-0.63 | 0.75 | 0.03 | 0.02 | 22.01 | 18.62 | 0.27 | 32.45 | 71.55 |
| **NFPP** | 8.0-4.6 | 6.42 | 1.68 | 1.39 | 19.46 | 17.66 | 2.20 | 33.00 | 82.33 |
| **YPP** | 6.6-3.4 | 4.82 | 3.33 | 2.67 | 32.29 | 28.94 | 3.02 | 53.42 | 80.32 |
| **VL** | 800.0-570.0 | 697.44 | 6795.17 | 5509.0 | 11.50 | 10.36 | 137.67 | 19.22 | 81.07 |
| **TSS** | 2.93-1.67 | 2.29 | 0.30 | 0.29 | 22.05 | 21.72 | 1.11 | 44.07 | 97.02 |
| **PC** | 219.6-138.1 | 182.04 | 1367.97 | 1290.5 | 18.30 | 17.78 | 71.88 | 35.57 | 94.34 |
| **ACC** | 16.9-11.2 | 14.61 | 3.18 | 3.05 | 12.41 | 12.14 | 3.52 | 24.47 | 95.72 |

$V_p$- phenotypic variance, $V_g$- genotypic variance, PCV- phenotypic coefficient of variance (%), GCV- genotypic coefficient of variance(%), DFFB- days to first flowering bud, FMFEN- first

male flower at early node, FFFEN- first female flower at early node, FFS- days to first fruit setting, FFP- days to first fruit picking, FL- fruit length (cm), FW- fruit width (cm), F Wt- average fruit weight (g), NFPP- number of fruits per plant, YPP- yield per plant (Kg), YPH- yield per ha (q), VL- vine length (cm), T.S.S- total Soluble Solid (°Brix), PC- protein Content (mg/100g), ACC- ascorbic acid content (mg/100g)

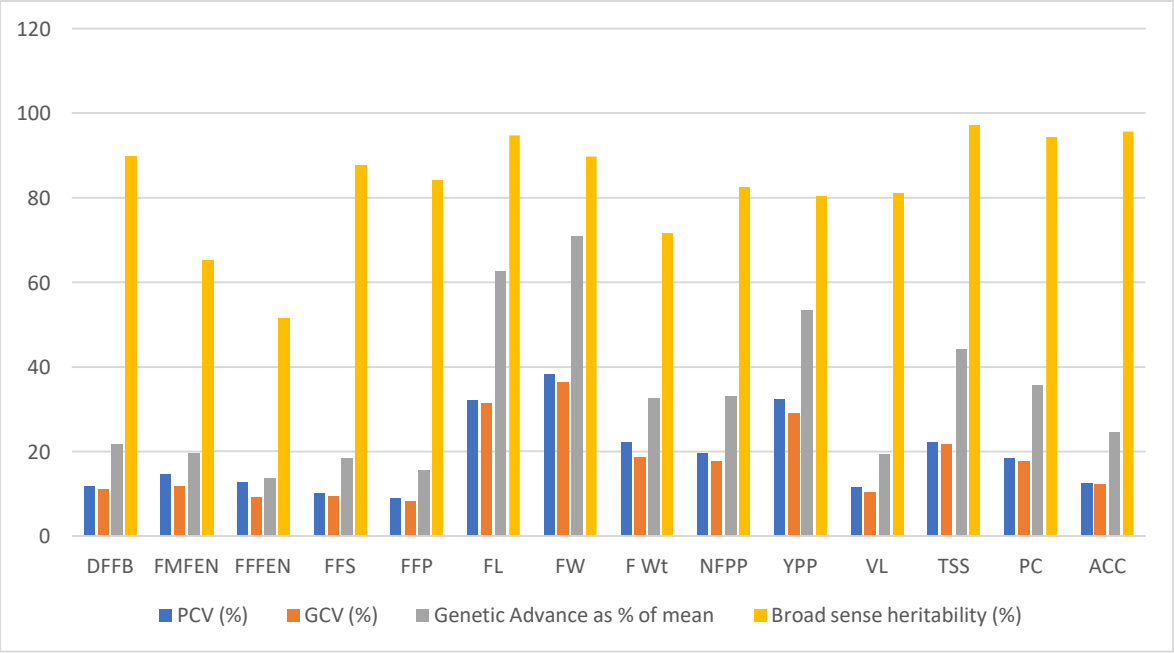


Fig. 4.5 Genetic variability for different characters in bottle gourd genotypes

## 4.4 Correlation Coefficient Analysis

Correlation coefficient is a parameter which is used to find out the direction of relationship between two or more variables. In selection process, it is very essential to have details on the nature of the association of characters with economic yield. The genotypic correlation coefficients were higher than the phenotypic correlation coefficients for most of the pair of traits. A positive value of correlation shows that the changes in two variables were in the same directions, *i.e.*, high value of one variable is associated with high value of other and *vice-versa*. When correlation is negative, the movement are in opposite directions, *i.e.,* high value of one variable is associated with low value of other. The correlation coefficient is represented by *"r",* whose value ranged from -1 to +1. The estimates of simple correlation coefficient among following genotypes of bottle gourd under study are presented in table (4.4.1) and (4.4.2).

The inherent association between two variables is known as genotypic correlation. This type of correlation may be either due to linkage or pleiotropic action of gene or more likely both. The main genetic cause of such correlation is pleiotropy, which refers to many effects of a gene (Falconer, 1981). The phenotypic correlation coefficient was computed to know the nature and magnitude of relationship existing between yield and its component characters as well as the association among the component characters. The relationship between two variables which can be directly observed is termed as phenotypic correlation. It includes both genotypic and environmental effects therefore, differs under different environmental conditions. The consequences of genotypic correlation coefficient and phenotypic correlation coefficient between various characters are described below:

## A. Growth and flowering parameters: -

### 4.4.1 Vine length (cm)

The vine length recorded significant positive correlation with days to ascorbic acid content (0.223), first fruit setting (0.221) and days to first flowering bud (0.217), at phenotypic level. It showed non-significant association both at genotypic and phenotypic level with majority of the traits. Vine length showed non-significant association with yield per plant both at genotypic and phenotypic level.

### 4.4.2 Days to first flowering bud

The days to first flowering bud recorded highly positive significant association both at genotypic and phenotypic level with days to first fruit picking (G=0.854, P=0.785), days to first fruit setting (G=0.842, P=0.789). At phenotypic level it showed positive significant correlation

with vine length (0.217) and negative significant correlation with fruit length (-0.249). This trait showed non-significant association both at genotypic and phenotypic level with rest of the traits. Days to first flowering bud showed non-significant association with yield per plant both at genotypic and phenotypic level.

### 4.4.3 Node number to first male flower appearance

The perusal of data stated that, node number to first male flower appearance had highly positive significant association both at genotypic and phenotypic level with node number to first female flower appearance (G=0.950, P=0.857) and protein content (G=0.498, P=0.399). Remaining characters showed non-significant association with this trait at both genotypic and phenotypic level. Node number to first male flower appearance recorded non-significant association with yield per plant both at genotypic and phenotypic level.

### 4.4.4 Node number to first female flower appearance

Node number to first female flower appearance recorded highly positive significant association with node number to first male flower appearance (G=0.950, P=0.857) and protein content (G=0.507, P=0.364) at genotypic and phenotypic level. Rest of the trait showed non-significant association at both genotypic and phenotypic level with node number to first female flower appearance. This trait showed non-significant association with yield per plant at both genotypic and phenotypic level.

Days to first flowering bud recorded highly positive significant association with days to first fruit setting, days to first fruit picking and non-significant association with yield per plant at both genotypic and phenotypic level. Likewise, vine length recorded positive significant correlation with days to first flowering bud, days to first fruit setting, ascorbic acid content at phenotypic level and with yield per plant it showed non-significant association both at genotypic and phenotypic level. The trait node number to first male flower appearance recorded highly positive significant association both at genotypic and phenotypic level with node number to first female flower appearance. Node number to first male and female flower appearance showed non-significant association with yield per plant both at genotypic and phenotypic level. According to the result findings those characters which showed significant and positive correlation with yield and one another would be preferred in a breeding programme for further improvement. These results are same with the findings of Panigrahi *et al.,* (2018), Muralidharan *et al.,* (2017), Husna *et al.,* (2011) and Janaranjani and Kanthaswamy, (2015) in bottle gourd.

## C. Yield parameters: -

### 4.4.5 Days to first fruit setting

Days to first fruit setting showed highly positive significant association both at genotypic and phenotypic level with days to first flowering bud (G=0.842, P=0.789), days to first fruit picking (G=0.995, P=0.981) and only at phenotypic level with ascorbic acid content (0.281), vine length (0.221). This trait showed non-significant association with majority of the traits at both genotypic and phenotypic level. Days to first fruit setting recorded negative non-significant association with yield per plant both at genotypic and phenotypic level.

### 4.4.6 Days to first fruit picking

The perusal of data stated that, days to first fruit picking had highly positive significant association both at genotypic and phenotypic level with days to first flowering bud (G=0.854, P=0.785), days to first fruit setting (G=0.995, P=0.981) and only at phenotypic level with ascorbic acid content (0.273). This trait showed non-significant association both at genotypic and phenotypic level with rest of the traits under study. Days to first fruit picking recorded negative non-significant association with yield per plant at both genotypic and phenotypic level.

### 4.4.7 Number of fruits per plant

Number of fruits per plant showed highly positive significant association both at genotypic and phenotypic level with yield per plant (G=0.799, P=0.810) and positive significant association only at phenotypic level with average fruit weight (0.229). This trait showed non-significant association both at genotypic and phenotypic level with majority of the traits under study.

### 4.4.8 Fruit length (cm)

At both genotypic and phenotypic level, fruit length recorded highly negative significant association with fruit width (G=-0.840, P=-0.778) and only at phenotypic level negative significant association with days to first flowering bud (-0.249). This trait showed non-significant association both at genotypic and phenotypic level with remaining traits. fruit length recorded non-significant association both at genotypic and phenotypic level with yield per plant.

### 4.4.9 Fruit width (cm)

At both genotypic and phenotypic level, fruit width stated highly positive significant association with average fruit weight (G=0.533, P=0.505), yield per plant (G=0.396, P=0.393)

and highly negative significant association with fruit length (G=-0.840, P=-0.778). Remaining traits showed non-significant association with fruit width both at genotypic and phenotypic level.

### 4.4.10 Average fruit weight (g)

Average fruit weight showed highly positive significant association both at genotypic and phenotypic level with fruit width (G=0.533, P=0.505) and yield per plant (G=0.817, P=0.810) and at phenotypic level it showed positive significant association with number of fruits per plant (0.229). Rest of the trait showed non-significant association with average fruit weight both at genotypic and phenotypic level.

### 4.4.11 Yield per plant (Kg)

The yield per plant recorded highly positive significant association both at genotypic and phenotypic level with average fruit weight (G=0.817, P=0.810) and number of fruits per plant (G=0.799, P=0.748). At phenotypic level it exhibited highly positive significant association with fruit width (0.393) and at genotypic level positive significant association with fruit width (0.3963). This trait showed non-significant association with majority of the traits under study at both genotypic and phenotypic level.

At both genotypic and phenotypic level, yield per plant were recorded highly positive significant association with number of fruits per plant, fruit width and average fruit weight indicated that the overall fruit yield per vine would increase as a result of selection for these traits. Days to first fruit setting recorded positive significant association with days to first flowering bud, days to first fruit picking. Fruit width showed positive significant correlation with average fruit weight and yield per plant revealing that these characters may be given importance in the selection of high yielding genotypes. Also, it showed negatively significant association with fruit length at both genotypic and phenotypic levels indicated that the movement are in opposite directions and these traits would be eliminate during selection. These observations are in agreement with the report of Varalakshmi *et al.,* (2018), Husna *et al.,* (2011), Mashilo *et al*., (2016), Mandal *et al*., (2015), Varpe *et al*., (2014), Raut *et al*., (2013), Muralidharan *et al.,* (2017), Chandra *et al.,* (2010) and Singh *et al.* (2006) in bottle gourd.

## C. Qualitative parameters: -

### 4.4.12 Total Soluble Solid (ºBrix)

At both genotypic and phenotypic level, total soluble solid recorded non-significant association with yield per plat and remaining traits under study.

### 4.4.13 Protein Content (mg/100g)

The protein content at both genotypic and phenotypic level recorded high positive significant association with node number to first male flower appearance (G=0.498, P=0.399) and node number to first female flower appearance (G=0.507, P=0.364) and only at phenotypic level highly significant negative association with ascorbic acid content (-0.320). This trait showed non-significant association with remaining traits at both genotypic and phenotypic level.

### 4.4.14 Ascorbic acid content (mg/100g)

The ascorbic acid content recorded highly positive significant association with days to first fruit setting (0.281), first fruit picking (0.273) and vine length (0.223) and highly significant negative association with protein content (-0.320) at phenotypic level. Whereas, non-significant association both at genotypic and phenotypic level with the remaining traits under study.

Ascorbic acid content recorded highly positive significant association with days to first fruit setting, first fruit picking and vine length and highly significant negative association with protein content at phenotypic level. Whereas, total soluble solid, protein content and ascorbic acid content at both genotypic and phenotypic level was recorded non-significant association with yield per plant. So, it can be inferred that simultaneous selection for fruit yield per plant and quality may not be possible and balanced selection criteria must be worked out to find out acceptable level of characters under improvement depending on the objective. Similar findings are reported by Deepthi *et al.,* (2014), Mashilo *et al.,* (2016) and Priyanka *et al.,* (2018).

**Table 4.4.1 Estimation of genotypic correlation coefficients for different characters of Bottle gourd**

| **Traits** | DFFB | FMFEN | FFFEN | FFS | FFP | FL | FW | FWt | NFPP | VL | TSS | PC | AAC | YPP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DFFB | 1 | | | | | | | | | | | | | |
| FMFEN | -0.098 | 1 | | | | | | | | | | | | |
| FFFEN | 0.065 | 0.950 ** | 1 | | | | | | | | | | | |
| FFS | 0.842 ** | -0.171 | 0.062 | 1 | | | | | | | | | | |
| FFP | 0.854 ** | -0.199 | 0.017 | 0.995 ** | 1 | | | | | | | | | |
| FL | -0.277 | 0.126 | -0.016 | -0.139 | -0.110 | 1 | | | | | | | | |
| FW | 0.164 | 0.056 | 0.100 | 0.022 | -0.014 | -0.840 ** | 1 | | | | | | | |
| FWt | 0.007 | 0.129 | 0.057 | 0.048 | 0.010 | -0.177 | 0.533 ** | 1 | | | | | | |
| NFPP | -0.060 | -0.059 | -0.031 | -0.083 | -0.135 | 0.107 | 0.130 | 0.312 | 1 | | | | | |
| VL | 0.308 | -0.189 | -0.097 | 0.290 | 0.269 | -0.090 | -0.022 | -0.283 | 0.023 | 1 | | | | |
| TSS | -0.062 | 0.061 | 0.020 | -0.198 | -0.209 | 0.002 | 0.069 | 0.004 | -0.100 | -0.143 | 1 | | | |
| PC | 0.016 | 0.498 ** | 0.507 ** | -0.081 | -0.081 | 0.078 | 0.089 | 0.051 | 0.013 | -0.145 | 0.177 | 1 | | |
| AAC | 0.185 | -0.302 | -0.272 | 0.323 | 0.316 | 0.135 | -0.045 | -0.036 | 0.022 | 0.255 | -0.021 | -0.325 | 1 | |
| YPP | -0.069 | 0.033 | -0.006 | -0.050 | -0.106 | -0.035 | 0.396 * | 0.817 ** | 0.799 ** | -0.172 | -0.055 | 0.032 | -0.019 | 1 |

***Significance at 5% level, **Significance at 1% level**

DFFB- days to first flowering bud, FMFEN- first male flower at early node, FFFEN- first female flower at early node, FFS- days to first fruit setting, FFP- days to first fruit picking, FL- fruit length (cm), FW- fruit width (cm), F Wt- average fruit weight (g), NFPP- number of fruits per plant, YPP- yield per plant (Kg), YPH- yield per ha (q), VL- vine length (cm), T.S.S- total Soluble Solid ($^{o}$Brix), PC- protein Content (mg/100g), ACC- ascorbic acid content (mg/100g)

**Table 4.4.2 Estimation of phenotypic correlation coefficients for different characters of Bottle gourd**

| **Traits** | DFFB | FMFEN | FFFEN | FFS | FFP | FL | FW | FWt | NFPP | VL | TSS | PC | AAC | YPP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DFFB | 1 | | | | | | | | | | | | | |
| FMFEN | -0.086 | 1 | | | | | | | | | | | | |
| FFFEN | 0.042 | 0.857 ** | 1 | | | | | | | | | | | |
| FFS | 0.789 ** | -0.177 | -0.031 | 1 | | | | | | | | | | |
| FFP | 0.785 ** | -0.188 | -0.062 | 0.981 ** | 1 | | | | | | | | | |
| FL | -0.249 * | 0.119 | 0.020 | -0.134 | -0.111 | 1 | | | | | | | | |
| FW | 0.136 | 0.079 | 0.124 | 0.010 | -0.019 | -0.778 ** | 1 | | | | | | | |
| FWt | 0.017 | 0.152 | 0.140 | 6e-04 | -0.025 | -0.132 | 0.505 ** | 1 | | | | | | |
| NFPP | -0.035 | 0.020 | 0.015 | -0.076 | -0.101 | 0.107 | 0.104 | 0.229 * | 1 | | | | | |
| VL | 0.217 * | -0.102 | -0.019 | 0.221 * | 0.196 | -0.069 | -0.014 | -0.199 | 0.018 | 1 | | | | |
| TSS | -0.071 | 0.062 | 0.021 | -0.173 | -0.177 | 0.006 | 0.062 | -0.007 | -0.099 | -0.108 | 1 | | | |
| PC | -0.006 | 0.399 ** | 0.364 ** | -0.077 | -0.077 | 0.071 | 0.091 | 0.048 | 0.017 | -0.089 | 0.179 | 1 | | |
| AAC | 0.179 | -0.193 | -0.133 | 0.281 ** | 0.273 ** | 0.126 | -0.052 | -0.025 | 0.029 | 0.223 * | -0.027 | -0.320 ** | 1 | |
| YPP | -0.038 | 0.100 | 0.084 | -0.064 | -0.094 | -0.011 | 0.393 ** | 0.810 ** | 0.748 ** | -0.138 | -0.063 | 0.034 | -0.009 | 1 |

***Significance at 5% level, **Significance at 1% level**

DFFB- days to first flowering bud, FMFEN- first male flower at early node, FFFEN- first female flower at early node, FFS- days to first fruit setting, FFP- days to first fruit picking, FL- fruit length (cm), FW- fruit width (cm), F Wt- average fruit weight (g), NFPP- number of fruits per plant, YPP- yield per plant (Kg), YPH- yield per ha (q), VL- vine length (cm), T.S.S- total Soluble Solid ($^{o}$Brix), PC- protein Content (mg/100g), ACC- ascorbic acid content (mg/100g)

## 4.5 Path analysis

Correlation coefficient values do not reveal the real association pattern of the independent variables with the dependent one. The path coefficient analysis is the standardized partial regression coefficient which divides the correlation coefficient into the measures of direct and indirect effect of independent variables on the genetic makeup of independent traits. To know these various effects, the correlation coefficient of different characters with fruit yield per plant was grouped into their direct and indirect effects. This helps the selection of genotypes based on those traits which will accurately contribute more towards yield, the results of path coefficient analysis given in table (4.5.1) and (4.5.2)

## A. Growth and flowering parameters: -

### 4.5.1 Vine length

Vine length exerted direct positive effect (0.0019) on fruit yield per plant. Vine length also showed indirect positive effect on fruit yield per plant through node number to first male flower appearance (0.073), days to first flowering bud (0.0264), number of fruits per plant (0.0124), total soluble solids (0.0029), protein content (0.0023) and indirect negative effect *via* node number to first female flower appearance (-0.0334), days to first fruit setting (-0.0012), first fruit picking (-0.0505), fruit length (-0.0090), fruit width (-0.0002), average fruit weight (-0.1964), ascorbic acid content (-0.0010) on fruit yield per plant.

### 4.5.2 Days to first flowering bud

Days to first flowering bud recorded direct positive effect (0.0859) on fruit yield per plant. It also showed indirect positive effect on fruit yield per plant through node number to first female flower appearance (0.0224), node number to first male flower appearance (0.0378), fruit width (0.0021), average fruit weight (0.0052), vine length (0.0005), total soluble solids (0.0013). While, indirect negative effect on fruit yield per plant *via* days to first fruit setting (-0.0036), first fruit picking (-0.1600), fruit length (-0.0277), number of fruits per plant (-0.0325), protein content (-0.0002), ascorbic acid content (-0.0007).

### 4.5.3 Node number to first male flower appearance

Node number to first male flower appearance recorded direct negative effect (-0.3856) on fruit yield per plant. It also recorded indirect positive effect on fruit yield per plant through node number to first female flower appearance (0.3265), days to first fruit setting (0.0007), first fruit picking (0.0374), fruit length (0.0126), fruit width (0.0007), average fruit weight (0.0900),

ascorbic acid content (0.0011). Whereas, indirect negative effect on fruit yield per plant *via* days to first flowering bud (-0.0084), number of fruits per plant (-0.0316), vine length (-0.0003), total soluble solids (-0.0012), protein content (-0.0081).

### 4.5.4 Node number to first female flower appearance

On fruit yield per plant, node number to first female flower appearance had direct positive effect (0.3435). This trait also showed positive indirect effects on fruit yield per plant *via* days to first flowering bud (0.0056), fruit width (0.0012), average fruit weight (0.0401), ascorbic acid content (0.0010). Whereas, indirect negative effect on fruit yield per plant through node number to first male flower appearance (-0.3665), days to first fruit setting (-0.0002), first fruit picking (-0.0032), fruit length (-0.0016), number of fruits per plant (-0.0170), vine length (-0.0001), total soluble solids (-0.0004), protein content (-0.0081).

Data revealed that, the character node number to first female flower appearance recorded highest positive direct effect on fruit yield per plant followed by days to first flowering bud and vine length suggesting that restricted simultaneous selection for the trait may be practiced to minimize the ill effects of indirect causal factors in order to benefit out of direct effect for improvement of yield. Node number to first male flower appearance recorded negative direct effect on yield per plant suggesting that selection for independent traits may help in enhancement of fruit yield per plant. Similar results were reported by Husna *et al.,* (2011), Mandal *et al.,* (2015), Chetariya *et al.,* (2018) and Janaranjani and Kanthaswamy, (2015) in bottle gourd.

## B. Yield parameters: -

### 4.5.5 Days to first fruit setting

Days to first fruit setting recorded direct negative effect (-0.0043) on fruit yield per plant. It also had indirect positive effect on fruit yield per plant through days to first flowering bud (0.0723), node number to first male flower appearance (0.0661), node number to first female flower appearance (0.0215), fruit width (0.0002), average fruit weight (0.0338), vine length (0.0005), total soluble solids (0.0041), protein content (0.0013). While, indirect negative effect on fruit yield per plant through first fruit picking (-0.1866), fruit length (-0.0138), number of fruits per plant (-0.0449), ascorbic acid content (-0.0012).

### 4.5.6 Days to first fruit picking

Days to first fruit picking showed direct negative effect (-0.1874) on fruit yield per plant. This also recorded indirect positive effect through days to first flowering bud (0.0733), node number to first male flower appearance (0.0770), node number to first female flower appearance (0.0058), average fruit weight (0.0075), vine length (0.0005), total soluble solids (0.0043), protein content (0.0013). Days to first fruit picking also had indirect negative effect on fruit yield per plant *via* days to first fruit setting (-0.0043), fruit length (-0.011), fruit width (-0.0001), number of fruits per plant (-0.0726), ascorbic acid content (-0.0012).

### 4.5.7 Fruit length (cm)

On fruit yield per plant, fruit length had direct positive effect (0.0998). Fruit length also had indirect positive effect on fruit yield per plant through days to first fruit setting (0.0006), days to first fruit picking (0.0206), number of fruits per plant (0.0577) and indirect negative effect on fruit yield per plant *via* days to first flowering bud (-0.0238), node number to first male flower appearance (-0.0488), node number to first female flower appearance (-0.0056), fruit width (-0.0108), average fruit weight (-0.1228), vine length (-0.0001), total soluble solids (-0.00004), protein content (-0.0012), ascorbic acid content (-0.0005).

### 4.5.8 Fruit width (cm)

On fruit yield per plant, fruit width showed direct positive effect (0.0128). It also exhibited indirect positive effect on fruit yield per plant through days to first flowering bud (0.0141), node number to first female flower appearance (0.0345), days to first fruit picking (0.0027), average fruit weight (0.3704), number of fruits per plant (0.0699), ascorbic acid content (0.0001) and indirect negative effect on fruit yield per plant *via* node number to first male flower appearance (-0.02162), days to first fruit setting (-0.0001), fruit length (-0.0839), vine length (-0.00004), total soluble solids (-0.0014), protein content (-0.0014).

### 4.5.9 Average fruit weight (g)

Average fruit weight stated direct positive effect (0.6940) on fruit yield per plant. It also exhibited indirect positive effect on fruit yield per plant through days to first flowering bud (0.0006), node number to first female flower appearance (0.0198), fruit width (0.0068), number of fruits per plant (0.1676), ascorbic acid content (0.0001) and indirect negative effect on fruit yield per plant *via* node number to first male flower appearance (-0.0500), days to first fruit setting (-0.0002), days to first fruit picking (-0.0020), fruit length (-0.0176), vine length (-0.0005), total soluble solids (-0.00009), protein content (-0.0008).

### 4.5.10 Number of fruits per plant

On fruit yield per plant, number of fruits per plant showed direct positive effect (0.5362). Number of fruits per plant also exhibited positive indirect effect on fruit yield per plant through node number to first male flower appearance (0.0227), days to first fruit setting (0.0003), days to first fruit picking (0.0254), fruit length (0.0107), fruit width (0.0016), average fruit weight (0.2169), vine length (0.00004), total soluble solids (0.0020). Whereas, it exhibited indirect negative effect on fruit yield per plant *via* days to first flowering bud (-0.0052), node number to first female flower appearance (-0.0109), protein content (-0.0002), ascorbic acid content (-0.00009).

The results from the present study shows that, the trait average fruit weight, number of fruits per plant and fruit length recorded highest positive direct effect on fruit yield per plant, hence it can be inferred that simultaneous improvement of fruit yield per plant is possible though manifestation of this traits. Days to first fruit picking and days to first fruit setting was recorded highest negative direct effect on fruit yield per plant was indicating that this can be nullified by selecting positive indirect effects during the selection. Similar findings were suggested by Muralidharan *et al.,* (2017), Mashilo *et al*., (2016), Janaranjani and Kanthaswamy (2015), Husna *et al.,* (2014) and Alok *et al*., (2007) in bottle gourd.

## C. Qualitative traits: -

### 4.5.11 Total Soluble Solid ($^{o}$Brix)

On fruit yield per plant, total soluble solid had direct negative effect (-0.0207). Total soluble solid also exhibited indirect positive effect on fruit yield per plant through node number to first female flower appearance (0.0068), days to first fruit setting (0.0008), days to first fruit picking (0.0393), fruit length (0.0002), fruit width (0.0008), average fruit weight (0.0029), ascorbic acid content (0.00009). While, indirect negative effect on fruit yield per plant *via* days to first flowering bud (-0.0053), node number to first male flower appearance (-0.0237), number of fruits per plant (-0.0540), vine length (-0.0002), protein content (-0.0029).

### 4.5.12 Protein Content (mg/100g)

Protein content showed direct negative effect (-0.0163) on fruit yield per plant. It also exhibited indirect positive effect on fruit yield per plant through days to first flowering bud (0.0013), node number to first female flower appearance (0.1743), days to first fruit setting (0.0003), days to first fruit picking (0.0153), fruit length (0.0078), fruit width (0.0011), average fruit weight (0.0360), number of fruits per plant (0.0073), ascorbic acid content (0.0012) and

indirect negative effect on fruit yield per plant *via* node number to first male flower appearance (-0.1921), vine length (-0.0002), total soluble solid (-0.0036).

### 4.5.14 Ascorbic acid content (mg/100g)

Ascorbic acid content recorded direct negative effect (-0.0039) on fruit yield per plant. It also showed indirect positive effect on fruit yield per plant through days to first flowering bud (0.0159), node number to first male flower appearance (0.1165), fruit length (0.0135), number of fruits per plant (0.0121), vine length (0.0004), total soluble solid (0.0004), protein content (0.0053). Whereas, indirect negative effect on fruit yield per plant *via* node number to first female flower appearance (-0.0936), days to first fruit setting (-0.0014), days to first fruit picking (-0.0594), fruit width (-0.0005), average fruit weight (-0.02535).

The qualitative traits total soluble solids, protein content and ascorbic acid content was reported negative direct effect on fruit yield per plant. Hence, selection based on this character is not effective for improving fruit yield per plant, so the casual factors having positive indirect effect on fruit yield per plant may be considered during the selection. Similar findings are reported by Deepthi *et al.,* (2014), Mashilo *et al.,* (2016), Chetariya *et al.,* (2018) and Priyanka *et al.,* (2018) in bottle gourd.

**Table 4.5.1 Direct (diagonal) and indirect diagonal (above and below diagonal) genotypic path effects of different characters towards yield in Bottle gourd**

| Traits | DFFB | FMFEN | FFFEN | FFS | FFP | FL | FW | FWt | NFPP | VL | TSS | PC | AAC | YPP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DFFB | **0.08591** | 0.03781 | 0.02245 | -0.00366 | -0.16009 | -0.02772 | 0.00211 | 0.0052 | -0.03252 | 0.00058 | 0.0013 | -0.00026 | -0.00073 | -0.0696 |
| FMFEN | -0.00842 | **-0.38564** | 0.32654 | 0.00075 | 0.03744 | 0.01265 | 0.00072 | 0.09008 | -0.03162 | -0.00036 | -0.00128 | -0.00814 | 0.00119 | 0.0339 |
| FFFEN | 0.00561 | -0.36652 | **0.34358** | -0.00027 | -0.0032 | -0.00165 | 0.00129 | 0.0401 | -0.01708 | -0.00018 | -0.00042 | -0.00829 | 0.00107 | -0.006 |
| FFS | 0.07237 | 0.06611 | 0.02159 | **-0.00435** | -0.18663 | -0.01389 | 0.00029 | 0.03387 | -0.04493 | 0.00055 | 0.0041 | 0.00133 | -0.00127 | -0.0509 |
| FFP | 0.07337 | 0.07703 | 0.00586 | -0.00433 | **-0.18746** | -0.011 | -0.00019 | 0.00755 | -0.07265 | 0.00051 | 0.00435 | 0.00133 | -0.00125 | -0.1069 |
| FL | -0.02384 | -0.04886 | -0.00569 | 0.00061 | 0.02065 | **0.09988** | -0.0108 | -0.12286 | 0.05772 | -0.00017 | -0.00004 | -0.00129 | -0.00053 | -0.0352 |
| FW | 0.0141 | -0.02162 | 0.03458 | -0.0001 | 0.00276 | -0.08394 | **0.01285** | 0.37045 | 0.06999 | -0.00004 | -0.00143 | -0.00147 | 0.00018 | 0.3963 * |
| FWt | 0.00064 | -0.05005 | 0.01985 | -0.00021 | -0.00204 | -0.01768 | 0.00686 | **0.69408** | 0.1676 | -0.00054 | -0.00009 | -0.00085 | 0.00014 | 0.8177 ** |
| NFPP | -0.00521 | 0.02274 | -0.01094 | 0.00036 | 0.0254 | 0.01075 | 0.00168 | 0.21693 | **0.53626** | 0.00004 | 0.00209 | -0.00023 | -0.00009 | 0.7998 ** |
| VL | 0.02648 | 0.07322 | -0.03349 | -0.00126 | -0.05054 | -0.00906 | -0.00028 | -0.19649 | 0.01246 | **0.0019** | 0.00297 | 0.00237 | -0.00101 | -0.1727 |
| TSS | -0.00539 | -0.02376 | 0.00689 | 0.00086 | 0.03935 | 0.00021 | 0.00089 | 0.00292 | -0.05408 | -0.00027 | **-0.0207** | -0.0029 | 0.00009 | -0.0559 |
| PC | 0.00137 | -0.19219 | 0.17433 | 0.00035 | 0.01531 | 0.00787 | 0.00115 | 0.03601 | 0.00739 | -0.00028 | -0.00368 | **-0.01634** | 0.00128 | 0.0326 |
| AAC | 0.01597 | 0.11659 | -0.09361 | -0.00141 | -0.05941 | 0.01353 | -0.00058 | -0.02535 | 0.01211 | 0.00048 | 0.00045 | 0.00532 | **-0.00393** | -0.0198 |

**Residual effect - 0.0024**

DFFB- days to first flowering bud, FMFEN- first male flower at early node, FFFEN- first female flower at early node, FFS- days to first fruit setting, FFP- days to first fruit picking, FL- fruit length (cm), FW- fruit width (cm), F Wt- average fruit weight (g), NFPP- number of fruits per plant, YPP- yield per plant (Kg), YPH- yield per ha (q), VL- vine length (cm), T.S.S- total Soluble Solid ($^{o}$Brix), PC- protein Content (mg/100g), ACC- ascorbic acid content (mg/100g)

**Table 4.5.2 Direct (diagonal) and indirect (above and below diagonal) phenotypic path effects of different characters towards yield in bottle gourd**

| Traits | DFFB | FMFEN | FFFEN | FFS | FFP | FL | FW | FWt | NFPP | VL | TSS | PC | AAC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DFFB | **-0.03184** | 0.0014 | -0.00016 | -0.03668 | 0.04454 | -0.00475 | 0.00169 | 0.01162 | -0.02116 | -0.00141 | -0.00019 | 0.00004 | -0.00201 |
| FMFEN | 0.00274 | **-0.01622** | -0.00319 | 0.00825 | -0.01068 | 0.00229 | 0.00098 | 0.1034 | 0.01233 | 0.00067 | 0.00017 | -0.0028 | 0.00217 |
| FFFEN | -0.00135 | -0.01391 | **-0.00372** | 0.00146 | -0.00356 | 0.00039 | 0.00154 | 0.09495 | 0.00936 | 0.00013 | 0.00006 | -0.00255 | 0.0015 |
| FFS | -0.02512 | 0.00288 | 0.00012 | **-0.04649** | 0.05565 | -0.00257 | 0.00013 | 0 | -0.04498 | -0.00144 | -0.00046 | 0.00054 | -0.00316 |
| FFP | -0.025 | 0.00306 | 0.00023 | -0.0456 | **0.05673** | -0.00212 | -0.00024 | -0.0169 | -0.06009 | -0.00127 | -0.00047 | 0.00054 | -0.00307 |
| FL | 0.00793 | -0.00194 | -0.00008 | 0.00626 | -0.00631 | **0.01908** | -0.00963 | -0.08941 | 0.06364 | 0.00045 | 0.00002 | -0.0005 | -0.00141 |
| FW | -0.00434 | -0.00129 | -0.00046 | -0.00048 | -0.00109 | -0.01485 | **0.01238** | 0.34184 | 0.06198 | 0.00009 | 0.00017 | -0.00064 | 0.00059 |
| FWt | -0.00055 | -0.00248 | -0.00052 | 0 | -0.00142 | -0.00252 | 0.00626 | **0.67388** | 0.13582 | 0.0013 | -0.00003 | -0.00034 | 0.00031 |
| NFPP | 0.00114 | -0.00034 | -0.00006 | 0.00353 | -0.00575 | 0.00205 | 0.00129 | 0.1549 | **0.59247** | -0.00012 | -0.00027 | -0.00012 | -0.00033 |
| VL | -0.00691 | 0.00167 | 0.00007 | -0.01028 | 0.01112 | -0.00132 | -0.00018 | -0.1349 | 0.01061 | **-0.0065** | -0.00029 | 0.00063 | -0.00251 |
| TSS | 0.00228 | -0.00101 | -0.00008 | 0.00808 | -0.01006 | 0.00012 | 0.00077 | -0.00656 | -0.05908 | 0.00071 | **0.00267** | -0.00125 | 0.00031 |
| PC | 0.00019 | -0.00648 | -0.00135 | 0.0036 | -0.00441 | 0.00136 | 0.00113 | 0.03285 | 0.01025 | 0.00058 | 0.00048 | **-0.007** | 0.00359 |
| AAC | -0.00571 | 0.00314 | 0.0005 | -0.0131 | 0.01552 | 0.00241 | -0.00065 | -0.01845 | 0.01736 | -0.00145 | -0.00007 | 0.00224 | **-0.01122** |

**Residual effect - 0.007**

DFFB- days to first flowering bud, FMFEN- first male flower at early node, FFFEN- first female flower at early node, FFS- days to first fruit setting, FFP- days to first fruit picking, FL- fruit length (cm), FW- fruit width (cm), F Wt- average fruit weight (g), NFPP- number of fruits per plant, YPP- yield per plant (Kg), YPH- yield per ha (q), VL- vine length (cm), T.S.S- total Soluble Solid ($^{o}$Brix), PC- protein Content (mg/100g), ACC- ascorbic acid content (mg/100g)

## 4.6 Genetic divergence

Genetic divergence is desirable to select suitable genetically divergent parents, based on information about the genetic diversity and genetic variations present in the available germplasm. In plant breeding, genetic diversity plays an important role as it helps in selecting the suitable parents for hybridization programme resulting in desirable recombinants and superior hybrids.

The genetic diversity in 30 genotypes of bottle gourd was estimated by using $D^2$ statistics. Based on ($D^2$) statistics of Mahalanobis (1936) and also by the use of non-hierarchical Euclidean cluster analysis, 30 genotypes were grouped into five divergent cluster. Cluster 1 have 10 genotypes, Cluster 2 have 7 genotypes, Cluster 3 have 9 genotypes, Cluster 4 have 3 genotypes and cluster 5 have 1 genotype.

### 4.6.1 Cluster distance

The inter cluster $D^2$ value was maximum (1105.4) between cluster 5 and 4. The minimum (284.7) distance was observed between cluster 2 and 1. which indicated close relationship among the 2 genotypes. table (4.9)

**Intra cluster distance**

Intra cluster distance was observed only in the cluster 1, 2, 3 and 4 as the remaining clusters 5 contained only one constituent genotype. Intra cluster distance was highest in the cluster 4 (586.5) followed by cluster 3 (324.0) and 2 (207.1).

**Table (4.6.1) Inter and Intra Cluster Distance: Tocher Method**

| | **Cluster 1** | **Cluster 2** | **Cluster 3** | **Cluster 4** | **Cluster 5** |
|---|---|---|---|---|---|
| **Cluster 1** | 166.6 | 284.7 | 348.8 | 410.4 | 549.9 |
| **Cluster 2** | | 207.1 | 393.9 | 483.3 | 450.2 |
| **Cluster 3** | | | 324.0 | 622.1 | 733. |
| **Cluster 4** | | | | 586.5 | 1105.4 |
| **Cluster 5** | | | | | 0.000 |

### 4.6.2 Percent contribution of characters

Percent contribution of 14 characters to total genetic diversity is presented table (4.10) and fig. (4.6). The characters namely, total soluble solids (22.7%) contributed maximum to the manifestation of genetic divergence. The characters like ascorbic acid content (18.4%), fruit length (11.5%), protein content (10.1%), fruit width (5.6%), average fruit weight (5.3%), days

to first flowering bud (5.3%), number of fruits per plant (4.7%), first fruit set (4.6%), vine length (4%), yield per plant (3.9%), node number to first female flower appearance (2%), first fruit picking (1%) and node number to first female flower appearance (0.9%).

**Table (4.6.2) Percentage contribution of different characters towards diversity in bottle gourd genotypes**

| Source | Contribution % | Source | Contribution % |
|---|---|---|---|
| TSS | 22.7 | NFPP | 4.7 |
| AAC | 18.4 | FFS | 4.6 |
| FL | 11.5 | VL | 4 |
| PC | 10.1 | YPP | 3.9 |
| FW | 5.6 | FMFEN | 2 |
| FWt | 5.3 | FFP | 1 |
| DFFB | 5.3 | FFFEN | 0.9 |

DFFB- days to first flowering bud, FMFEN- first male flower at early node, FFFEN- first female flower at early node, FFS- days to first fruit setting, FFP- days to first fruit picking, FL- fruit length (cm), FW- fruit width (cm), F Wt- average fruit weight (g), NFPP- number of fruits per plant, YPP- yield per plant (Kg), YPH- yield per ha (q), VL- vine length (cm), T.S.S- total Soluble Solid (°Brix), PC- protein Content (mg/100g), ACC- ascorbic acid content (mg/100g)

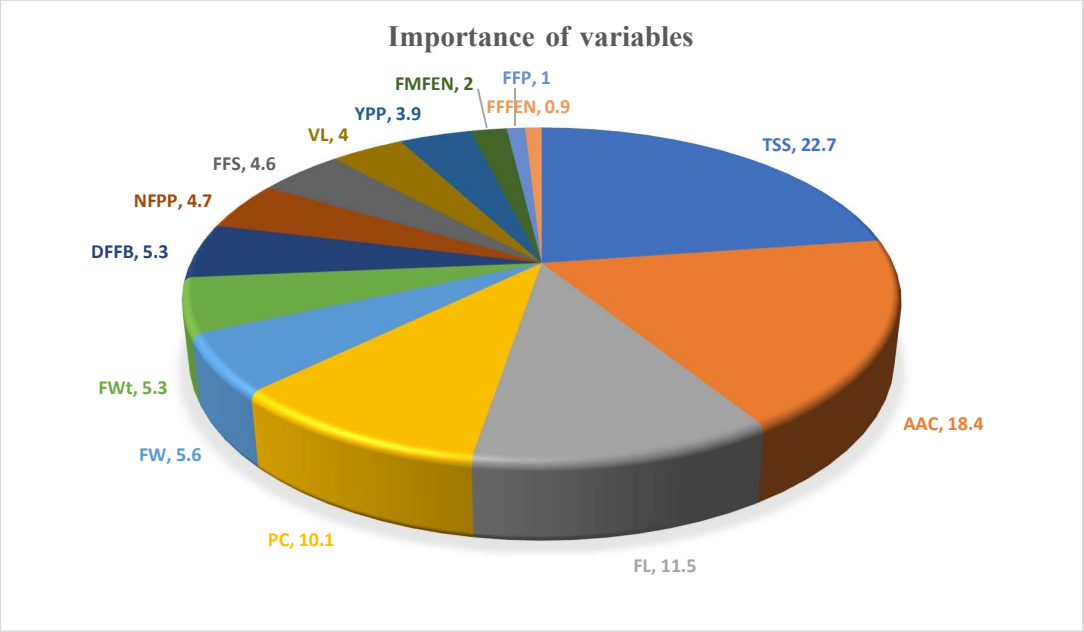


Fig. (4.6) Contribution percent towards divergence

**Table (4.6.3) Clustering pattern of 30 bottle gourd genotypes by Tocher's method**

| Group | Number of genotypes | Genotypes |
|---|---|---|
| **Cluster 1** | 10 | RBG-8, RBG-9, Pusa Samrudhi, Mahi, Amrit $F_1$, MAHY 8, Surag RBG-13, RBG-7, Sharada |
| **Cluster 2** | 7 | RBG-11, RBG-14, RBG-10, Hybrid Green Gold, RBG-12, RBG-3, Pusa Santushti |
| **Cluster 3** | 9 | Madhu Sree, RBG-4, RBG-16, RBG-5, RBG-6, RBG-1, Narendra Madhuri, IC-594545, Narendra Shishir |
| **Cluster 4** | 3 | Muskan, Arka Bahar, RBG-2 |
| **Cluster 5** | 1 | Pusa Naveen |

Thirty genotypes of bottle gourd taken for multivariate analysis were differed significantly with regards to the character under study and displayed marked divergence, when taking 14 characters together. In general, an overview of the above results showed that cluster 1 included most of the genotypes which were promising for most of the yield attributing traits like fruit length, protein content, fruit width, average fruit weight, days to first flowering bud, number of fruits per plant and these genotypes can be used as donors in breeding high yielding varieties. Similar findings were also reported by Ahmad *et al.,* (2021), Rambabu *et al.,* (2020), Rehan *et al.,* (2020), Chetariya and vaddoria, (2017) and Damor *et al.,* (2017) in bottle gourd.

# 5. Summary and conclusion

The present investigation on "studies on genetic diversity in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was carried out by using thirty bottle gourd genotypes, in randomized block design with three replications at the experimental farm in vegetable research farm of the college of horticulture and forestry, RLBCAU, Jhansi during *kharif* 2022 with the following objectives:

- To assess the genetic variability, heritability and genetic advance in bottle gourd.
- To estimate the correlation coefficient among the yield and yield components.
- Path coefficient analysis for yield and yield components.
- To study the genetic divergence in bottle gourd for growth, yield and quality attributes.

The results of the experiment have been briefed and salient findings are given as under:

- ❖ The analysis of variance of the experiment indicated highly significant differences among the 30 genotypes for all the characters under study. The results suggested existence of adequate amount of variability among the experimental material and hence, a greater scope for improvement of desired characters through selection in bottle gourd.
- ❖ A wide range of mean values among the genotypes for different traits under study were observed. Based on mean performance Hybrid Green Gold followed by MAHY 8 and Pusa Samrudhi, produced significantly higher fruit yield per plant. Which indicated direct selection of these genotypes for Bundelkhand region.
- ❖ Higher magnitude of GCV and PCV was recorded for fruit length (cm), fruit width (cm) and yield per plant (Kg), which demonstrating the presence of a broad range of genetic variability for these traits in the germplasm. Additionally, the very low or insignificant difference between GCV and PCV for these traits indicated that the selection based on phenotypic performance will be trustworthy since the investigated traits were less impacted by environment.
- ❖ High heritability with high genetic advance per cent of mean was recorded for days to first flowering bud, fruit length, fruit weight, fruit width, number of fruits per plant, yield per plant, total soluble solids, protein content and ascorbic acid content. Hence, this indicates that these traits are having predominant role of additive gene action and phenotypic selection will be rewarding.

- For the study of genotypic and phenotypic correlation the result finding suggested that there was strong genetic association among the characters but the significant influence of environment minimized the phenotypic relationship. The inter-character association at phenotypic and genotypic correlation coefficients suggested that yield per plant recorded highly positive significant correlation with fruit width, average fruit weight and number of fruits per plant at genotypic and phenotypic levels indicating that these traits are less influenced by the environment and an increase in any of these component traits will result in the increase of fruit yield per plant in bottle gourd. Hence, these characters may be given importance in the selection of high yielding genotypes.
- Path coefficient analysis revealed highly positive direct contribution towards yield per plant with number of fruits per plant, fruit width and average fruit weight at both genotypic and phenotypic level. On the other hand, vine length, days to first flowering bud, days to first fruit setting, days to first fruit picking and fruit length showed negative direct effect on fruit yield per pant. Considering the nature and magnitude of correlation along with direct and indirect effects, it can be inferred that simultaneous improvement of fruit yield per plant is possible through manifestation of important fruit yield contributing traits like number of fruits per plant, fruit width and average fruit weight.
- Based on ($D^2$) statistics of Mahalanobis (1936) and non-hierarchical Euclidean cluster analysis, thirty genotypes were grouped into five highly divergent cluster based on similarity in traits. Grouping of genotypes into different clusters showed considerable amount of diversity among the genotypes. The inter cluster $D^2$ value was maximum between cluster 5 and 4. The genotypes of distant clusters may be used for hybridization and desirable segregates in segregating generation. The minimum distance was observed between cluster 2 and 1, which indicates close relationship among the genotypes of these clusters. Intra cluster distance was observed only in the cluster 1, 2, 3 and 4 with maximum distance in the cluster 4 (586.5) followed by cluster 3 (324.0) and 2 (207.1) and cluster 5 is mono-genotypic in nature.

Considering the data on various important economic traits with respect to phenotypic and genotypic coefficients of variability, heritability, genetic advance in per cent of mean, phenotypic and genotypic correlation coefficients and phenotypic and genotypic path coefficient and genetic divergence analysis, it might be very conveniently concluded that there is a great possibility for improvement in the desired attributes of this seemingly high valuable vegetable crop which has been little explored for its great potentials. Genotypes Hybrid Green Gold followed by MAHY 8 and Pusa Samrudhi,

may be used for higher fruit yield per plant and also, these possess earlier to days to first flowering bud, earliest node number to first female flower appearance, highest fruit weight and more protein content.

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## APPENDIX I. Genotypes of bottle gourd and their source of collection

| Treatment | Name of genotypes | Sources |
|---|---|---|
| T1 | Sharada | Monsanto Holdings Pvt. Ltd. |
| T2 | Pusa Santushti | IARI, New Delhi |
| T3 | Amrit $F_1$ | HM. Clause India Pvt. Ltd. |
| T4 | Narendra Shishir | NDUAT, Faizabad, Uttar Pradesh |
| T5 | Surag | Tropical Seeds Pvt. Ltd. |
| T6 | Madhu Sree | NDUAT, Faizabad, Uttar Pradesh |
| T7 | Pusa Samrudhi | IARI, New Delhi |
| T8 | IC-594545 | MPUAT, Udaipur, Rajasthan |
| T9 | RBG-1 | Local collection, Lalitpur, Uttar Pradesh |
| T10 | RBG-2 | Local collection, Udaipur, Rajasthan |
| T11 | RBG-3 | Local collection, Kota, Rajasthan |
| T12 | RBG-4 | Local collection, Udaipur, Rajasthan |
| T13 | RBG-5 | Local collection, Jhalawar, Rajasthan |
| T14 | RBG-6 | Local collection, Jobner, Rajasthan |
| T15 | RBG-7 | Local collection, Udaipur, Rajasthan |
| T16 | Pusa Naveen | IARI, New Delhi |
| T17 | Hybrid Green Gold | Speciality Seeds Pvt. Ltd. |
| T18 | MAHY 8 | MAHYCO |
| T19 | Muskan | Pahuja Seeds Pvt. Ltd. |
| T20 | Mahi | VNR Seed Pvt. Ltd. |
| T21 | Narendra Madhuri | NDUAT, Faizabad, Uttar Pradesh |
| T22 | Arka Bahar | IIHR, Bangalore |
| T23 | RBG-8 | Local collection, Kota, Rajasthan |
| T24 | RBG-9 | Local collection, Jhalawar, Rajasthan |
| T25 | RBG-10 | Local collection, Kota, Rajasthan |
| T26 | RBG-11 | Local collection, Jobner, Rajasthan |
| T27 | RBG-12 | Local collection, Jhalawar, Rajasthan |
| T28 | RBG-13 | Local collection, Kota, Rajasthan |
| T29 | RBG-14 | Local collection, Jhalawar, Rajasthan |
| T30 | RBG-16 | Local collection, Jobner, Rajasthan |

## Appendix II. Mean performance of bottle gourd genotypes for different characters

| S. No. | Genotypes | DFFB | FMFEN | FFFEN | FFS | FFP | FL | FW | F Wt | NFPP | YPP | YPH | VL | T.S. S | PC | AAC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | **Sharada** | 27.67 | 12.00 | 13.67 | 43.00 | 51.67 | 37.67 | 6.23 | 0.800 | 6.67 | 5.33 | 281.43 | 593.3 | 2.03 | 203.93 | 13.33 |
| **2.** | **Pusa Santushti** | 31.00 | 9.33 | 10.67 | 46.33 | 55.00 | 19.33 | 9.90 | 0.867 | 6.00 | 5.17 | 293.70 | 570.0 | 2.17 | 155.13 | 13.83 |
| **3.** | **Amrit $F_1$** | 34.00 | 10.33 | 13.33 | 48.00 | 56.67 | 38.33 | 6.20 | 0.767 | 7.67 | 5.87 | 325.13 | 696.7 | 2.20 | 170.50 | 15.63 |
| **4.** | **Narendra Shishir** | 39.33 | 11.67 | 14.00 | 57.33 | 65.67 | 20.00 | 12.67 | 0.833 | 6.33 | 5.30 | 281.43 | 706.7 | 2.07 | 159.33 | 16.40 |
| **5.** | **Surag** | 33.33 | 10.33 | 12.67 | 47.00 | 55.00 | 38.33 | 6.00 | 0.867 | 7.00 | 6.07 | 327.73 | 613.3 | 2.53 | 196.33 | 11.90 |
| **6** | **Madhu Sree** | 33.33 | 12.00 | 13.33 | 47.00 | 56.00 | 19.00 | 10.80 | 0.767 | 7.00 | 5.37 | 326.23 | 676.7 | 2.47 | 200.33 | 12.60 |
| **7.** | **Pusa Samrudhi** | 26.00 | 12.33 | 13.67 | 42.00 | 51.00 | 37.00 | 6.87 | 0.867 | 7.33 | 6.30 | 333.67 | 620.0 | 2.73 | 218.67 | 15.17 |
| **8.** | **IC-594545** | 31.67 | 8.67 | 11.00 | 45.33 | 54.00 | 10.00 | 12.07 | 0.867 | 6.67 | 5.83 | 287.00 | 786.7 | 2.37 | 165.13 | 16.67 |
| **9.** | **RBG-1** | 31.33 | 13.00 | 14.33 | 45.67 | 53.67 | 33.33 | 6.13 | 0.800 | 5.00 | 3.93 | 207.03 | 680.0 | 2.53 | 195.33 | 11.23 |
| **10.** | **RBG-2** | 36.67 | 9.67 | 11.67 | 54.33 | 65.33 | 42.33 | 5.33 | 0.700 | 5.33 | 3.70 | 201.07 | 733.3 | 1.83 | 182.67 | 16.40 |
| **11.** | **RBG-3** | 30.67 | 9.33 | 11.00 | 46.67 | 55.33 | 32.33 | 5.77 | 0.700 | 5.33 | 3.73 | 199.20 | 730.0 | 2.03 | 145.93 | 16.60 |
| **12.** | **RBG-4** | 30.00 | 9.33 | 11.33 | 46.00 | 54.00 | 12.33 | 11.70 | 0.667 | 6.67 | 4.57 | 241.43 | 786.7 | 2.83 | 182.33 | 12.37 |
| **13.** | **RBG-5** | 32.67 | 9.00 | 11.33 | 45.33 | 50.67 | 19.00 | 6.50 | 0.733 | 4.67 | 3.43 | 193.67 | 623.3 | 2.33 | 173.67 | 14.23 |
| **14.** | **RBG-6** | 32.33 | 13.00 | 15.33 | 43.67 | 52.00 | 20.00 | 11.10 | 0.633 | 7.00 | 4.33 | 244.03 | 706.7 | 2.13 | 178.40 | 13.87 |
| **15.** | **RBG-7** | 27.33 | 10.67 | 13.00 | 45.67 | 52.33 | 31.67 | 5.20 | 0.767 | 6.67 | 5.10 | 285.13 | 650.0 | 1.80 | 181.30 | 13.50 |
| **16.** | **Pusa Naveen** | 27.00 | 11.67 | 13.67 | 44.00 | 51.00 | 30.67 | 5.80 | 0.733 | 5.67 | 4.13 | 218.47 | 673.3 | 1.70 | 185.77 | 14.33 |
| **17.** | **Hybrid Green Gold** | 27.33 | 11.67 | 13.67 | 45.67 | 53.00 | 38.33 | 6.43 | 0.833 | 8.00 | 6.60 | 344.80 | 723.3 | 2.33 | 181.65 | 14.03 |
| **18.** | **MAHY 8** | 27.00 | 10.33 | 11.33 | 37.33 | 46.00 | 45.00 | 5.27 | 0.833 | 7.67 | 6.40 | 339.97 | 736.7 | 2.20 | 219.67 | 14.10 |
| **19.** | **Muskan** | 30.00 | 10.00 | 11.33 | 44.67 | 52.33 | 46.67 | 4.37 | 0.733 | 6.33 | 4.63 | 246.97 | 776.7 | 2.40 | 138.13 | 16.00 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **20.** | **Mahi** | 27.00 | 12.67 | 15.00 | 40.00 | 48.00 | 41.67 | 6.40 | 0.667 | 6.67 | 4.43 | 228.87 | 640.0 | 2.63 | 184.20 | 14.57 |
| **21.** | **Narendra Madhuri** | 36.00 | 12.67 | 14.67 | 47.00 | 60.67 | 15.00 | 11.70 | 0.767 | 5.33 | 4.10 | 219.20 | 686.7 | 2.37 | 213.33 | 14.60 |
| **22.** | **Arka Bahar** | 35.00 | 10.00 | 12.00 | 49.00 | 64.00 | 34.00 | 5.67 | 0.800 | 6.00 | 4.77 | 238.87 | 650.0 | 2.73 | 176.20 | 16.00 |
| **23.** | **RBG-8** | 30.67 | 12.00 | 13.67 | 43.33 | 56.67 | 30.67 | 5.67 | 0.740 | 5.67 | 4.18 | 212.93 | 683.3 | 2.23 | 174.33 | 15.17 |
| **24.** | **RBG-9** | 33.67 | 12.00 | 14.67 | 49.33 | 56.67 | 35.67 | 5.00 | 0.667 | 5.33 | 3.67 | 221.80 | 800.0 | 2.93 | 208.67 | 16.97 |
| **25.** | **RBG-10** | 39.33 | 10.33 | 13.00 | 57.33 | 66.33 | 30.67 | 4.83 | 0.767 | 7.67 | 5.90 | 321.03 | 740.0 | 2.03 | 182.67 | 16.13 |
| **26.** | **RBG-11** | 36.00 | 12.33 | 14.33 | 48.00 | 55.67 | 34.00 | 5.40 | 0.633 | 6.33 | 4.07 | 224.80 | 716.7 | 1.67 | 156.67 | 14.33 |
| **27.** | **RBG-12** | 33.33 | 9.00 | 11.67 | 49.67 | 56.67 | 33.00 | 4.30 | 0.633 | 6.67 | 4.20 | 229.23 | 773.3 | 2.10 | 202.67 | 16.97 |
| **28.** | **RBG-13** | 35.00 | 9.67 | 11.00 | 46.67 | 54.33 | 36.67 | 5.50 | 0.667 | 7.33 | 4.93 | 262.90 | 693.3 | 2.07 | 185.00 | 13.93 |
| **29.** | **RBG-14** | 36.67 | 10.00 | 13.00 | 50.67 | 58.67 | 33.33 | 5.53 | 0.700 | 6.67 | 4.70 | 247.37 | 750.0 | 2.60 | 182.67 | 14.40 |
| **30.** | **RBG-16** | 35.00 | 12.00 | 14.67 | 51.67 | 60.33 | 26.67 | 5.37 | 0.667 | 6.00 | 4.00 | 214.80 | 706.7 | 2.77 | 160.70 | 13.03 |

**Name:** Ms. Sneha Rathore **Id. No.**: H/PG/012/21

**Semester and year of admission:** IV and 2022-23 **Degree:** M.Sc. (Hort.)

**Department:** Vegetable Science **Major subject:** Vegetable Science

**Thesis Title:** Studies on genetic diversity in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]

**Advisor:** Dr. Arjun Lal Ola

## ABSTRACT

The present experiment entitled "Studies on genetic diversity in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was carried out during *kharif 20*22 at Vegetable Research Farm, RLBCAU, Jhansi. In current investigation, a total of 30 genotypes of bottle gourd were sown in a randomized block design with three replications to estimate genetic variability, heritability and genetic advance, correlation studies, path coefficient analysis and genetic diversity among the genotypes. Observations were recorded on 15 characters. Analysis of variance of the experiment indicated highly significant differences among the 30 genotypes for all the characters and also a wide range of mean values among the genotypes for different traits under study were observed. Higher magnitude of GCV and PCV was recorded for fruit length (cm), fruit width (cm) and yield per plant (Kg). A very low or insignificant difference between GCV and PCV was recorded for most of the traits indicated that the investigated traits were less impacted by environment. High heritability with high genetic advance per cent of mean was recorded for days to first flowering bud, fruit length, fruit weight, fruit width, number of fruits per plant, yield per plant, total soluble solids, protein content and ascorbic acid content. The inter-character association at phenotypic and genotypic correlation coefficients suggested that yield per plant recorded highly positive significant correlation with fruit width, average fruit weight and number of fruits per plant at both genotypic and phenotypic levels. Path coefficient analysis revealed highly positive direct contribution towards yield per plant with number of fruits per plant, fruit width and average fruit weight at both genotypic and phenotypic level. On the other hand, vine length, days to first flowering bud, days to first fruit setting, days to first fruit picking and fruit length showed negative direct effect on fruit yield per pant. Based on ($D^2$) statistics, thirty genotypes were grouped into five highly divergent cluster based on similarity in traits. Grouping of genotypes into different clusters showed considerable amount of diversity among the genotypes. Based on yield performance, Genotypes Hybrid Green Gold followed by MAHY 8 and Pusa Samrudhi, were found to be the superior yielding genotypes.

Dr. Arjun Lal Ola
(Advisor)

Sneha Rathore
(Student)

**नाम: सुश्री स्नेहा राठौर** **पहचान संख्या-: एच/पीजी/012/21**

**सेमेस्टर और प्रवेश का वर्ष:** IV और 2022-23 **डिग्री- स्नातकोतर (उद्यानिकी)**

**विभाग:** सब्जी विज्ञान **प्रमुख विषय:** सब्जी विज्ञान

**थीसिस शीर्षक:** लौकी में आनुवंशिक विविधता पर अध्ययन [*लेगेनेरिया सिसेरिया* (मोल.) स्टैंडल।]

**सलाहकार:** डॉ. अर्जुन लाल ओला

## सारांश

"लौकी में आनुवंशिक विविधता पर अध्ययन [*लेगेनेरिया सिसेरिया* (मोल.) स्टैंडल.]" शीर्षक वाला वर्तमान प्रयोग सब्जी अनुसंधान फार्म, आरएलबीसीएयू, झाँसी में खरीफ 2022 के दौरान किया गया था। वर्तमान जांच में, आनुवंशिक परिवर्तनशीलता, आनुवंशिकता और आनुवंशिक उन्नति, सहसंबंध अध्ययन, पथ गुणांक विश्लेषण और जीनोटाइप के बीच आनुवंशिक विविधता का अनुमान लगाने के लिए तीन प्रतिकृति के साथ एक यादृच्छिक ब्लॉक डिजाइन में लौकी के कुल 30 जीनोटाइप बोए गए थे। 15 पात्रों पर अवलोकन दर्ज किए गए। प्रयोग के विचरण के विश्लेषण से सभी लक्षणों के लिए 30 जीनोटाइप के बीच अत्यधिक महत्वपूर्ण अंतर का पता चला और अध्ययन के तहत विभिन्न लक्षणों के लिए जीनोटाइप के बीच औसत मूल्यों की एक विस्तृत श्रृंखला भी देखी गई। फल की लंबाई (सेमी), फल की चौड़ाई (सेमी) और प्रति पौधा उपज (किलो) के लिए जीसीवी और पीसीवी का उच्च परिमाण दर्ज किया गया। अधिकांश लक्षणों के लिए जीसीवी और पीसीवी के बीच बहुत कम या नगण्य अंतर दर्ज किया गया था, जिससे संकेत मिलता है कि जांच किए गए लक्षण पर्यावरण से कम प्रभावित थे। उच्च आनुवंशिक अग्रिम प्रतिशत के साथ उच्च आनुवंशिकता, पहले फूल आने के दिनों से लेकर फल की लंबाई, फल का वजन, फल की चौड़ाई, प्रति पौधा फलों की संख्या, प्रति पौधा उपज, कुल घुलनशील ठोस पदार्थ, प्रोटीन सामग्री और एस्कॉर्बिक एसिड सामग्री दर्ज की गई थी। फेनोटाइपिक और जीनोटाइपिक सहसंबंध गुणांक पर अंतर-वर्ण एसोसिएशन ने सुझाव दिया कि प्रति पौधे की उपज में फल की चौड़ाई, औसत फल का वजन और जीनोटाइपिक और फेनोटाइपिक दोनों स्तरों पर प्रति पौधे फलों की संख्या के साथ अत्यधिक सकारात्मक महत्वपूर्ण सहसंबंध दर्ज किया गया है। पथ गुणांक विश्लेषण से प्रति पौधे फलों की संख्या, फल की चौड़ाई और जीनोटाइपिक और फेनोटाइपिक दोनों स्तरों पर औसत फल वजन के साथ प्रति पौधे उपज में अत्यधिक सकारात्मक प्रत्यक्ष योगदान का पता चला। दूसरी ओर, बेल की लंबाई, पहली बार फूल आने के दिन, पहली बार फल लगने के दिन, पहली बार फल तोड़ने के दिन और फल की लंबाई ने प्रति पौधे फल की उपज पर नकारात्मक प्रत्यक्ष प्रभाव दिखाया। ($d^2$) आँकड़ों के आधार पर, तीस जीनोटाइप को लक्षणों में समानता के आधार पर पाँच अत्यधिक भिन्न समूहों में वर्गीकृत किया गया था। जीनोटाइप को अलग-अलग समूहों में समूहित करने से जीनोटाइप के बीच काफी विविधता दिखाई दी। उपज प्रदर्शन के आधार पर, जीनोटाइप हाइब्रिड ग्रीन गोल्ड, उसके बाद MAHY 8 और पूसा समृद्धि, बेहतर उपज देने वाले जीनोटाइप पाए गए।

अर्जुन

डॉ अर्जुन लाल ओला

(सलाहकार)

स्नेहा राठौर

स्नेहा राठौर

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# CURRICULUM VITAE

**Name** – Sneha Rathore

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**Permanent Address**-Village- Raipur, Post- Raipur, Tehsil- Raipur, District- Jhalawar, Rajasthan 326036.

**Academic Qualification:**

| **Degree** | **Board/University** | **Institution/School** | **Year of Passing** | **Percentage** |
|---|---|---|---|---|
| M.Sc. (Hort.) Vegetable Science | Rani Lakshmi Bai Central Agricultural University | College of Horticulture & Forestry | 2023 | 86.0 |
| B.Sc. (Hons.) Horticulture | Agriculture University Kota | College of Horticulture & Forestry, Jhalawar | 2021 | 79.5 |
| Intermediate/10+2 | RBSE | Govt. Sr. Sec. School, Jhalrapatan | 2017 | 75.4 |
| High School/10th | RBSE | Govt. Smt. Bhawar bai dhupiya, girls sen. Sec. school, Raipur | 2015 | 68.6 |

**DECLARATION**

I do hereby declare that the information given above is true to the best of my knowledge and belief.

Your truly,

Sneha Rathore