

**STUDIES OF GENETIC DIVERSITY,
CORRELATION AND PATH COEFFICIENT ANALYSIS
IN SPONGE GOURD (*Luffa cylindrica* (Roem.) L.)**



THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE
In
HORTICULTURE
(VEGETABLE SCIENCE)

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Submitted by
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HR-0457/2021

UNDER THE GUIDANCE OF

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*Affectionately Dedicated To my
Grandparents(My Amma..) &
Parents*

Thanks & Regards

Mohit dubey.....



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CERTIFICATE

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Place: Kanpur

Date: , 2023

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Acknowledgment for a few might be just a trifle thing written on a piece of paper. But in its true essence it gives us an opportunity to remember and express our feelings for those whom we love and revere. Here I get a chance to express my token of thanks to people who have touched me in one way or the other by their small things.

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*It is great opportunity for me to present our sense for love to my beloved family, whose great deed and pray to God to make me in this position to write this thesis. From the cordial of my heart uncountable word of cordial veneration and gratitude to pious facts My grand-parents Late **Shri Harnarayan dubey** & Late **Smt. Vitan Devi**, My parents, **Shri Sanjay dubey** and **Smt. Anuradha dubey**. All the words in lexicon will be futile and meaningless if, I fail to express the obligation of my brothers, **Ravi, Deepak, Rohit, sohit, Ankit** and my cute niece **Niyati(pee hu)** and Friends **Ankit, Arvind, Govind** and **Saurabh** for their love, inspirations and encouragement during the odd and difficult period, otherwise the present study would have never been possible.*

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*Lastly, I bow at the feet of "**Kalivahan Mai**" with whose omnipresent blessing today on the eve of completion of my thesis. This is a long adventurous*

journey to the unknown destination with a hope for future. I was not alone in this journey, to accomplish this Hercules task. Today is one of delightful moments of my life. I am in a position to acknowledge all those, who helped me a lot to cross the way, in finishing the marathon work.

Date: ,2023

Nawab Ganj, Kanpur

Mohit dubey

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Id No. : HR-0457/2021
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Title of thesis : Studies on genetic diversity,
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in Sponge gourd [*Luffa cylindrica*
(Roem.) L.]

ABSTRACT

An experiment name “**Studies on genetic diversity, correlation and path coefficient analysis in Sponge gourd [*Luffa cylindrica* (Roem.) L.]**” was taken in Vegetable Research Farm, Department of Vegetable Science of C.S.A.U.A. & T. Kalyanpur, Kanpur during kharif season 2022-23 to evaluate the 60 genotype of sponge gourd in randomized block design with three replication for yield. The limitation of genetic variability, association between yield and related traits, path analysis and genetic divergence were studied. The observations were based on 10 characters viz., days to first male flower emergence, days to first female flower emergence, days to first picking, fruit diameter, internodal length, number of fruits per plant, average fruit weight, vine length, length of fruit, fruit yield per plant.

The phenotypic coefficient of variation was higher than the genotypic coefficient of variation. The PCV was observed high for the number of fruits per plant followed by fruit yield per plant and fruit length.

All the characters under study showed high value of heritability. Genetic advance was also high for character like fruit yield per plant, fruit length, fruit diameter, internode length and vine length.

Characters like average fruit weight, fruit length, fruit diameter, vine length, number of fruits per plant showed highly significant positive correlation with fruit yield per plant.

Study of path coefficient analysis reported that all the characters like days to first female flower, days to first picking, average fruit weight, fruit diameter and vine length and number of fruits per plant exhibited positive direct effect on fruit yield per plant. It also possesses direct negative effects on days to first male flower, fruit length and internode length.

Analysis of genetic divergence by D^2 statistics grouped the 60 genotypes under study were classified into three clusters. Out of them, clusters II had maximum number of genotype (25), followed by cluster I(19) and III(16). Cluster 1 has shown maximum inter cluster distance with cluster II followed by cluster III and cluster II has shown maximum inter cluster distance with cluster III. The maximum intra-cluster distance was shown by cluster 1 followed by cluster II.

Key word – Sponge gourd, Correlation, Path Coefficient, Heritability, Genetic Advance, Genetic Divergence and Variability.

ABBREVIATION

%	Percentage
°C	Degree centigrade
ANOVA	Analysis of Variance
cm	Centimeter
COV	Covariance
df	Degree of freedom
e.g.	For example
<i>et al.</i>	Co-authors [et all ii]
etc.	<i>Et cetera</i>
/	Per
g	gram
<i>i.e.</i>	that is
m	meter
MSE	Mean sum of square due to error
MSR	Mean sum of square due to replication
MSS	Mean sum of squares
MST	Mean sum of square due to treatment
Σ	Summation
<i>Viz.</i>	Videlicet (namely)
RBD	Randomized Block Design

SE	Standard error
SSE	Sum of square due to error
σ	Variance
h^2	Heritability
PCV	Phenotypic Coefficient of Variation
GCV	Genotypic Coefficient of Variation
D^2	Mahalanobis Statistics
P	Level of Significance

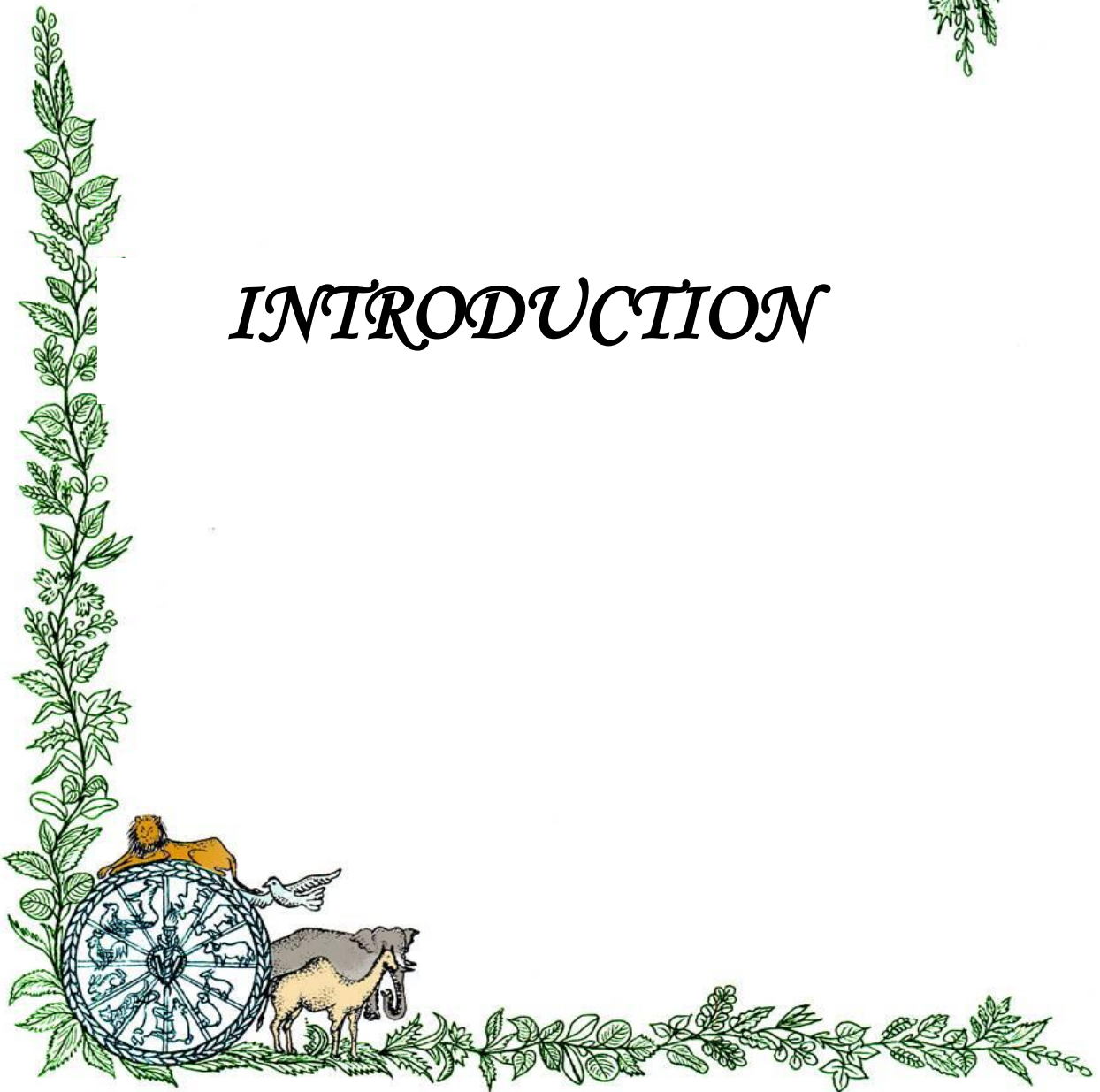
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INTRODUCTION



Horticulture has a significant influence in the agricultural GDP. In India, total horticulture output is anticipated to reach 341.63 million tonnes in 2021–22, that increase up 7.03 million tonnes (or 2.10%) from 2020–21. Over the previous year, it is anticipated that output of fruits, vegetables, and honey will increase while production of spices, flowers, aromatics, medicinal plants, and plantation crops will drop. Over 33% of the agriculture Gross Value Added (GVA) is made up of the horticulture sector, which significantly impacts the Indian economy. Horticultural crop productivity increased by roughly 38.5% between 2004–05 and 2021–22. Vegetables are an important crop in the horticulture sector, occupying an area of 11.35 Million Hectare as per 2021-22 with a total production of 204.84 Million Tonne with average productivity of 18.1 Tonnes/Hectare. India is the second-largest producer of vegetables in the world, behind China. The largest vegetable producing states in the nation include Gujrat, Madhya Pradesh, West Bengal, Karnataka, Orissa, and Uttar Pradesh. With a share of 14.8%, Uttar Pradesh produced the most vegetables in India during the 2022 fiscal year, West Bengal stands at second position in vegetable production. **(Ministry of Agriculture, Annual reports 2022-23)**

Sponge gourd belongs to Cucurbitaceae family and have diploid chromosome number of $2n=2x=26$. It is locally known different name in all over India such as chikani turai (Hindi), Jhinga (Bengali), pirkanga (Tamil), Gisoda (Gujrati), Bhol (Assamese) etc. It is one of the most important cucurbits grown tropical and subtropical parts of the country as a summer and rainy season vegetable. Although, the name ‘Luffa’ or ‘Loofah’ is Arabic origin and signifies its sponge characteristics. The genus luffa consists of ten species viz, *L. aegyptiaca* syn. *L. cylindrica*, *L. acuta* ngula, *L. echinate*, *L. umbellate*, *L. tuberosa*, *L. astorii*, *L. quinquefida*, *L. saccata*, *L. graveolens*, and *L.*

hermafrodita . out of ten species two species are cultivated all over the world i.e., *L. cylindrica* and *L. acutangula*. The *L. hermaphrodita* , mostly called satputiya . It bears hermaphrodite flowers and it is cultivated minor areas of our country . **(Marr et al. , 2005 & Nath and Swamy,2016)**

Nowadays, sponge gourd grown all over the world. such countries as Malaysia, Korea, Indonesia, Thailand, central America, Philippines, Taiwan and China are growing for vegetable as well as it's medicinal value. Major exporter country of sponge gourd is Japan whereas the major importer countries of sponge gourd is Brazil and U.S.A. **(Arya and Prakash, 2002)**

In India, sponge gourd is cultivated all over states as a vegetable crop such as Uttar Pradesh, Uttarakhand, Bihar, West Bengal, Madhya Pradesh, Orissa, Andhra Pradesh, Kerala and Assam.

Sponge gourd is fast growing, annual climber, herbaceous and highly cross-pollinated crop. it's flower color is deep yellow and opening in morning at 6 to 8 a.m. Flowers open in early morning hours and suitable for crossing and selfing throughout the day. The *L. cylindrica* is monoecious that means male and female flower found in same plant but different position. Male flower has raceme inflorescence and female flower is solitary axillary. sometimes pistillate and staminate flower are born on same node. Pistil has three placentae with many ovules and stigmas are three, bilobate. The ovary is inferior, one to three celled, tricarpeal and parietal placentation. flowers are unisexual and situated at different position of the same plant. Fruits of sponge gourd is oblong to cylindrical with marking on skin. **(Kumar et al. , 2013)**

The fruits are 15 to 30 cm long and have cylindrical curved or straight. There is a wide variability in fruit size ranging from one cm to one meter and have various shapes like lengthened cylindrical, spindle type, club shaped,

elliptical and elongated and color like dark green, light green, intermediate green with white strips.

Sponge gourd is cultivated for its tender and immature fruits and cooked as vegetable dish which is easily digestible and has nutritive value. Therefore, it is recommended for malaria and other seasonal fevers patient. Among cucurbits, sponge gourd is good producer of biological water and easily digestive. cellulose fiber/sponge is obtained from its matured and dried fruits, which is used in filtering and cleaning of vehicles, kitchen utensils and also used as bathing sponge that increases the blood circulation. Tender fruits of sponge gourd are rich source of vitamin A, vitamin C and iron. Fruits have 55 to 90% cellulose, 10 to 23% lignin, 8 to 22% hemicellulose and 2.4 % ash. Sponge gourd have highly nutritive value, it contains protein 1.2g, carbohydrate 2.9g, moisture 93.2g, vitamins (carotene 120mg, riboflavin 0.06mg, thiamine 0.02mg and niacin 0.04mg), minerals (calcium 36mg, phosphorous 19mg , ferrous 1.1 mg) and fibers 0.20g of edible portion. **(Gopalan et al. , 1999)**

Sponge gourd has a broad spectrum of variability for maturity, yield potential, fruit size and shape and other compositions. These traits are complex and controlled by several genes. Therefore, it is very important to assess the variability present for crop improvement work. Center of diversity of luffa is south -East Asia. various type germplasms lines are available in these areas but there is no systematic germplasm collection, conservation, evaluation programme at national and international level. **(Singh et al ., 2005)**

Serious attention is required towards identification of superior types (parents), assessment of genetic variability in existing pool and hybrid breeding programs for realizable increase in production and productivity of this crop.

The present study was carried out to assess genetic parameters among sponge gourd accessions for various traits with the following objectives.

1. To study the genetic variability in sponge gourd for growth and fruit yield characters.
2. To estimate the heritability and genetic advance in present study.
3. To study the correlation and path coefficients between yield and yield contributing characters .
4. To study the genetic divergence among the genotypes .

*REVIEW OF
LITERATURE*

In spite high commercial and nutraceutical importance of sponge gourd, meagre works on assessment of genetic variability have been done. However, the relevant works in this crop or related ones have been reviewed under following heads:

2.1 Variability in Plant growth and Fruit Yield Characters

2.2 Genetic Variability Parameters

2.3 Correlation and Path Coefficient Analysis

2.4 Genetic Divergence

2.1 Variability in Plant growth and Fruit Yield Characters

Kumar *et al.* (2023) , The experiment conducted on 15 genotypes of sponge gourd was subjected to evaluate parameters of variability, correlation and path analysis for fruit yield and its attributing traits. Significant variation were observed for all the character in all the genotypes used in the experiment. Highest genotypic and phenotypic variation were observed for fruit yield q/ha followed by fruit length, fruit yield per plot, vine length, number of fruit per plant and average fruit weight. The fruit yield q/ha followed by fruit yield per plot, number of fruit per plant, average fruit weight, days to 1st fruit harvest, fruit girth and fruit length showed high heritability coupled with high genetic advance.

Myla *et al.* (2022) The experiment was conducted in a Randomized Block Design with three replications during the Kharif season, 2020- 2022 at Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini. Analysis of variance showed significant differences among hybrids for all 10 characters.

Out of Sponge gourd hybrids evaluated for various characters, 5 hybrids were found superior for different characters. These 5 hybrids were found better for more than one character. High genetic advance as % mean (>20%) was recorded for fruit yield per plot(kg) and fruit yield (kg/plant) along with high heritability.

Som et al. (2020) carried out an experiment conducted on 15 genotypes of sponge gourd was subjected to evaluate parameters of variability, correlation and path analysis for fruit yield and its attributing traits. Significant variation were observed for all the character in all the genotypes used in the experiment. Highest genotypic and phenotypic variation were observed for fruit yield q/ha followed by fruit length, fruit yield per plot, vine length, number of fruit per plant and average fruit weight. The fruit yield q/ha followed by fruit yield per plot, number of fruit per plant, average fruit weight, days to 1st fruit harvest, fruit girth and fruit length showed high heritability coupled with high genetic advance.

Singh et al. (2019) carried out an experiment conducted on twenty eight genotypes of sponge gourd were evaluated for their genetic variability, heritability and potential for screening suitable genotypes for future improvement programmes. The genotypes exhibited highly significant differences for all the traits under study. A wide range of variability along with high estimates of PCV and GCV was observed for node number to anthesis first staminate flower, node number to anthesis first pistillate flower, vine length, number of fruits per plant and average fruit yield per plant indicating high variability available in the germplasm for these characters for further improvement.

Pandit et al. (2019) experiment conducted to determine phenotypic performance, genetic variability, heritability, genetic advance, diversity, correlation and path analysis for yield and seventeen yield attributing

characters of forty five sponge gourd germplasm. PCV was higher than GCV for all the traits studied. High PCV and GCV were recorded for number of primary branches, number of fruiting nodes on main stem, sex ratio, fruits per plant and yield per plant. Thirteen characters showed high heritability coupled with high genetic advance. Correlation coefficient study indicated that yield per plant had highly significant positive relationship with number of primary branches, fruiting nodes on main stem, fruit length, fruit weight, fruits per plant, seeds per fruit and 100 seed weight.

Singh *et al.* (2018) carried out an experiment to get most promising hybrids for earliness and yield. Fifteen hybrids of sponge gourd were developed using six parents in half diallel fashion Hybrids PSG-82 $\times$ PSG-07-04, PSG-07-04 $\times$ PSG-161 and PSG-07-04 $\times$ PSG-199 were found most promising for earliness and yield. These hybrids exhibited heterosis on 10 yield contributing traits and showed 59.36, 48.45 and 43.85 per cent over their better parents and 81.58, 69.16 and 63.91 per cent, respectively over the check cultivar for fruit yield per hectare. The cross combination PSG-82 $\times$ PSG-07-04 recorded highest significant heterosis for yield and its contributing traits and it was identified for evaluation in multi-location trial and commercial cultivation.

Krishnamoorthy and Ananthan (2017) carried out evaluation trials ridge gourd at TNAU, Madurai with 20 genotypes collected from different parts of Tamil Nadu during November 2013 to Nov, 2015. The results revealed that among the twenty genotypes, LA 2 recorded highest yield (9.37 kg/plant) followed by LA 12 collected from Virdhu nagar (8.81 kg/plant). LA 15 collected from Ottanchatram recorded earliness in first female lowering node and first female flowering days (11th node and 52.67 DAS). The genotype LA 19 collected from Seranma devi recorded high number of fruits per plant (33.47 Nos.), fruit length (26.67 cm), individual fruit weight (377.67g) with the average

yield of 5.7 kg per plant. The genotype LA 1 (PKM 1), LA 18 (Natham Local) and LA 20 (Sreerampuram Local) recorded highest fruit weight (576.33 g, 544 g and 525 g, respectively). The high yielding genotype LA 2 recorded 31.17 numbers of fruits per plant and individual fruit weight of 576.33g .

Bhargawa *et al.* (2017) conducted an experiment on twenty nine diverse genotypes of ridge gourd. The GCV and PCV estimate were high for node no. to anthesis of first staminate flower per plant followed by node no. to anthesis of first pistillate flower, days to anthesis of first staminate flower, days to anthesis of first pistillate flower, average fruit length(cm), days to anthesis of first pistillate flower, days to first fruit harvest, vine length(m), no. of nodes per vine.

Rathore *et al.* (2017) conducted an investigation on genetic variability in 12 genotypes of ridge gourd at SHIATS, Allahabad, during the year 2014. Results indicated that RIGVAR-6 exhibited minimum days to germination (3.53 days), days to first appearance of male and female flower (34.07 and 38.30 days), node number at which first male and female flower appear (5.60 and 11.53), sex ratio (34.00), length of main vine (5.30m), minimum days to first harvesting (43.93 days), fruit length (24.27 cm), fruit weight (132.60 gm), fruit diameter (4.75 cm), fruit yield (60.17t/ha), T.S.S. (4.58 °Brix) and vitamin C (4.59 mg/100 g). This genotype was found to be the best out of 12 genotypes in terms of growth, yield, quality and economic returns (highest B:C ratio *i.e.* 3.86).

Varalakshmi *et al.* (2015) conducted an experiment on 10 yield contributing traits in ridge gourd. A wide variability was observed for days taken to first female flower appearance, fruit length, fruit number/plant, fruit weight and fruit yield/ha.

In an experiment on varietal evaluation, Kumar *et al.* (2013) observed that number of fruits and length of fruits were found to be the important characters for increasing the yield potential in sponge gourd. Among the genotypes, three genotypes viz., UDSG-1 UDSG-5 and UDSG-4 were found to be higher in total yield per vine (8.30 kg, 5.46kg and 5.40 kg, respectively) which could be gainfully utilized in further breeding/ improvement programme.

Patidar *et al.* (2014) evaluated 22 genotypes of sponge gourd and revealed that phenotypic variance was higher as compared to genotypic variance for all the characters the GCV and PCV were high for number of seeds per fruit weight, number of days to first harvest and number of days to female flower anthesis.

Islam *et al.* (2009) evaluated 10 sponge gourd hybrids and found that there were certain hybrids which promising for one or more than one desirable traits. The best performing hybrids for different characters include DSG-6 × ‘Pusa Sneha’ for earliness; DSG-7 × PSG-9 for fruit length and average fruit weight; DSG-6 × CHSG-2 for fruit diameter and vine length; DSG-7 × NSG-1-11 for number of fruits per plant, average fruit weight and total yield per plant.

Singh *et al* (2002) observed the magnitude of genotypic and phenotypic variation in sponge gourd. The GCV is higher than PCV for all the characters. Total fruit yield average, fruit weight and dry fruit weight showed higher estimates of PCV and GCV.

Kumar *et al* (2002) reported that the analysis of variance indicated highly significant differences among the genotypes for all the characters. High

magnitude of phenotypic as well as genotypic coefficients of variations were observed in case of fruit yield per plant followed by number of fruit per plant, fruit weight, number of fruit per plant.

2.2 Genetic Variability Parameters

Bartaula *et al.* (2019) found that significant differences were present among genotypes for growth and yield traits. The estimates of GCV and PCV were highest for weight of fruit whereas traits namely fruit length, fruit diameter and days to maturity had medium value for both GCV and PCV. Broad sense heritability estimates ranged from 0.74 for fruit diameter to 0.98 for days to germination. Traits namely weight per fruit, days of germination, number of flower and days to flowering can be used effectively in selection process of crop improvement program as they had high GCV, PCV and heritability along with high genetic advance as percentage of mean.

Kumar *et al.* (2019) studied genetic variability in 45 genotypes of sponge gourd at BCKV, West Bengal and observed a wide range of variability. They also found that PCV was higher than GCV for all traits which are studied. High PCV and GCV were recorded for number of primary branches, number of fruiting nodes on main axis stem, sex ratio, number of fruits per plant and yield per plant. Thirteen characters showed high heritability coupled with high genetic advance.

Kannan *et al.* (2019) evaluated genetic variability in selected genotypes from two crosses *viz.*, Virudhunagar local x Periyakottai local (L3xT1) and Virudhunagar local x Alathur local (L3xT2) of ridge gourd along with their parents in (RBD) at Department of Horticulture, Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu, during July 2018 to November 2018. The results revealed that both crosses showed low PCV, GCV coupled with high heritability and high genetic advance for the character notes

to first male flower. Whereas low PCV, GCV coupled with low heritability and low genetic advance for the character fruit diameter.

Singh *et al.* (2019) studied genetic variability in 28 genotypes of sponge gourd during summer, 2015 in NDUAT, Kumarganj and observed a wide range of variability along with high estimates of PCV and GCV for node number to anthesis first staminate flower, node number to anthesis first pistillate flower, vine length, number of fruits per plant and average fruit yield per plant. High heritability coupled with high genetic advance as per cent of mean was observed for node number to anthesis of first staminate flower, node number to anthesis of first pistillate flower, days to anthesis of first staminate flower, vine length, number of nodes per vine, number of primary branches per plant, fruit length, fruit diameter, number of fruits per plant, average fruit weight and average fruit yield per plant indicating existence of high genetic variability and additive gene effect for these characters and therefore, the traits were found more reliable for effective selection.

Ahirwar and Singh (2018) carried out an experiment in cucumber for genetic variability at VRC of GBPUAT Pantnagar, Uttarakhand during the July-October, 2014 and February-June, 2015 in RBD. During first season, PCV was highest for fruit length (32.52), in second season, it was highest for yield (38.58) and in pooled analysis, highest for yield (33.50) was recorded. During first season, GCV was highest for fruit length (30.04), in second season, highest for yield (38.47) and in pooled analysis, it was found moderate for characters, namely, fruit length (27.65). The range of heritability in broad sense varied from days to first male flowers (40.91) to fruit weight (98.51) in first season, yield (99.44) to seed index (67.18) in second season and in pooled analysis fruit weight (g) (88.85) to primary branches per plant (25.31). Genetic advance as percentage of mean was found highest for fruit length (57.16), yield (79.03) and fruit number (52.15) in first season, second season and pooled data analysis.

Deepa et al. (2018) studied genetic variability in 30 cucumber genotypes. The PCV were higher than the corresponding values of GCV, there was very less difference in majority of the cases, thus showing that these traits were less influenced by environmental factors. High phenotypic and genotypic coefficient of variation were observed for vine length, number of leaves at 90 days after sowing, leaf area, internodal length, number of branches per vine, number of fruits per vine, average fruit weight, fruit length, fruit yield per vine, fruit yield per plot and fruit yield per hectare. High heritability coupled with high to moderate genetic advance were observed for all the characters except for days to first male and female flowering and fruit set percentage.

Manoj et al. (2018) conducted an experiment on 35 genotypes of sponge gourd and revealed that the GCV was low compared to the PCV for all the characters studied. The highest GCV and PCV observed for sex ratio, leaf area, leaf area index, fruit yield per plant and fruit yield per hectare. High heritability coupled with high genetic advance as percent mean observed for number of nodes, sex ratio, days to first harvest, leaf area, leaf area index, chlorophyll content, fruit length, percent fruit set, fruit weight, fruit yield per plant, fruit yield per hectare, rind thickness and flesh thickness indicating greater scope of improvement through selection.

Ramesh et al. (2018) evaluated the genetic variability in the fourteen genotypes of ridge gourd, in which one variety is the standard check (Arka Sumeet). Observation were recorded on various yield and yield contributing traits viz., days to 1st male flowering, days 1st female flowering, days to 50% flowering, node to first male flower, node to first female flower, sex ratio, vine length cm at 90 days, days to 1st harvest, days to last harvest, fruit length, flesh thickness, rind thickness, fruit set %, fruit diameter, fruits/ plant, average fruit weight, fruit yield/plant, fruit yield per hectare. Analysis of variance showed the significant variability for all the studied characters. High values of GCV and

PCV were observed for characters viz., fruit yield per plant (45.09 and 45.92), fruit yield per ha (45.10 and 45.91), fruit diameter (29.74 and 30.00), number of fruits per plant (27.42 and 28.31), average fruit weight (26.10 and 26.62), sex ratio (24.84 and 25.15), rind thickness (22.11 and 22.65), fruit length (20.01 and 20.40) and which indicates the presence of high genetic variation.

Ananthan and Krishnamoorthy (2017) studied genetic variability and heritability in ridge gourd. The genotypes exhibited higher percentage of genotypic coefficient variability, phenotypic coefficient variability and genetic advance with fruit yield per plant (31.55, 32.86

and 62.39) respectively and the heritability was high with fruit length (98%).

Bhargawa *et al.* (2017) conducted an experiment on twenty-nine diverse genotypes of ridge gourd. The GCV and PCV estimate were high for node number to anthesis of first staminate flower followed by node number to anthesis of first pistillate flower, days to anthesis of first staminate flower, days to anthesis of first pistillate flower, average fruit length (cm), days to anthesis of first pistillate flower, days to first fruit harvest, vine length (m), number of nodes per vine, number of primary branches per plant, average fruit diameter (cm), number of fruit per plant, average fruit weight (g) and marketable fruit yields per plant (kg).

Sharma *et al.* (2017) evaluated 15 genotypes of sponge gourd and reported that PCV was higher than GCV for all the traits and were higher for character viz., number of nodes at which first appearance of staminate flower followed by vine length at 15 DAS, number of nodes at which first appearance of pistillate flower and number of leaves per vine at 15 DAS.

Chavan *et al.* (2015) studied genetic variability during the period 2012-14. The results revealed that PCV was higher than GCV for the most of the characters. Higher heritability with moderate to high GCV, PCV and genetic

advance as percentage of mean was recorded for chlorophyll and proline contents at 45 DAS and total yield per vine.

Koppad *et al.* (2015) evaluated eighteen genotypes of ridge gourd for growth, earliness, biochemical, yield and fruit quality parameters. The results revealed that high heritability with moderate to high GCV, PCV and GAM (Genetic advance over mean) was recorded for chlorophyll and proline content during 45 days DAS and total yield per vine indicated that these characters could be improved by simple selection.

Varalakshmi *et al.* (2015) conducted an experiment and found a wide variability in days taken to first female flower appearance, fruit length, fruit number/plant, fruit weight and fruit yield/ha. Phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the traits studied, indicating environmental influence on the expression of these traits. However, high heritability (broad-sense), along with high genetic advance, was recorded in node number at which first female-flower appeared, number of branches, fruit length, number of fruits/plant and fruit weight, indicating presence of additive gene effects.

Patidar (2014) evaluated 22 genotypes of sponge gourd and revealed that phenotypic variance was higher as compared to genotypic variance for all the characters. The GCV and PCV were high for number of seeds per fruit, fruit weight, number of days to first harvest and number of days to female flower anthesis.

Dubey *et al.* (2013) evaluated ridge gourd genotypes during June–Oct. 2011 to estimate the magnitude of genetic variability and yield character associations. Genotypic coefficient of variation and heritability estimates were high for fruit length, fruit diameter, number of fruit per plant, and number of branches per plant. Genotypic coefficients of variation and heritability estimates were low for

days to first male flower anthesis, days to first female flower anthesis, and days to first harvest. Vine length, fruit length, number of fruit/ plant, and fruit weight can be used as selection criteria to increase fruit yield in *Luffa*.

Kumar et al. (2013) evaluated 20 genotypes of sponge gourd from Rajasthan during 2010 and found that highest genotypic and phenotypic variations were observed for total yield per vine followed by number of seeds per fruit, average weight of fruit and total soluble solids. Number of seeds per fruit, average weight of fruit and specific gravity showed high heritability with high genetic advance.

Pandey et al. (2013) observed higher estimates of phenotypic as well as genotypic coefficient of variation (PCV, GCV) for node number for appearance of first node flower (28.68, 23.87%) followed by average fruit weight (26.48, 25.58%), number of fruit per plant (26.03, 25.01%) average fruit length (22.86, 22.44%) fruit diameter (20.38, 19.67%) and vine length (20.93, 18.89%) in sponge gourd.

Pandey et al. (2012) conducted experiment on 30 genotypes of sponge gourd and evaluated for yield and yield contributing traits. High to moderate heritability and genetic advance was estimated for the characters viz. average fruit length, number of fruit/ plant, average fruit weight, fruit diameter and vine length, while, average fruit yield/ plant had high heritability but moderate genetic advance and days to taken for anthesis of first female flower exhibited high heritability and low genetic advance.

Khule et al. (2011) reported that high magnitude of genotypic and phenotypic variance was observed for all the characters viz., days to appear first male flower, days to appear first female flower, node number at which first female flower appear, number of fruit /plant, fruit weight, fruit length, fruit

diameter, number of seeds / fruit, 100-seed weight, and marketable fruit yield per plant in sponge gourd.

Sanandia (2010) evaluated 19 quantitative characters of sponge gourd to study the genetic variability and association of the traits. The analysis of variance revealed considerable genetic variability in the evaluated germplasm. The GCV and PCV estimates were high for fruit yield per plant, number of fruit per plant and number of seeds per fruit indicating better scope for improvement through simple selection. These characters also depicted high estimates for heritability and genetic gain indicating additive type of gene action.

Singh et al. (2009) studied thirty-five genotype of sponge gourd and reported that the genotypic and phenotypic coefficient of variation were highest for fruit weight (40.65-40.38), yield per plant (36.35-34.26), fruit length (26.79-25.22), node at which first female flower appears (24.23-24.41) and fruit per plant (24.0-21.32) indicating maximum variability in these characters and have ample scope for effective improvement through selection.

Yadav et al. (2009) studied genetic variability in 20 genotypes of cucumber and found that maximum phenotypic and genotypic coefficient (PCV & GCV) was observed for number of days to first female flowering. High estimates of heritability in broad sense, genotypic coefficient of variation and genetic advance were observed for number of fruits per plant, fruit length and fruit width.

Ram et al. (2005) studied that phenotypic coefficient of variation was greater than genotypic coefficients of variation indicating influence of environment in *Luffa* spp. Days to 50 percent flowering, fruit length and fruit breadth showed high heritability values. All characters recorded high genetic gain except days to 50 percent flowering and node at which first female flower appears. Hence, characters with high genotypic coefficient of variation, high

heritability and high genetic gain are controlled by additive gene action and hence direct selection is effective. Days to 50 percent flowering and node at which first female flower appears showed low genotypic coefficient of variation, moderate heritability and low genetic gain indicating preponderance of non-additive gene action and influence of environment.

Karuppaiah *et al.* (2002) observed that high genotypic coefficient of variation (GCV) for number of female flowers per plant, fruit yield per plant number of fruits per plant and flesh thickness in ridge gourd.

Singh *et al.* (2002) studied 80 genotypes of ridge gourd for genetic variability. High degree of variation was observed in respect of all the characters studied. The estimates of genotypic coefficient of variation were low as compared to phenotypic coefficient of variation for all the characters under study. The highest GCV and PCV were observed for sex ratio on branches.

Chowdhury and Sharma (2002) studied genetic variation, heritability, genetic advance, and correlation for yield and yield components (vine length, number of nodes, node on which the first flower appeared, number of fruits per plant, fruit length, fruit girth, and fruit weight) were studied in 12 *Luffa acutangula* cultivars (AAUJ-1, AAUJ-2, AAUJ-3, Mangaldoi, Tezpeu, Tihu, Mirza Short, Rangamati Long, Borpeta Long, Tiniali Long, Pusa Nasdar, and HRS C-2). The genetic coefficient of variation (GCV) was higher than the phenotypic coefficient of variation (PCV) for all characters. High values of heritability, PCV, GCV, and genetic advance were recorded for vine length, yield per hectare, and fruit weight, indicating that these traits were characterized by additive gene effects.

Khanikar *et al.* (1996) evaluated genetic variability in 15 genotypes of ridge gourd and significant genotypic variability was observed for characters like growth maturity and fruit yield.

Arora et al. (1983) observed a wide range of variability for fruits per plant among the genotypes of sponge gourd (0.3-12.0). They found significant variation for fruit length and diameter in this crop.

Panwar et al. (1977) observed high phenotypic coefficients of variation for characters such as yield per plant, number of fruits per plant, length of fruit, girth of fruit, average fruit weight, number of days taken for the first harvest, length of vine and node number of the first female flowers emergence in sponge gourd.

2.3 Correlation and Path Coefficient Analysis

Bartaula et al. (2019) found that fruit yield was highly significant and positively correlation with fruit diameter ($r = 0.649$) and negative significant correlation ($r = -0.538$) with days to flowering.

Kannan et al. (2019) evaluated Correlation and Path Coefficient Analysis in selected genotypes from two crosses viz., Virudhunagar local x Periyakottai local (L3xT1) and Virudhunagar local x Alathur local (L3xT2) of ridge gourd along with their parents in (RBD) at Dept. of Horticulture, TNAU, Tamil Nadu, during July 2018 to November 2018. The significantly and positively correlation was found in cross L3xT1 in respect to trait fruit yield with node to first male, node to first female flower, fruit weight, fruit length, number of fruits per plant and flesh thickness. Whereas cross L3xT2, also gave significantly and positively correlation in fruit yield with node to first male, node to first female flower, fruit weight, fruit diameter and flesh thickness. Path coefficient analysis showed that fruit length in L3xT1cross has contributed the maximum positive direct effect whereas the fruit diameter in L3xT2 cross contributed the maximum positive direct effect.

Kumar et al. (2019) studied correlation coefficient in 45 genotypes of sponge gourd at BCKV, West Bengal and found that yield per plant had highly

significant positive relationship with number of primary branches, fruiting nodes on main stem, fruit length, fruit weight, fruits per plant, seeds per fruit and 100 seed weight. Path co-efficient analysis showed that fruits per plant (0.7013) and number of seeds per fruit (0.6833) exhibited the highest positive direct effect on yield per plant.

Ananthan and Krishnamoorthy (2017) conducted an experiment on correlation studies in ridge gourd. The genotypic and phenotypic correlation coefficients showed that the fruit yield per plant significantly contributed by fruit weight (0.722 and 0.681), fruit diameter (0.426 and 0.393), number of fruits per plant (0.504 and 0.477) and first female flower node (0.467 and 0.428). They also reported that number of fruits per plant exhibited significant positive direct effect on yield per plant (1.4792) followed by fruit weight directly (0.9346) and indirectly (0.7220) in ridge gourd.

Gautam *et al.* (2017) studied Character association in 42 genotypes of ridge gourd during summer, 2013 at VRC of GBPUAT Uttarakhand. studies revealed that average fruit weight (0.774), number of fruits per plant (0.945), vine length (0.547), number of primary branches (0.472), fruit length (0.390), seed length (0.240) all with fruit yield had positive and significant correlation whereas, fruit yield had negative and significant correlation with number of node of first female/hermaphrodite flower (-0.458), days of first female/hermaphrodite flower anthesis (-0.314) and days of first fruit harvesting (-0.401).

Sharma *et al.* (2017) studied 15 genotypes of sponge gourd. In the path analysis, substantial positive direct effect on fruit yield/vine was exerted by days to first harvest after sowing, number of fruits per vine, days to first pistillate flowering, number of branches per vine at 45 DAS, vine length at 45 DAS, number of nodes at which first appearance of staminate flower, number of leaves per vine at 45 DAS, sex ratio and number of nodes at which first appearance of pistillate flower and also reported that fruit yield per vine had

highly significant and positive correlation with number of leaves per vine at 45 DAS, number of branches per vine, number of fruits per vine, fruit length and average fruit weight in sponge gourd. However, negative and significant correlations were noted with number of nodes at which first staminate flower, number of nodes at which pistillate flower and days to first harvesting.

Koppad *et al.* (2015) worked out correlation coefficients among different plant growth, fruit yield and biochemical traits of eighteen genotypes of ridge gourd (*Luffa acutangula* **Roxb.**). They found that fruit yield per vine was positively and significantly correlated with proline content in the leaf at 45 (0.5784) and 90 DAS (0.8659), average fruit weight (0.9298) and tendril length (0.4955) whereas it exhibited significantly negative correlation with sex ratio (-0.4606) and days to first female flowering (-0.5120).

Varalakshmi *et al.* (2015) reported that fruit yield/ha was significantly and positively associated with peduncle length, fruit length, number of fruits/plant (at the phenotypic level), fruit weight and fruit yield/plant. Fruit weight had the highest direct effect (0.847) on fruit yield/ha followed by fruit yield/plant (0.793), fruit number (0.344), peduncle length (0.237) and number of branches (0.216). Therefore, for yield improvement in ridge gourd, emphasis may be laid on indirect selection using fruit parameters like fruit weight, number of fruits/plant and fruit yield/plant.

Choudhary *et al.* (2014) studied correlation in six genotypes of ridge gourd and found that marketable yield/plant had positive and highly significant correlation with fruit weight (0.834) and number of marketable fruit/plant (0.624) at phenotypic level.

Dubey *et al.* (2013) found that vine length, fruit length, number of fruits per plant and fruit weight had a significant ($P < 0.01$) positive correlation with fruit yield per plant. The results indicated that vine length, fruit length, number of

fruits per plant and fruit weight can be used as selection criteria to increase fruit yield in ridge gourd.

Kumar *et al.* (2013) studied correlation and path coefficients between different traits of 20 genotypes of sponge gourd during 2010 and found that total yield per vine was found to be positively and significantly correlated with number of fruits per vine, average weight of fruit and number of seeds per fruit. Path coefficient analysis revealed that average diameter of fruit, number of primary branches, number of fruits per vine, average weight of fruit and total soluble solids showed positive direct effects on total yield per vine. Hence, selection for these traits for improving yield per vine in sponge gourd is suggested.

Hanumegowda *et al.* (2012) revealed that fruit yield per plant showed positive and significant correlation with number of fruits per plant, average fruit weight, fruit yield per plot, fruit yield per ha, fruit length, fruit diameter, percent fruit set, number of seeds per fruit, 100-seed weight, seed yield per fruit and rind thickness at the genotypic level and the number of fruits per plant, average fruit weight, fruit yield per plot, fruit yield per ha, fruit length, fruit diameter, number of seeds per fruit, seed yield per fruit, percent fruit set, rind thickness and 100-seed weight at phenotypic level ridge gourd.

Pandey *et al.* (2012) revealed that average fruit weight, number of fruit per plant and days to first marketable fruit harvest had positive direct effect on marketable fruiting yield per plant. The above finding indicated that an ideal plant with days to first marketable fruit harvest, days taken for anthesis of first female flower, days taken for anthesis of first male flower, higher fruit weight and maximum number of fruit per plant might be help in improving marketable fruit yield per plant in sponge gourd for formulating desirable plant with high yield and superior marketable character.

Rabbani et al. (2012) conducted an experiment on 60 genotypes of ridge gourd (*Luffa acutangula* Roxb.) which were collected from different locations of Bangladesh. And studied Correlation coefficient and found that yield per plant had highly significant positive relationship with the number of fruits per plant ($r = 0.874^{**}$), average fruit weight ($r = 0.707^{**}$), vine length at harvest ($r = 0.359^{**}$) and length of fruit ($r = 0.334^{**}$). On the other hand, the sex ratio and circumference of fruit exhibited negative association with yield. Path coefficient analysis showed that number of fruits per plant exhibited the highest positive direct effect (0.7192) on yield followed by average fruit weight (0.4656).

Khule et al. (2011) conducted a trial on correlation studies in genotypes of sponge gourd and revealed that marketable fruit yield per plant exhibited significant positive correlation with number of fruits per plant and fruit length. In general, genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficient suggested that the environmental influence reduces the relation between yield and contributing characters of sponge gourd.

Singh et al. (2011) Observed that number of fruits had maximum direct effect (0.858) followed by fruit weight (0.443) on fruit yield per plant. The fruit length, fruit weight and number of fruits exhibited significant positive correlation and also most of them had either direct or indirect effect on fruit yield per plant, emerged as important components contributed fruit yield and selection primarily based on these traits may results in development of high yielding genotypes in sponge gourd.

Karuppiah et al. (2005) reported correlation and path analysis among 18 yield related characters in 12 genotype of ridge gourd. The fruit yield was significantly and positively correlated with single fruit weight, fruit length fruit girth fruit number per plant, fruit size index, flesh thickness and number of male

and female flowers per plant. Yield was negatively correlated with sex ratio, days to first male flowering, days to fruit harvestable maturity from anthesis and node number of first female flowering.

Prasana *et al.* (2002) studied the correlation between the yield and yield components of ridge gourd (*Luffa acutangula*) in Bangalore, Karnataka, India, during the Rabi season of 1999.

Fruit yield per hectare was positively associated with vine length at 90 days after sowing (DAS), number of leaves at 90 DAS, number of female flowers, total dry weight of plant, number of fruits, and fruit girth and weight. Path coefficient analysis showed that vine length at 90 DAS, number of female flowers per vine, number of branches per vine, number of fruits per vine, fruit girth, and fruit weight had direct positive effects on fruit yield, whereas the number of leaves at 90 DAS, total dry weight of the plant, and fruit length had negative direct effects on fruit yield. The fruit yield of ridge gourd can be enhanced through the improvement of vine length at 90 DAS, number of female flowers, number of branches, number of fruits per vine, fruit girth, and fruit weight.

Singh *et al.* (2002) found that fruit weight, fruit girth and fruit length had high correlations with fruit yield in ridge gourd. Genotypic correlation coefficients were higher than the phenotypic correlation coefficients, which indicated strong inherent association among these traits.

Shah and Kale (2002) were studied correlation in ridge gourd and reported that the fruit weight per vine (dependent character) was positively and significantly correlated with the fruit number per vine, average fruit weight, number of female flowers per vine and vine length, indicating the close association and dependency of yield on these characters. The fruit length was

negatively correlated with fruit diameter and fruit number per vine, while it was positively correlated with the average fruit weight.

Rao et al. (2000) conducted correlation and path-coefficient analyses in 36 genotypes of ridge gourd. The majority of genotypic correlation coefficients were higher than phenotypic correlation coefficients, indicating a strong inherent association among various characters studied. Fruit yield per vine was significantly and positively correlated with number of fruits per vine, fruits per branch, girth, weight and volume of the fruit, but was negatively correlated with days to first female flower.

Varalakshmi and Reddy (1994) worked out the correlation and path analysis studies in Ridge gourd. Use a total of 58 genotypes of Ridge gourd collected from diverse sources of the country to know the association between yield and yield attributes. Path analysis of yield and its component revealed that vine length, node at which female flower appeared and fruit length had positive direct effect on yield when correlations and path analysis are viewed together it revealed that the yield improvement in ridge gourd can be achieved by selection for vine length days to female appearance fruit length fruit diameter and fruit weight.

Prasad et al. (1981) reported that days of flowering and number of fruits per plant had positive and significant correlation with number of pistillate flowers per vine both at genotypic and phenotypic levels. They further recorded significant and positive correlation between yield and number of fruits per plant while yield showed significant and negative correlation with days to flower and age of edible fruit in *Luffa* species.

Ananthan and Krisnamoorthy (2017) conducted an experiment on correlation studies in ridge gourd. The genotypic and phenotypic correlation coefficient showed that the fruit yield per plant significantly contributed by fruit weight (0.722 and 0.681), fruit diameter (0.426 and 0.393), number of fruit per plant (0.504 and 0.477) and first female flower node (0.467 and 0.428).

Janaranjani et al. (2015) conduct a trial on correlation and path- analysis studies in 18 different characters in bottle gourd and revealed that fruit yield was positively and significant correlated with fruit flesh thickness, number of fruit per vine and number of fruit pickings. The path-analysis indicated that number of fruit per vine, days to first female opening, fruit cavity and fruit weight had positive direct effect on fruit yield. There for emphasis should be given on fruit flesh thickness, number of fruit per vine, number of fruit pickings, days to first female flower openings, fruit cavity and fruit weight, while selecting a good hybrids for enhancing the yield of bottle gourd.

Choudhary et al. (2014) studied correlation in six genotypes of ridge gourd and found that marketable yield/plant had positive and highly significant correlation with fruit weight (0.834) and snumber of marketable fruit/plant (0.624) at phenotypic level.

2.4 Genetic Divergence

Kumar et al. (2019) studied genetic divergence in 45 genotypes of sponge gourd at BCKV, West Bengal. They used D^2 statistics and principal component analysis and revealed that all genotypes were grouped into seven different clusters. The cluster- III (541.13) showed maximum intra cluster distance while cluster IV and cluster V (5177.9) showed maximum inter cluster distance between them. The characters were yield per plant, fruit weight and number of fruiting nodes on main stem showed maximum contribution towards divergence, hence these diverse parents' characters were considered for future hybridization programme.

Singh et al. (2019) studied genetic divergence in 28 genotypes of sponge gourd during summer, 2015 in NDUAT, Kumarganj. They used D^2 statistics and principal component analysis. The genotypes under study were grouped into six clusters. Cluster III had nine genotypes. The intra-cluster value was maximum in cluster VI and minimum in cluster II. The maximum inter cluster distance was observed between cluster I and cluster IV. The lowest inter cluster divergence was observed between cluster III and IV. Cluster I showed maximum desirable mean values for node number to anthesis of first pistillate flower, days to anthesis of first staminate flower, days to anthesis of first pistillate flower, days to first fruit harvest, number of fruits per plant and average fruit yield per plant (kg), while cluster VI revealed the highest mean values for vine length (m), number of nodes per vine, number of primary branches per plant and fruit length (cm). Cluster I and VI would offer a good scope of improvement of the crop through rational selection for hybrid breeding program. The characters like average fruit yield per plant (41.27%) followed by number of fruits per plant and node number to anthesis first staminate flower each (11.38%) contributed maximum to genetic divergence and hence played a major role in improvement of sponge gourd.

Manoj et al. (2018) studied genetic divergence using Mahalanobis D^2 statistic to assess the genetic diversity in 35 ridge gourd genotypes. The all 35 genotypes were grouped into eight clusters, where Cluster I and II included eleven lines followed by cluster IV and VI with four genotypes each and cluster VII with two, whereas cluster III, V and VIII were solitary. Maximum intra-cluster diversity ($D^2 = 20.50$) observed in cluster VI followed by cluster IV ($D^2 = 17.87$), cluster II ($D^2 = 17.59$) and cluster I ($D^2 = 16.84$). Based on intercluster distance, the average D^2 value was maximum ($D^2 = 42.40$) between cluster IV and cluster VII having four and two genotypes, respectively. Flesh thickness

(38.66 %) contributed maximum to the total genetic diversity followed by rind thickness (16.30%) and fruit weight (9.58%).

Studies were carried out to assess the genetic divergence among 14 ridge gourd genotypes using mahalanobis D^2 by Ramesh *et al.* (2018). For genetic divergence fourteen varieties were grouped into four clusters. Maximum varieties (7) were included in cluster IV and minimum (1) in cluster I. The maximum inter-cluster distance was observed between cluster II and cluster IV (8506.65) followed by cluster II and III (4428.51) and cluster I and cluster III (1659.88) showed minimum inter-cluster distance. The varieties with specific characters can be utilized for hybridization programme.

Gautam *et al.* (2017) studied genetic divergence in 42 genotypes of ridge gourd during summer, 2013 at VRC of GBPUAT Uttarakhand. All genotypes were grouped into I, II, and III cluster, 5, 22, and 15 genotypes in respectively. Highest intra cluster distance was observed (5.984) between cluster I and II, and lowest (3.419) between cluster II and III.

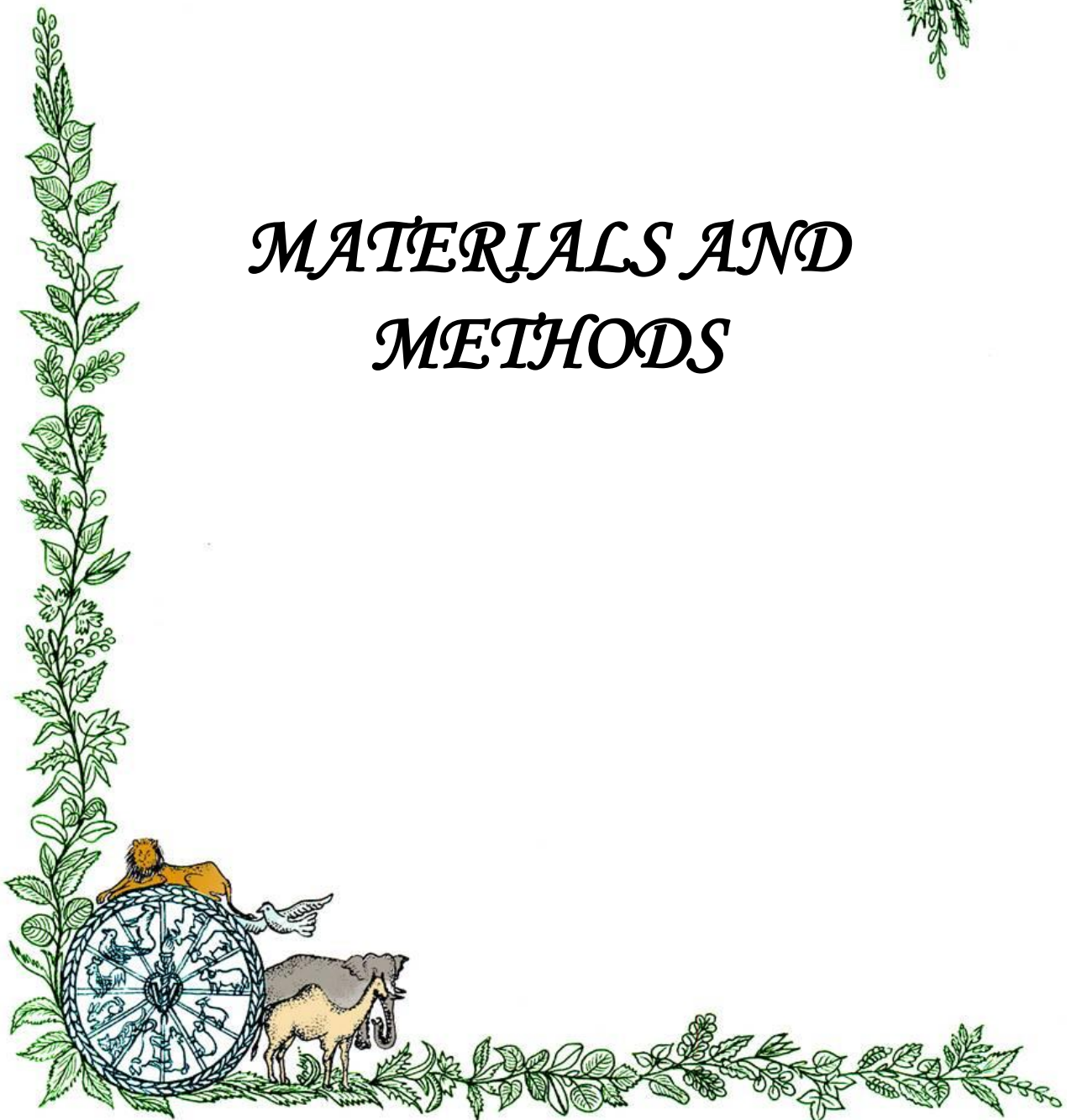
Gaffar *et al.* (2015) assessed genetic divergence in 15 genotypes of sponge gourd using D^2 statistics and principal component analysis. The genotypes under study were grouped in to five different clusters. The cluster I had maximum number of four genotypes (G1, G3, G5 & G6) whereas cluster IV included only one genotype (G11). Highest intra-cluster distance was observed in cluster III (0.999) indicating maximum variability within the cluster. The maximum inter-cluster distance was found between cluster IV and cluster V (51.31) indicating more genetic divergence between genotypes included in these clusters whereas the lowest inter cluster distance was found between cluster I and cluster IV (5.1). Cluster I registered highest cluster mean for yield per plant (6.55 kg) whereas cluster III was promising for internodal length ((17.62 cm). Maximum

cluster mean was recorded in cluster V for leaf length (30.43 cm), leaf breadth (24.65 cm) and petiole length (13.28 cm), cluster IV for earliest emergence of first male flower (58.50 DAS), first female flower (61.00 Das), node number of first male flower (9.20) and first female flower (13.38). Considering the genetic divergence parameters and agronomic performance, crosses viz., G01 x G02, G01 x G07, G01 x G15, G01 x G04, G01 x G14, G01 x G10, G11 x G07, G05 x G14, G02 x G03 and G04 x G11 were recommended for future hybridization programme.

Rabbani *et al.* (2012) studied genetic divergence in 60 genotypes of ridge gourd by using the Mahalanobis' D2 statistics, the sixty genotypes were grouped into four different clusters. Clustering pattern revealed that genotypes collected from the same location were grouped into different clusters. The average inter cluster distances were always higher than the average intra cluster distances suggesting wider genetic diversity among the genotypes within the cluster. Custer-III had the highest intra cluster distance .



MATERIALS AND METHODS



MATERIAL AND METHODS

The present investigation entitled “**Studies on genetic diversity, correlation and path coefficient analysis in sponge gourd [*Luffa cylindrica* (Roem.) L.]**” using morphological characters was undertaken with a view to find out the genetics of quantitative traits on sponge gourd . The research work was carried out at the Department of Vegetable Science, Kalayanpur, Chandra Shekher Azad University of Agriculture and Technology, Kanpur.

The details of the experimental materials used and procedures followed during the course of investigation have been described below.

3.1 Experimental Details

3.1.1 Location of experimental site

The experiment was conduct in kharif 2022 at the department of vegetable science, kalayanpur, Chandra shekhar azad university of agriculture and technology, Kanpur (U.P.). the university is located about 70 km away from lucknow (State Capital of Uttar Pradesh), which is situated at an altitude of 127 meters. The latitude being 26.40°N and longitude 80.10°E at elevation of 125.90 m above mean sea level. The experimental site's land topography was mostly homogeneous, with good surface drainage. The experimental location has a modest internal drainage system.

3.1.2 Season

The present experiment was conducted during kharif season (2022).

3.1.3 Weather: The data on rainfall, maximum and minimum temperature and relative humidity recorded during the cropping period Kharif, (Rainy) 2022 are presented in table 3.1

Table:- 3.1. Mean weakly weather parameters during the crop growth period (Kharif, 2022)

Month	Week	Temperature °C		Relative Humidity (%)		Rainfall (mm)
		Max	Min	Max	Min	
Aug.6-12	32	33.5	26	83	68	31.6
	33	32.8	25.4	85	69	99.6
	34	32.6	24.8	85	73	25.1
	35	33.6	25.8	86	72	15.5
Sept.3-9	36	35.2	25.8	83	58	00
	37	30.9	24.4	93.0	80.0	156.2
	38	31.4	23.9	89.0	78.0	83.0
	39	32	23.4	87.0	72.0	13.2
Oct.1-7	40	31	22.8	90.0	71.0	62.6
	41	29.3	21.1	90.0	71.0	159
	42	31.7	18.7	94.0	71.0	00
	43	31.4	16	84.0	49.0	00
	44	31.3	15.3	88.0	42.0	00
Nov.5-11	45	29.9	16.3	94.0	53	00
	46	27.9	12.9	81.0	39.0	00
	47	27.0	9.9	87.0	37.0	00
	48	26.8	10.3	92.0	45.0	00
Dec.3- 9	49	24.7	9.7	91.0	47.0	00
	50	25.3	10.1	87.0	42.0	00
	51	23.3	7.5	95.0	55.0	00
	52	22.2	7.6	95.0	63.0	00
	1	21.7	7.7	94.0	62.0	00

Jan. 22	2	13.9	5.4	95.0	69	00
	3	17.8	6.3	95.0	68	00
	4	20.4	7.4	93.0	46.0	00
	5	22.3	10.8	92.0	71.0	18.2

Source: Recorded in the AICRP's agro meteorology project at the College of Agriculture at Chandra Shekhar Azad University of Agricultural and Technology Kanpur, Uttar Pradesh.

3.1.4 Soil

The soil of experimental field had a medium black colour, good drainage a consistent texture, and a medium NPK status.

3.2 Experimental materials

The experimental material for present investigation comprised of 60 genetically diverse strains/cultivars of sponge gourd obtained from the germplasm maintained at Department of Vegetable Science, Kalayanpur, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur on the basis of morphological variability for different traits . The sowing of experimental material was done on 11 August 2022. Recommended dose of fertilizers and other cultural package of practices were adopted for better crop growth. The name and sources of genotypes are presented below:

Table 3.2: List of sponge gourd (*Luffa cylindrica* (L.) Roem.) genotypes and their sources

S. No.	Genotypes	Sources
1.	SG-6610	C.S.A. Univ. of Tech., kanpur, (U.P.)
2.	SG-7237	C.S.A. Univ. of Tech., kanpur, (U.P.)

3.	SG-5403	C.S.A. Univ. of Tech., kanpur, (U.P.)
4.	SG-5610	C.S.A. Univ. of Tech., kanpur, (U.P.)
5.	SG-7234	C.S.A. Univ. of Tech., kanpur, (U.P.)
6.	SG-5122	C.S.A. Univ. of Tech., kanpur, (U.P.)
7.	SG-8125	C.S.A. Univ. of Tech., kanpur, (U.P.)
8.	SG-7207	C.S.A. Univ. of Tech., kanpur, (U.P.)
9.	SG-5136	C.S.A. Univ. of Tech., kanpur, (U.P.)
10.	SG-5401	C.S.A. Univ. of Tech., kanpur, (U.P.)
11.	SG-7108	C.S.A. Univ. of Tech., kanpur, (U.P.)
12.	SG-7008	C.S.A. Univ. of Tech., kanpur, (U.P.)
13.	SG-7103	C.S.A. Univ. of Tech., kanpur, (U.P.)
14.	SG-7116	C.S.A. Univ. of Tech., kanpur, (U.P.)
15.	SG-8227	C.S.A. Univ. of Tech., kanpur, (U.P.)
16.	SG-7524	C.S.A. Univ. of Tech., kanpur, (U.P.)
17.	SG-7140	C.S.A. Univ. of Tech., kanpur, (U.P.)
18.	SG-5130	C.S.A. Univ. of Tech., kanpur, (U.P.)
19.	SG-7305	C.S.A. Univ. of Tech., kanpur, (U.P.)
20.	SG-7304	C.S.A. Univ. of Tech., kanpur, (U.P.)
21.	SG-7303	C.S.A. Univ. of Tech., kanpur, (U.P.)
22.	SG-7302	C.S.A. Univ. of Tech., kanpur, (U.P.)
23.	SG-7124	C.S.A. Univ. of Tech., kanpur, (U.P.)
24.	SG-7120	C.S.A. Univ. of Tech., kanpur, (U.P.)
25.	SG-7220	C.S.A. Univ. of Tech., kanpur, (U.P.)
26.	SG-8401	C.S.A. Univ. of Tech., kanpur, (U.P.)
27.	SG-8301	C.S.A. Univ. of Tech., kanpur, (U.P.)
28.	SG-8302	C.S.A. Univ. of Tech., kanpur, (U.P.)
29.	SG-8305	C.S.A. Univ. of Tech., kanpur, (U.P.)

30.	SG-8306	C.S.A. Univ. of Tech., kanpur, (U.P.)
31.	SG-8602	C.S.A. Univ. of Tech., kanpur, (U.P.)
32.	SG-8603	C.S.A. Univ. of Tech., kanpur, (U.P.)
33.	SG-8608	C.S.A. Univ. of Tech., kanpur, (U.P.)
34.	SG-8701	C.S.A. Univ. of Tech., kanpur, (U.P.)
35.	SG-8702	C.S.A. Univ. of Tech., kanpur, (U.P.)
36.	SG-8703	C.S.A. Univ. of Tech., kanpur, (U.P.)
37.	SG-8801	C.S.A. Univ. of Tech., kanpur, (U.P.)
38.	SG-9401	C.S.A. Univ. of Tech., kanpur, (U.P.)
39.	SG-8901	C.S.A. Univ. of Tech., kanpur, (U.P.)
40.	SG-8802	C.S.A. Univ. of Tech., kanpur, (U.P.)
41.	SG-9101	C.S.A. Univ. of Tech., kanpur, (U.P.)
42.	SG-9202	C.S.A. Univ. of Tech., kanpur, (U.P.)
43.	SG-2006-1	C.S.A. Univ. of Tech., kanpur, (U.P.)
44.	SG-2006-2	C.S.A. Univ. of Tech., kanpur, (U.P.)
45.	SG-2006-3	C.S.A. Univ. of Tech., kanpur, (U.P.)
46.	SG-2007-1	C.S.A. Univ. of Tech., kanpur, (U.P.)
47.	SG-2007-2	C.S.A. Univ. of Tech., kanpur, (U.P.)
48.	SG-2007-3	C.S.A. Univ. of Tech., kanpur, (U.P.)
49.	SG-2007	C.S.A. Univ. of Tech., kanpur, (U.P.)
50.	KHC	C.S.A. Univ. of Tech., kanpur, (U.P.)
51.	Pusa chikini	C.S.A. Univ. of Tech., kanpur, (U.P.)
52.	SG-5736	C.S.A. Univ. of Tech., kanpur, (U.P.)
53.	SG-2008-1	C.S.A. Univ. of Tech., kanpur, (U.P.)
54.	SG-0901	C.S.A. Univ. of Tech., kanpur, (U.P.)
55.	SG-0902	C.S.A. Univ. of Tech., kanpur, (U.P.)
56.	SG-0903	C.S.A. Univ. of Tech., kanpur, (U.P.)

57.	SG-0904	C.S.A. Univ. of Tech., kanpur, (U.P.)
58.	SG-0905	C.S.A. Univ. of Tech., kanpur, (U.P.)
59.	PSG-2009-10-1	C.S.A. Univ. of Tech., kanpur, (U.P.)
60.	PSG-2009-10-2	C.S.A. Univ. of Tech., kanpur, (U.P.)

Table 3.3 Experimental details

The details of experiment are given below :

1.Crop	Sponge gourd
2. Family	Cucurbitaceae
3. Number of germplasm	60
4. Experimental Design	Randomized Block Design (RBD)
5. Replications	3 (Three)
6. Total number of plots	180
7. Plot size	2.5x 3m
8. Number of plants per plot	3
9. Season	Kharif - 2022-23
10. Date of sowing seed in nursery bed	11-8-22
11. Place of research work	Vegetable Research farm, Department of Vegetable Science

3.3 Cultural Operations

3.3.1 Field preparation for Experiment

The field was prepared in well pulverized condition by deep ploughing with disc harrow, clod breaking with the help of rotavator and two subsequent ploughing with common cultivator and planking. Before the final ploughing well rotten FYM @ 20 t/ha was spread in the field and mixed by ploughing.

3.3.2 Seed treatment and sowing

Before sowing, the seeds were treated with Carbendazim 50% @ 2.0 g per kg seed. The seeds were directly sown in the field at depth of 3-5 cm in furrows and ridges in rainy seasons.

3.3.3 Fertilizer application

The recommended dose of chemical fertilizers @ 50 kg/ha N, 60 kg/ha P_2O_5 and 40 kg/ha K_2O was applied into the soil (Anon., 2019). The full dose of phosphorous and potassium and half nitrogen were thoroughly mixed and placed in furrow/ridges in each plot as basal dose before sowing. The rest amount of nitrogen was applied at 45 DAS as top dressing.

3.3.4 Intercultural operations

For taking a good and healthy crop the experimental area was kept always weed free by manual weeding throughout the cropping period. The recommended package of practices was adopted.

3.3.5. Irrigation:

Proper irrigation was carried out during the growing season for improved sponge gourd crop establishment and future growth development; as a result,

the initial irrigation was supplied right away after seeding. After that, the crop was watered every 8-10 days or as needed.

3.3.6 Harvesting:

As soon as the first fruit reached an edible, commercial stage, regular harvesting began. According to each germplasm's specified maturation stage, harvesting was carried out.

3.4 Observations to be recorded

In all plots 3 randomly plants are selected and tagged. All observations have been record from these tagged plants.

3.3.1. Days to first male flower emergence (days after sowing, DAS)

The no. of days were counted from the date of sowing to date of first male flower anthesis in all tagged plants in each replication was note down and the average was calculated.

3.3.2. Days to first female flower emergence (DAS)

The no. of days were counted from the date to sowing to date of first female flower anthesis in all tagged plants in each replication was note down and average was calculated.

3.3.3. Inter nodal length (cm)

At the time of first picking from tagged plant the inter nodal length were measured by measuring scale of 3 different inter nodal length on same plant then average is calculated and note down. This is done in all selected plants and average was calculated.

3.3.4. Vine length (cm)

The length of vine was measured the help of meter scale with from the base of plant to the apex of vine length in cm.

3.3.5. Days to first picking (DAS)

The days was counted from days to sowing to days to first harvest of fruit from each tagged plant and average days were calculated.

3.3.6. Fruit length (cm)

The 3 fruits from each treatments and in each replication at edible maturity were harvested and length was measured in centimeter with the help of measuring scale and the average was calculated.

3.3.7. Fruit diameter (cm)

The fruits whose length were measured their diameter were also measured with the help of Vernier Calipers and average were calculated.

3.3.8. Fruit weight (g)

The average weight of fruit was recorded on the base of weighing of 3 fruits from 3 randomly selected plants individually in each treatments and from each replications and then average is calculated.

3.3.9. Number of fruits per plant

The total number of fruits was counted from first harvest to last fruit harvest in tagged plant and note down individually in each treatments and in each replications.

3.3.10. Fruit yield per plant (kg)

The total weight of harvested fruits from each 3 tagged plants for each harvesting was summed together and then average weight of fruit per plant was observed.

3.4 Statistical Analysis

The data collected on different quantitative traits were processed for the Analysis of variance as per suggested the procedure by Panse and Sukhatme (1967). The table for analysis of variance (ANOVA) was set as explained by Gomez and Gomez (1983).

Source of variation	Degree of Freedom	Sum of Square	Mean sum of Square	Variance ratio (F value)
Replication (r)	r – 1	Sr	$\frac{Sr}{r-1}$	$\frac{Mr}{Me}$
Treatment (t)	t-1	St	$\frac{St}{t-1} = Mt$	$\frac{Mt}{Me}$
Error (e)	(r-1)(t-1)	Se	$\frac{Se}{(r-1)(t-1)} = Me$	

The calculated 'F' values were compared with tabulated 'F' value for test of significance. Standard Error (SE), Critical Differences (CD) and Coefficient of Variance (CV) were calculated to find out the superiority of one genotype over the others with the help of following formulae:

$$SE (m)_{\pm} = \sqrt{\frac{Me}{r}}$$

$$SE (d)_{\pm} = \sqrt{\frac{2Me}{r}}$$

$CD_{(0.05)} = SE (d) \times \text{table value of } t_{(0.05)} \text{ at error degree of freedom.}$

Where,

$SE (m)_{\pm}$ = Standard error of mean

$SE (d)_{\pm}$ = Standard error of difference

$CD_{(0.05)}$ = Critical difference at 5% level of significance

All the characters, which showed significant differences among genotypes were further subjected to analysis for the following parameters:

3.4.1 Parameters of variability

3.4.2 Heritability

3.4.3 Genetic advance

3.4.4 Genetic Advance as Percentage of Mean (Genetic Gain)

3.4.5 Correlation coefficients

3.4.6 Path coefficient analysis

3.4.7 Genetic divergence

3.4.1 Parameters of variability

Parameters of variability were estimated as per formula given by Burton and De Vane (1953).

a. Phenotypic coefficient of variation (PCV)

$$PCV (\%) = \frac{\sqrt{\text{Phenotypic variance } (V_p)}}{\text{General mean of population } (GM)} \times 100$$

b. Genotypic coefficient of variation (GCV)

$$GCV (\%) = \frac{\sqrt{\text{Genotypic variance } (V_g)}}{\text{General mean of population } (GM)} \times 100$$

c. Environmental coefficient of variation (ECV)

$$ECV (\%) = \frac{\sqrt{\text{Environmental variance } (V_e)}}{\text{General mean of population } (GM)} \times 100$$

Where,

$$V_e = M_e$$

$$V_g = \frac{Mt - Me}{r}$$

$$V_p = V_g + V_e$$

$$GM = \frac{\text{Grand total}}{r \times t}$$

3.4.2 Heritability

Heritability in broad sense was calculated as per formula given by Burton and De vane (1953) and Allard (1960).

$$\text{Heritability (h}^2 \text{ \%)} = \frac{\text{Genotypic variance (Vg)}}{\text{Phenotypic variance (Vp)}} \times 100$$

3.4.3 Genetic Advance

The expected genetic advance resulting from selection of five per cent superior individuals were worked out as suggested by Lush (1940) and further used by Burton and De vane (1953) and Johnson *et al.* (1955).

$$\text{Genetic advance} = h^2 \times \sqrt{Vp} \times K$$

Where,

h^2 = Heritability in broad sense

—
 $\sqrt{Vp}$ = Phenotypic variance deviation

K = Selection differential at 5% selection intensity

The value of K = 2.06 (Allard, 1960).

3.4.4 Genetic Advance as Percentage of Mean (Genetic Gain)

Genetic advance expressed as per cent of population mean was calculated by Johnson *et al.* (1955).

$$\text{Genetic gain (\%)} = \frac{\text{Genetic advance}}{\text{General mean of population } (\bar{X})} \times 100$$

For categorizing the magnitude of different parameters the limits used, are given below:

PCV and GCV > 30 % - High

15 – 30 % - Moderate

< 15 % - Low

Heritability (h^2) > 80 % - High

50 – 80 % - Moderate

< 50 % - Low

Genetic gain (GG) >30 % - High

15 – 30 % - Moderate

< 15 % - Low

3.4.5 Correlation Coefficients

The correlation between all characters under study, at genotypic, phenotypic and environmental levels was estimated as per the method described by Robinson *et al.* (1951) and Searle (1961).

1. Phenotypic correlation between character X and Y

$$r_{xy(p)} = \frac{Cov_{xy(p)}}{\sqrt{Var_{x(p)} \times Var_{y(p)}}}$$

2. Genetic correlation between character X and Y

$$r_{xy(g)} = \frac{Cov_{xy(g)}}{\sqrt{Var_{x(g)} \times Var_{y(g)}}}$$

3. Environmental correlation between character X and Y

$$r_{xy(e)} = \frac{Cov_{xy(e)}}{\sqrt{Var_{x(e)} \times Var_{y(e)}}}$$

Where,

$Cov_{xy(p)}$, $Cov_{xy(g)}$ and $Cov_{xy(e)}$ denote phenotypic, genotypic and environmental covariance between characters X and Y, respectively.

$Var_{x(p)}$, $Var_{y(g)}$ and $Var_{x(e)}$ denote phenotypic, genotypic and environmental variances for character X, whereas

$Var_{y(p)}$, $Var_{y(g)}$ and $Var_{y(e)}$ denote phenotypic, genotypic and environmental variances for character Y, respectively.

3.4.6 Path coefficient analysis

The path coefficient analysis of component traits with fruit yield per plant was done by following Dewey and Lu (1959). The direct and indirect effects were calculated by solving the following set of simultaneous equations.

$$Py_1 + Py_2 r_{12} + Py_3 r_{13} + \dots + Py_n r_{1n} = ry_1$$

$$Py_1 r_{12} + Py_2 + Py_3 r_{23} + \dots + Py_n r_{2n} = ry_2$$

- - - - -

- - - - -

$$Py_1 r_{1n} + Py_2 r_{2n} + Py_3 r_{3n} + \dots + Py_n = ry_n$$

Where

Py_1 , Py_2 , Py_3 ..., Py_n are the direct path effects of 1,2,3, ...n variables on dependent variable 'y'.

r_{12} , r_{13} , r_{1n} are the genotypic coefficients of correlation between various independent variables.

ry_1 , ry_2 , ry_n are the genotypic correlation coefficients of independent variables with dependent variable 'y'.

$P_{y_1 r_{12}}, P_{y_3 r_{23}}, \dots, P_{y_n r_{2n}}$ are the indirect effects.

The variation in the independent variable, which remained undetermined by including all variables, was assumed to be due to variable (s) not included in the present investigation. The degree of determination (p^2_{yx}) of such variable (s) on dependent variable was calculated as follows:

$$P^2_{yx} = 1 - (P^2_{y_1} + 2P_{y_1} P_{y_2 r_{12}} + 2P_{y_1} P_{y_3 r_{13}} + \dots$$

$$+ P^2_{y_2} + 2P_{y_2} P_{y_3 r_{23}} + \dots$$

$$+ P^2_{y_3} + 2P_{y_3} P_{y_4 r_{34}} + \dots + P^2_{y_n}) \text{ and}$$

$$\text{Residual effect } (R^2) = \sqrt{p^2_{yx}}$$

3.4.7 Genetic divergence

The genetic divergence in sixteen genotypes was estimated by Mahalanobis 'D²' statistics (generalized distance as suggested by (Rao, 1952) and canonical variate analysis. The calculation of D² values involved following steps (Murty and Arunachalam, 1967).

i. A set of uncorrelated linear combinations (Y's) was obtained by pivotal condensation of the common dispersion matrix (Rao, 1952) of a set of correlated variable (X's) and this matrix was arranged with the help of error mean sum of square and sum of products. ii. Using the relationship between Y's and X's the mean value of different genotypes for different characters (X₁ to X₁₃) were transformed into the mean values of asset of uncorrelated linear combinations (Y₁ to Y₁₃).

iii. The D² values between ith and jth genotypes for Pth characters was calculated

$$\text{as under } D^2_{ij} = \sum_{t=1}^P (Y_{it} - Y_{jt})^2$$

Where

Y_{it} is uncorrelated mean value of i^{th} genotype for 't' characters

Y_{jt} is uncorrelated mean value of j^{th} genotype for 't' characters D^2_{ij} is D^2 between i^{th} and j^{th} accessions.

In all combinations each character was ranked based on their contribution towards divergence between two entries ($d_i = Y_{it} - Y_{jt}$). Rank 1 is given to the highest mean difference and rank P to the lowest difference, where, P is the total number of characters.

i. The 'P' component and D^2 for each combination were ranked in descending order of magnitude. ii. The ranks were added up for each component D^2 over all combination and the rank totals were obtained.

3.4.7.1 Group constellation

Varieties were grouped into a number of clusters. D^2 being treated as the square of generalized distance, according to the method described by Tocher (Rao, 1952). The criterion used in clustering by this method is that any two genotypes belonging to the same cluster should, at least on an average, show a smaller D^2 value than those belonging to two different clusters. In other words, if variety V_1 and V_2 are close together and variety V_3 is distinct from both shown by this generalized distance, V_1 and V_2 form one cluster.

The average D^2 values of all possible genotypes combinations in one cluster with those in the other were computed and its square root was used to represent the 'statistical distance' between two clusters.

3.4.7.2 Intra-and cluster genetic distances

For the measure of intra cluster D^2 values, the following formula was used

$$\text{Intra-and inter cluster } D^2 = \frac{\sum D_i^2}{N}$$

$$N = n (n-1) / 2$$

Where,

$\sum D_i^2$ is the sum of D^2 values between all possible combinations (N) within and between clusters, respectively.

n = number of populations included in a cluster

Intra-and inter cluster genetic distances (d) where computed square root of average intra-and inter cluster D^2 values *i.e.*, $d = \sqrt{D^2}$

3.4.7.3 Contribution of different characters to divergence

The relative contribution of different characters to the total D^2 between each pair of genotypes was given a score of 1 to P (P being the number of characters) based on the magnitude of D^2 value due to each character. A rank of 1 represented the highest contribution and P the lowest of characters 'X'.

Contribution of each character was calculated using the following formula

$$\text{Percentage contribution of character} = A = \frac{N(X)}{n(n-1)/2} \times 100$$

Where,

$N(X)$ = Number of genotypic combinations which are ranked first for character 'X' out of the total genotypic combinations of $n(n-1) / 2$.

n = number of genotypes

Another modified formula was also used to calculate the percentage contribution of a character towards divergence as given below:

$$\frac{B - A_i}{\sum (B - A_i)} \times 100$$

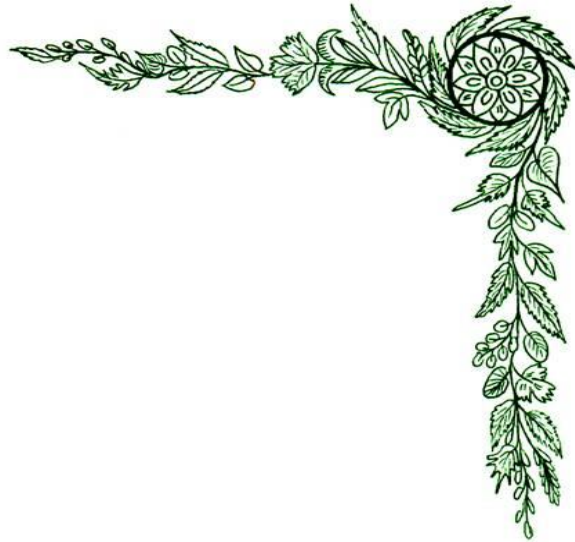
Where,

A_i = Total rank of i^{th} characters

B = Constant value which is higher than the highest value of the A .







EXPERIMENTAL FINDINGS



A detailed investigation named “**Studies on genetic diversity, correlation and path coefficient analysis in sponge gourd [*Luffa cylindrica* (Roem) L.]**” was taken in vegetable research farm of C.S.A.U.A.&T. Kalyanpur, Kanpur during the kharif season 2022. The experiment exploits and the process engaged in studying varied plant traits and the genetic parameters have been narrated in the antecedent chapter. The limitation of genetic variability, association between yield and related traits, path analysis and genetic divergence were studied. The result of the existent exploration is presented under the following heads.

- ❖ Analysis of variance
- ❖ Mean Performance of Genotypes
- ❖ Genetic Variability, Heritability and genetic advance
- ❖ Correlation coefficient
- ❖ Path Coefficient Analysis
- ❖ Genetic Divergence

4.1 Analysis of variance

The analysis of variance revealed that mean sum of square due to genotypes was highly significant for all characters. Which revealed existence of considerable amount of present at variability in material studied for the study of various traits. These finding are in general agreement with the findings of **Khule et al. (2010)** in Sponge gourd, **Kumar et al. (2013)** in Sponge gourd and **Koppad et al. (2015)** in ridge gourd, **Yadav and Kumar et al. (2012)** and **Bhardwaj et al. (2013)** in bottle gourd.

4.2 Range and mean performance of the genotype

Range and mean performance (maximum and minimum) of the sixty genotypes of sponge gourd for all the ten characters are presented in table 4.2a, b and c.

4.2.1 Days to first male flower emergence (DAS)

There was significant difference among the genotypes for days to first male flower emergence during rainy seasons. Minimum days to first male flower emergence was recorded in SG-7305(32.44) followed by SG-7207 (33.11

Table No. 4.1 Mean sum squares for different characters in Sponge gourd

Source of variation	df	Days To First Male Flower	Days To First Female Flower	Days To 1st Picking	Average Fruit Weight (gm)	Fruit Length (cm)	Internode Length (cm)	Fruit Diameter (cm)	Vine length (cm)	No of fruit/plant	Fruit Yield per plant (kg)
Repl	2	0.14	0.03	0.96	0.75	0.93	1.26	0.03	7.20	3.16	0.07
Treat	59	38.46**	40.14**	53.26**	507.38**	49.16**	17.08**	0.69**	4352.33**	103.97**	1.30**
Error	118	0.31	0.30	0.56	1.63	0.28	1.10	0.02	3.36	2.71	0.07
Total	179	12.89	13.43	17.93	168.32	16.39	6.37	0.24	1436.86	36.09	0.48

*, ** significant at 5% and 1% level, respectively

DAS), SG-8603 (33.22 DAS) and SG-7304(33.11DAS). The maximum number of days to first male flower emergence was noted in SG-8702(46.22) followed by SG-2006-3(45.22DAS) and SG-8301 (44.88DAS).

The population mean for this trait was 38.90 DAS.

4.2.2 Days to first female flower emergence (DAS)

The data on days to first female flower emergence was found significantly variable across the genotypes and season of cultivation. During rainy season, minimum number of days to first female flower emergence was noted in SG-7305 (37.32 DAS) followed by SG-0904, SG-2007-3, SG-7207 (38.22 DAS),SG-7304 (38.33 DAS) and SG-8603 (38.44 DAS) In the rest of the genotypes .

The population mean for this trait was 43.79 DAS.

4.2.3 Days to first picking (DAS)

The data on days to first picking was found significantly variable across the genotypes and season of cultivation. During rainy season, lowest number of days to first picking was noted in SG-8603 (50.10 DAS), SG-7207 (50.11 DAS) and SG-6610 (51.33 DAS).Maximum number of days to first picking was noted in SG-8702 (65.22 DAS) and population mean was 56.98 DAS.

4.2.4 Fruit diameter (cm)

The genotypes included in present investigation varied significantly for fruit diameter during rainy seasons. Maximum fruit diameter was noted in SG-0904, SG-2007-3 (3.85 cm) SG-0902 (3.80cm) followed by SG-8602, PSG-2009-10-1 (3.70cm). Minimum fruit diameter was recorded in SG-0901 (2.10 cm) followed by SG-8801(2.20 cm) and SG-7120 (2.40 cm) ,SG-5401(2.50cm).

The population mean for this trait was 2.92 cm

4.2.5 Internodal length (cm)

During rainy season, the genotypes included in this investigation exhibited a significant difference for internodal length with a range of 10.00cm in SG-2006-3 to 20.50 cm in SG-2006-2. Other genotypes with shorter internodal length were SG-8701 (12.00 cm) and SG-5401(12.16 cm) SG-08301 (12.33cm). The mean value of population was 15.32 .

4.2.6 Number of fruit per plant

The number of fruits per plant varied significantly from genotype to genotype, minimum number of fruits per plant was noted in SG-9401(8 fruits) While, it was maximum in SG-2007 (36 fruits) followed by SG-8603(35fruits) and PSG-2009-10-1

Number of fruit per plant is inherent character of a genotype which was greatly influence by environmental factors also. Hence, proper management of crop helps to produce maximum number of fruit per plant.

4.2.7 Average fruit weight (gram)

Average fruit weight varied from genotype to genotype, minimum weight of fruit was noted 110g(SG-5736) with an overall mean of 129.64 g fruit weight. While, it was Maximum fruit weight was recorded in SG-8703 (165 g) which was followed by SG-2007-3 (153 g) and SG-7303 (152 g).

Weight of fruit is inherent character of a genotype which greatly influence by environmental factors also. Hence, was proper management of crop help to improve fruit weight.

Table No. 4.2 Mean value of different characters for the genotypes

s.no	Genotypes	Days To First Male Flower	Days To First Female Flower	Days To 1st Picking	Average Fruit Weight (gm)	Fruit Length (cm)	Internode Length (cm)	Fruit Diameter (cm)	Vine length (cm)	No of fruit/plant	Fruit Yield per plant (kg)
1	SG-6610	35.66	39.22	51.33	126.03	24.83	13.83	2.80	322.00	32.66	3.80
2	SG-7237	37.33	42.53	54.33	125.63	23.16	15.33	2.80	300.17	28.83	3.50
3	SG-5403	42.66	48.33	61.66	110.53	20.67	18.16	2.20	289.83	23.11	2.00
4	SG-5610	38.11	43.22	56.11	129.50	21.90	12.50	2.70	360.00	27.20	3.30
5	SG-7234	36.77	41.88	53.77	117.33	16.50	15.67	2.20	275.00	22.97	2.80
6	SG-5122	41.44	45.92	58.44	134.00	21.83	17.33	3.10	360.00	27.00	3.21
7	SG-8125	43.43	48.44	62.77	138.00	24.33	13.00	3.37	325.00	31.24	3.90
8	SG-7207	33.11	38.22	50.11	132.00	20.83	16.70	2.75	310.00	24.77	3.35
9	SG-5136	42.77	47.33	60.77	124.00	15.83	14.67	2.10	270.00	21.43	2.50
10	SG-5401	34.66	40.09	51.66	110.50	17.16	12.16	2.50	265.17	24.78	3.00
11	SG-7108	40.75	45.11	56.75	127.50	28.00	15.83	3.50	310.00	29.44	3.44
12	SG-7008	42.99	49.64	64.66	127.00	19.67	12.50	2.70	270.00	23.82	3.06
13	SG-7103	40.57	46.22	58.11	118.33	22.83	17.00	2.90	240.00	18.40	2.20
14	SG-7116	35.55	41.66	55.22	140.00	27.16	13.50	2.90	340.00	27.50	3.80
15	SG-8227	42.44	48.39	61.44	123.50	23.33	15.16	3.27	282.00	26.00	3.10
16	SG-7524	36.77	41.67	56.77	111.00	21.50	12.67	3.40	279.67	20.20	2.20
17	SG-7140	34.66	38.22	52.66	117.00	18.16	14.83	2.60	310.00	25.20	2.90
18	SG-5130	40.00	44.22	59.33	123.00	25.67	17.00	3.50	310.00	26.50	3.20
19	SG-7305	32.44	37.32	50.38	126.33	17.43	13.33	2.70	365.00	24.40	3.00
20	SG-7304	33.33	38.33	53.33	122.00	21.00	18.16	2.50	290.00	20.50	2.43
21	SG-7303	39.77	44.22	58.77	152.00	29.83	14.50	3.37	360.00	30.11	3.82
22	SG-7302	37.66	42.11	53.66	165.00	27.16	12.83	3.10	340.00	26.33	3.97
23	SG-7124	41.33	46.22	58.33	130.00	19.35	16.33	2.60	325.00	14.50	2.38
24	SG-7120	39.22	44.00	55.22	119.00	16.50	13.00	2.40	260.00	15.33	2.14
25	SG-7220	34.11	40.11	52.11	150.00	23.67	15.67	3.15	360.00	25.00	3.75
26	SG-8401	36.77	42.81	54.77	147.50	29.67	18.33	2.90	315.00	29.33	3.90

27	SG-8301	44.88	49.23	64.88	142.00	27.16	12.33	3.00	340.00	23.11	3.25
28	SG-8302	36.33	41.33	56.33	135.50	26.50	15.16	3.40	355.00	31.50	3.80
29	SG-8305	38.11	42.57	53.07	112.57	18.16	13.83	2.80	270.00	16.80	2.10
30	SG-8306	41.77	46.33	59.77	122.33	17.33	16.67	2.70	270.00	20.90	2.60
31	SG-8602	40.11	45.22	56.11	128.00	17.33	13.50	3.70	325.00	24.11	3.20
32	SG-8603	33.22	38.44	50.10	134.00	23.83	15.33	3.27	360.00	35.50	3.90
33	SG-8608	41.66	46.66	60.66	125.50	19.83	18.83	2.60	345.00	19.50	2.40
34	SG-8701	39.33	44.00	55.33	137.00	24.50	12.00	2.90	370.00	23.00	3.16
35	SG-8702	46.22	50.44	65.22	120.50	20.13	14.50	2.60	285.00	17.33	2.00
36	SG-8703	43.11	48.22	60.11	165.00	18.50	17.33	2.20	315.00	12.00	1.90
37	SG-8801	38.00	43.11	56.00	152.00	15.16	19.50	2.20	300.00	15.80	2.30
38	SG-9401	36.66	39.33	52.66	133.00	20.93	12.16	2.50	290.00	8.33	1.04
39	SG-8901	39.77	44.66	57.77	143.50	22.67	15.67	3.80	369.33	25.11	3.60
40	SG-8802	42.11	47.33	60.11	122.50	20.33	13.00	2.50	245.00	24.50	2.80
41	SG-9101	37.33	42.22	55.33	134.33	24.83	16.83	2.90	370.00	26.80	3.15
42	SG-9202	43.11	48.44	64.11	147.00	27.67	14.50	3.10	324.83	30.33	3.35
43	SG-2006-1	40.44	45.22	60.31	126.00	25.32	17.16	3.37	340.00	30.50	3.60
44	SG-2006-2	35.77	41.66	57.77	110.00	20.93	20.50	2.10	300.00	22.00	2.95
45	SG-2006-3	45.22	50.33	64.22	122.00	18.50	10.00	3.27	275.00	15.11	2.20
46	SG-2007-1	38.66	42.22	53.66	128.00	16.16	12.33	2.90	280.00	26.00	3.30
47	SG-2007-2	42.44	47.11	60.44	116.00	17.16	16.50	2.50	260.00	19.50	2.65
48	SG-2007-3	34.33	38.22	51.20	153.00	29.83	13.33	3.85	380.00	30.50	3.80
49	SG2007	40.44	45.22	57.44	138.00	27.50	18.00	2.70	340.00	36.80	3.95
50	KHC	39.11	44.06	58.60	122.00	17.33	19.83	2.30	315.00	26.00	3.15
51	Pusa chikini	43.22	48.22	61.22	128.00	21.34	14.50	3.40	300.00	15.11	1.95
52	SG-5736	35.33	40.22	54.33	110.00	18.33	18.33	3.10	280.00	21.33	2.85
53	SG-2008-1	34.11	39.33	50.11	125.00	19.16	16.00	3.10	260.00	16.80	2.50
54	SG-0901	44.44	49.22	64.44	135.50	21.67	12.50	2.10	310.00	23.00	3.14
55	SG-0902	38.22	43.33	56.22	135.50	24.83	17.83	3.80	340.00	29.90	3.70
56	SG-0903	36.44	40.11	52.44	118.33	16.83	15.67	3.27	370.00	24.11	2.85
57	SG-0904	33.33	38.22	54.33	133.33	29.50	19.50	3.85	380.00	25.00	3.15
58	SG-0905	35.22	40.22	52.22	127.00	23.00	13.67	2.90	310.00	24.11	3.35

59	PSG-2009-10-1	43.77	48.33	61.77	139.00	21.33	18.50	3.70	345.00	35.33	3.80
60	PSG-2009-10-2	37.22	42.99	58.22	110.50	18.16	14.16	3.00	260.00	18.50	2.45
	Mean	38.90	43.79	56.98	129.64	21.83	15.32	2.92	313.55	24.01	3.01
	Min	32.44	37.32	50.10	110.00	15.16	10.00	2.10	240.00	8.33	1.04
	Max	46.22	50.44	65.22	165.00	29.83	20.50	3.85	380.00	36.80	3.97
	SE(d)	0.46	0.45	0.61	1.04	0.43	0.86	0.12	1.50	1.35	0.22
	C.D. at 5%	0.91	0.88	1.21	2.07	0.85	1.70	0.24	2.97	2.67	0.43
	C.V. (%)	1.44	1.25	1.31	0.98	2.40	6.85	4.99	0.59	6.86	8.82

4.2.8 Vine length (cm)

Vine length varied from 240 cm (SG-7103) to 380cm (SG-2007-3) with a mean of 313.55cm. Longest vine length was recorded in SG-2007-3 (380cm) which was followed by SG- 8701(370cm) and SG-8901 (369.33cm) where'as, minimum length was recorded from SG-7103(240cm) followed by SG-8802 (245cm) and SG-2007-2 (260cm).

Vine length of plant is an inherent character of a genotype which was greatly influence by environmental factors also. Hence, proper management of crop help to improve vine length.

4.2.9 Length of fruit (cm)

Length of fruit varied from 15.16 cm (SG-8801) to 29.83 cm (SG-2007-3) with overall mean of 21.83cm. Maximum length of fruit was recorded in SG-2007-3 (29.83cm) which was followed by SG- 8401(29.67cm) and SG-8401 (29.50cm) where'as, minimum length of fruit was recorded from SG-8801 (15.16cm) followed by SG- 5136 (15.83cm) and SG-2007-1 (16.16).

Length of fruit is an inherent character of a genotype which was greatly influence by environmental factors only. Hence, proper management of crop help to length o+f fruit.

4.2.10 Fruit yield per plant

Fruit yield per plant varied from 1.04kg (SG-9401) to 3.97kg (SG-7302) with an overall mean of 3.01kg. Maximum yield of fruit per plant was recorded in genotype SG-7302 (3.97kg) which was followed by SG-8603 (3.90kg) and SG- 7303(3.82kg) where's, minimum fruit yield per plant was recorded in SG-9401 (1.04kg) which was followed by SG-8703 (1.90kg) and Pusa Chikini (1.95kg).

All these characters as mentioned and described here showed the efficiency of genotypes for expression of characters are much more important in production point of view and can be harvested with proper management practices with timely application of resources utilized by plant during growth and development.

4.3 Genetic variability, Heritability and Genetic Advance

4.3.1 Coefficient of variability

The coefficient of variation (CV) is defined as the ratio of the standard deviation to the mean. It shows the extent of variability in relation to the mean of the population. The coefficient of variation should be computed only for data measured on a ratio scale, that is scales that have a meaningful zero and hence allow relative comparison of two measurements (*i.e.*, division of one measurement by the other) .

4.3.1.1 Phenotypic coefficient of variation

The phenotypic coefficient of variation was normally higher than GCV. The PCV was found to be high for the number of fruit per plant (25.15%) , followed by fruit yield per plant (23.05%), fruit length(18.65%). Other characters like, fruit diameter(16.88%),internode length(16.55%), vine length (12.16%) and average fruit weight (10.06%)also show moderate value of PCV. And days to first male flower (9.28%), days to first female flower (8.42%), days to first picking (7.47%) also shows lower value of PCV.

4.3.1.2 Genotypic coefficient of variation

The genotypic coefficient of variation was found to be high for the number of fruit per plant (24.19%), fruit yield per plant (21.30%) . other character like fruit length (18.49%), fruit diameter (16.12%) and internode length (15.06%) shows moderate value of GCV . And days to first male flower (9.17%), days to

first female flower (8.32%) and days to first picking (7.36%) shows lower value of GCV .

4.3.2 Heritability

Heritability in broad sense was found high for vine length (99.77%), average fruit weight (99.04%), fruit length (98.34%), days to first female flower (97.81%), days to first male flower (97.60%), days to first picking (96.93%), number of fruit per plant (92.56%) and fruit diameter (91.25%) .

4.3.3 Genetic Advance as Percentage of Mean (Genetic Gain)

During rainy season, high genetic advance as percentage of mean (genetic gain) was recorded for most of the traits ranging from 47.95% for number of fruit per plant to 14.92% days to first picking . Other traits with high genetic advance as percentage of mean were fruit yield per plant (40.54%), fruit length (37.78%), fruit diameter (31.72%), internode length (28.24%), vine length (24.99%) and average fruit weight (20.53%).

4.4 Correlation coefficient

The correlation coefficient describes how one variable move in relation to another. A positive correlation indicates that the two move in the same direction, with a +1.0 correlation when they move in tandem. A negative correlation coefficient tells you that they instead move in opposite direction. A correlation of zero suggests no correlation at all.

The value of phenotypic correlation coefficient and genotypic correlation coefficient of variation show in the table.

4.4.1 Phenotypic correlation coefficient

Days to first male flower exhibited highly significant positive correlation with days to first female flower (0.970) and days to first picking (0.905). it also exhibited non-significant positive correlation with average fruit weight (0.059), while significant negative correlation with vine

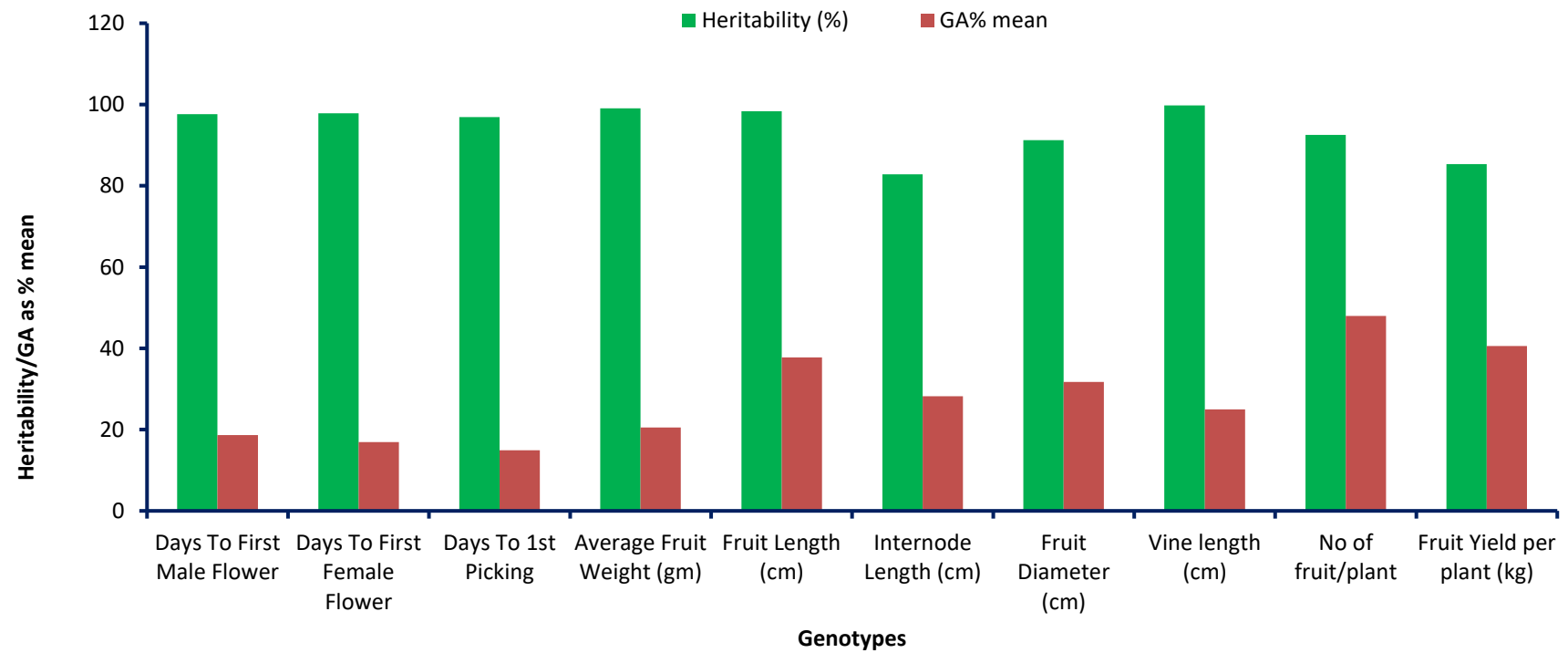


Fig. Heritability and genetic advance as percent of mean for different characters

length(-0.217), fruit yield per plant(-0.204) and number of fruit per plant(-0.147). Non-significant negative correlation seen with internode length(-0.109), fruit length(0.072).

Days to first female flower exhibited significant positive correlation with days to first picking(0.925). it also exhibited non-significant positive correlation with average fruit weight(0.051). while significant negative correlation with vine length(-0.244), fruit yield per plant(-0.179). Non-significant negative correlation with number of fruit per plant(-0.133), fruit diameter(-0.097), internode length(-0.082).

Days to first picking exhibited non-significant positive correlation with fruit length(0.016), average fruit weight(0.009). while significant negative correlation with vine length(-0.183), fruit yield per plant(-0.165). Non-significant negative correlation seen with number of fruit per plant(-0.087), fruit diameter(-0.067), internode length(-0.011).

Average fruit weight exhibited highly significant positive correlation with vine length(0.574), fruit length(0.518), fruit yield per plant(0.413) and fruit diameter(0.232). Non-significant negative correlation seen with internode length(-0.015).

Fruit length exhibited highly significant positive correlation with fruit yield per plant(0.571), number of fruit per plant(0.564), vine length(0.545) and fruit diameter(0.507). it also exhibited non-significant positive correlation with internode length(0.027).

Internode length exhibited non-significant positive correlation with vine length(0.113), number of fruit per plant(0.100) and fruit yield per plant(0.037). Non-significant negative correlation seen with fruit diameter(-0.069).

Fruit diameter exhibited highly significant positive correlation with

Table No. 4.4.1. Genotypic correlations for different characters

Characters	Days To First Male Flower	Days To First Female Flower	Days To 1st Picking	Average Fruit Weight (gm)	Fruit Length (cm)	Internode Length (cm)	Fruit Diameter (cm)	Vine length (cm)	No of fruit/plant	Fruit Yield per plant (kg)
Days To First Male Flower	1.000	0.988**	0.931**	0.060	-0.070	-0.132	-0.083	-0.220**	-0.153*	-0.224**
Days To First Female Flower			0.948**	0.052	-0.062	-0.086	-0.098	-0.247**	-0.141	-0.194**
Days To 1st Picking				0.009	0.017	-0.024	-0.074	-0.187*	-0.109	-0.172*
Average Fruit Weight (gm)					0.525**	-0.019	0.246**	0.576**	0.253**	0.448**
Fruit Length (cm)						0.033	0.539**	0.549**	0.591**	0.638**
Internode Length (cm)							-0.075	0.125	0.109	0.030
Fruit Diameter (cm)								0.468**	0.430**	0.475**
Vine length (cm)									0.527**	0.600**
No of fruit/plant										0.943**
Fruit Yield per plant (kg)										1.000

*, ** significant at 5% and 1% level, respectively

Table No. 4.2.2. Phenotypic correlations for different characters

Characters	Days To First Male Flower	Days To First Female Flower	Days To 1st Picking	Average Fruit Weight (gm)	Fruit Length (cm)	Internode Length (cm)	Fruit Diameter (cm)	Vine length (cm)	No of fruit/plant	Fruit Yield per plant (kg)
Days To First Male Flower	1.000	0.970**	0.905**	0.059	-0.072	-0.109	-0.084	-0.217**	-0.147*	-0.204**
Days To First Female Flower			0.925**	0.051	-0.059	-0.082	-0.097	-0.244**	-0.133	-0.179*
Days To 1st Picking				0.009	0.016	-0.011	-0.067	-0.183*	-0.087	-0.165*
Average Fruit Weight (gm)					0.518**	-0.015	0.232**	0.574**	0.239**	0.413**
Fruit Length (cm)						0.027	0.507**	0.545**	0.564**	0.571**
Internode Length (cm)							-0.069	0.113	0.100	0.037
Fruit Diameter (cm)								0.446**	0.409**	0.436**
Vine length (cm)									0.504**	0.554**
No of fruit/plant										0.849**
Fruit Yield per plant (kg)										1.000

*, ** significant at 5% and 1% level, respectively

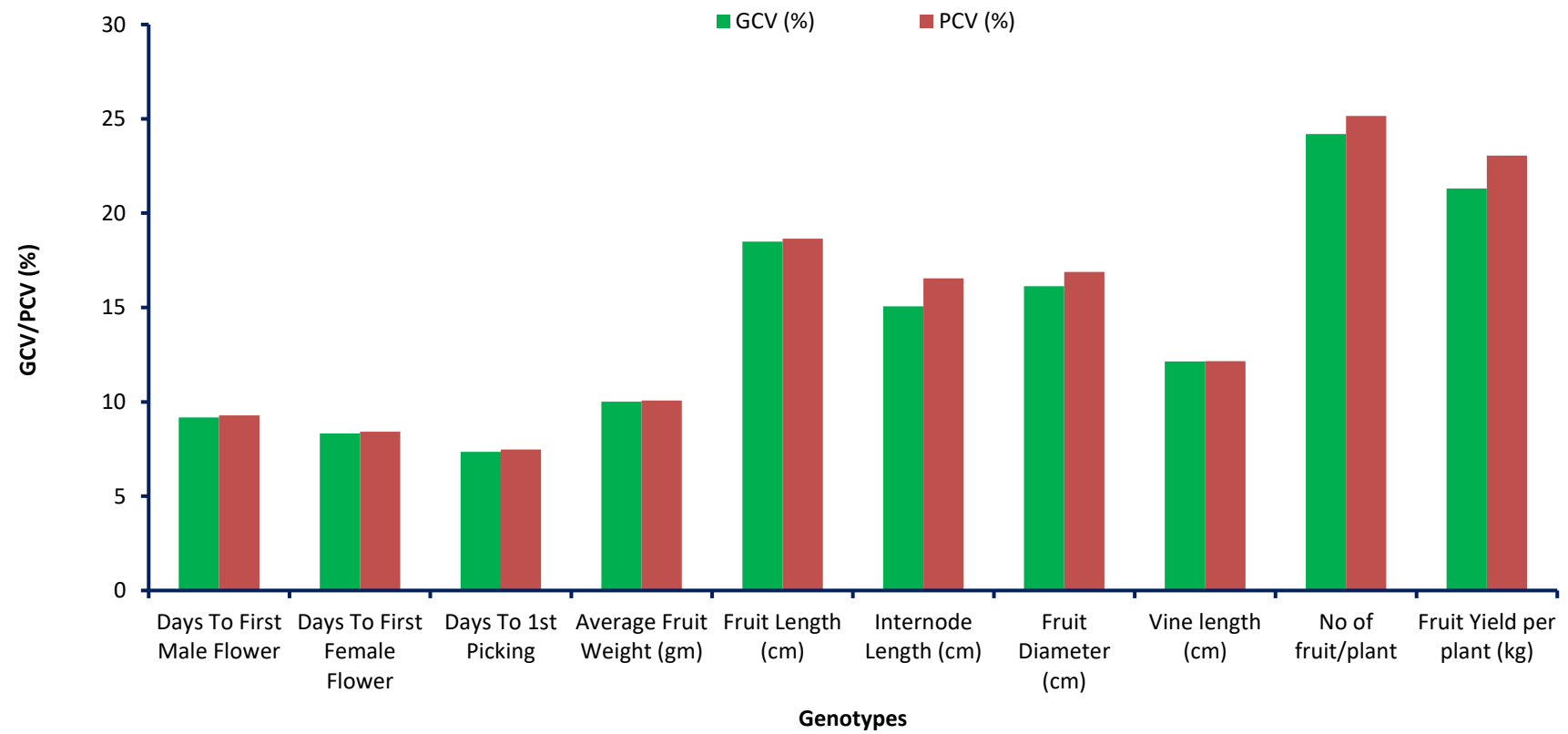


Fig. Genotypic and Phenotypic coefficient of variation for different characters in sponge gourd

vine length(0.446), fruit yield per plant(0.436) and number of fruit per plant(0.409).

Vine length exhibited highly significant positive correlation with fruit yield per plant(0.554) and number of fruit per plant(0.504).

Number of fruit per plant exhibited highly significant positive correlation with fruit yield per plant(0.849).

4.5 Path Coefficient analysis

To measure the direct as well as indirect association of one variable (cause) through another on the end product (effect), path coefficient was calculated at genotypic and phenotypic level for all the yield attributes traits. The observed correlation coefficient of fruit yield with its contributing traits were partitioned into direct and indirect effect. In the present investigation, important character viz., fruit yield per plant is been used as dependable variable. Since the values of genotypic path are more reliable in predicting the correct idea about the direct and indirect effects of the component traits, only this has been discussed below.

4.5.1 Direct effect

Study of the table revealed that some characters possess direct positive effects while others showed direct negative effects. The positive direct effects on average fruit yield per plant were shown by days to first female flower(0.144), days to first picking(0.0236), average fruit weight(0.2404), fruit diameter(0.0636) and vine length(0.0404) and number of fruit per plant(0.8537). It also possesses direct negative effects on days to first male flower(-0.2667), fruit length(-0.0629) and internode length(-0.1246).

4.5.2 Indirect effect

Days to first male flower exhibited positive effect via days to first female flower(0.1307), days to first picking(0.0219), average fruit weight(0.0143), fruit length(0.0044) and internode length(0.0164). while negative effect was shown via fruit diameter(-0.0053), vine length(-0.0089) and number of fruit per plant(-0.1306) on fruit yield per plant.

Days to first female flower showed positive effect via days to first picking(0.0224), average fruit weight(0.0124), fruit length(0.0039) and internode length(0.0108). while negative effect was shown via days to first male flower(-0.2516), fruit diameter(-0.0063), vine length(-0.0100) and number of fruit per plant(-0.1200) on fruit yield per plant.

Days to first picking exhibited positive effect via days to first female flower(0.0854), average fruit weight(0.0022) and internode length(0.0029). while negative effect was shown via days to first male flower(-0.1794), fruit length(-0.0011), fruit diameter(-0.0047), vine length(-0.0075) and number of fruit per plant(-0.0932) on fruit yield per plant.

Average fruit weight exhibited positive effect via days to first female flower(0.0591), days to first picking(0.0002), internode length(0.0024), fruit diameter(0.0157), vine length(0.0233) and number of fruit per plant(0.2159). while negative effect was shown via days to first male flower(-0.0755), fruit length(-0.0331) on fruit yield per plant.

Fruit length exhibited positive effect via days to first male flower(0.0886), days to first picking(0.0004), average fruit weight(0.1262), fruit diameter(0.0342), vine length(0.0222) and number of fruit per plant(0.5043). while negative effect was shown via days to first female flower(-0.0714) and internode length(-0.0041) on fruit yield per plant.

Internode length showed positive effect via days to first male

Table NO. 4.5.1. Genotypic path with Fruit Yield per plant (kg)

Characters	Days To First Male Flower	Days To First Female Flower	Days To 1st Picking	Average Fruit Weight (gm)	Fruit Length (cm)	Internode Length (cm)	Fruit Diameter (cm)	Vine length (cm)	No of fruit/plant	Fruit Yield per plant (kg)
Days To First Male Flower	-0.2667	0.1307	0.0219	0.0143	0.0044	0.0164	-0.0053	-0.0089	-0.1306	-0.224**
Days To First Female Flower	-0.2516	0.1444	0.0224	0.0124	0.0039	0.0108	-0.0063	-0.0100	-0.1200	-0.194**
Days To 1st Picking	-0.1794	0.0854	0.0236	0.0022	-0.0011	0.0029	-0.0047	-0.0075	-0.0932	-0.172*
Average Fruit Weight (gm)	-0.0755	0.0591	0.0002	0.2404	-0.0331	0.0024	0.0157	0.0233	0.2159	0.448**
Fruit Length (cm)	0.0886	-0.0714	0.0004	0.1262	-0.0629	-0.0041	0.0342	0.0222	0.5043	0.638**
Internode Length (cm)	0.1671	-0.0989	-0.0006	-0.0046	-0.0021	-0.1246	-0.0047	0.0050	0.0935	0.030
Fruit Diameter (cm)	0.1049	-0.1125	-0.0018	0.0592	-0.0339	0.0093	0.0636	0.0189	0.3669	0.475**
Vine length (cm)	0.2785	-0.2821	-0.0044	0.1386	-0.0346	-0.0155	0.0297	0.0404	0.4497	0.600**
No of fruit/plant	0.1938	-0.1609	-0.0026	0.0608	-0.0372	-0.0136	0.0273	0.0213	0.8537	0.943**

Resi = 0.0197

*, ** significant at 5% and 1% level, respectively

Table No. 4.5.2 Phenotypic path with Fruit Yield per plant (kg)

Characters	Days To First Male Flower	Days To First Female Flower	Days To 1st Picking	Average Fruit Weight (gm)	Fruit Length (cm)	Internode Length (cm)	Fruit Diameter (cm)	Vine length (cm)	No of fruit/plant	Fruit Yield per plant (kg)
Days To First Male Flower	-0.3378	0.3286	-0.0907	0.0125	0.0012	0.0046	-0.0059	-0.0047	-0.1114	-0.204**
Days To First Female Flower	-0.3278	0.3386	-0.0928	0.0110	0.0010	0.0035	-0.0068	-0.0053	-0.1007	-0.179*
Days To 1st Picking	-0.3055	0.3131	-0.1003	0.0019	-0.0003	0.0005	-0.0047	-0.0040	-0.0660	-0.165*
Average Fruit Weight (gm)	-0.0198	0.0174	-0.0009	0.2141	-0.0088	0.0007	0.0163	0.0125	0.1815	0.413**
Fruit Length (cm)	0.0243	-0.0200	-0.0016	0.1108	-0.0169	-0.0011	0.0356	0.0118	0.4279	0.571**
Internode Length (cm)	0.0368	-0.0278	0.0011	-0.0033	-0.0005	-0.0422	-0.0048	0.0024	0.0755	0.037
Fruit Diameter (cm)	0.0285	-0.0330	0.0068	0.0497	-0.0086	0.0029	0.0701	0.0097	0.3099	0.436**
Vine length (cm)	0.0733	-0.0826	0.0184	0.1229	-0.0092	-0.0048	0.0313	0.0217	0.3827	0.554**
No of fruit/plant	0.0496	-0.0450	0.0087	0.0512	-0.0095	-0.0042	0.0286	0.0110	0.7585	0.849**

Resi = 0.211

*, ** significant at 5% and 1% level, respectively

flower(0.1671), vine length(0.0050) and number of fruit per plant(0.0935). while negative effect shown via days to first female flower(-0.0989), days to first picking(-0.0006), average fruit weight(-0.0046), fruit length(-0.0021), fruit diameter (-0.0047) on fruit yield per plant.

Fruit diameter showed positive effect via days to first male flower(0.1049), average fruit weight(0.0592), internode length(0.0093), vine length(0.0189), number of fruit per plant(0.3669). while negative effect shown via days to first female flower(-0.1125), days to first picking(-0.0018) and fruit length(-0.0339) on fruit yield per plant.

Vine length exhibited positive effect via days to first male flower(0.2785), average fruit weight(0.1386), fruit diameter(0.0297) and number of fruit per plant(0.4497). while negative effect shown via days to first female flower(-0.2821), days to first picking(-0.0044), fruit length(-0.0346) and internode length (-0.0155) on fruit yield per plant.

Number of fruit per plant showed positive effects via days to first male flower(0.1938), average fruit weight(0.0608), fruit diameter(0.0273), vine length(0.0213). while negative effect shown via days to first female flower(-0.1609), days to first picking(-0.0026), fruit length(-0.0372) and internode length(-0.0136) on fruit yield per plant.

4.6 Genetic divergence

Genetic divergence is the process in which two or more population of an ancestral species accumulate independent genetic changes through time, often leading to reproductive isolation and continued mutation even after the populations have become for some period of time, as there isn't genetic exchange anymore. In some cases, sub population living in

Table No. 4.6.1 Number of genotypes in each cluster

Clusters	No of genotypes	Genotypes
I	19	5 8 10 16 17 19 20 24 29 37 38 44 46 50 52 53 56 58 60
II	25	1 2 4 6 7 11 14 18 21 22 25 26 28 31 32 34 39 41 42 43 48 49 55 57 59
III	16	3 9 12 13 15 23 27 30 33 35 36 40 45 47 51 54

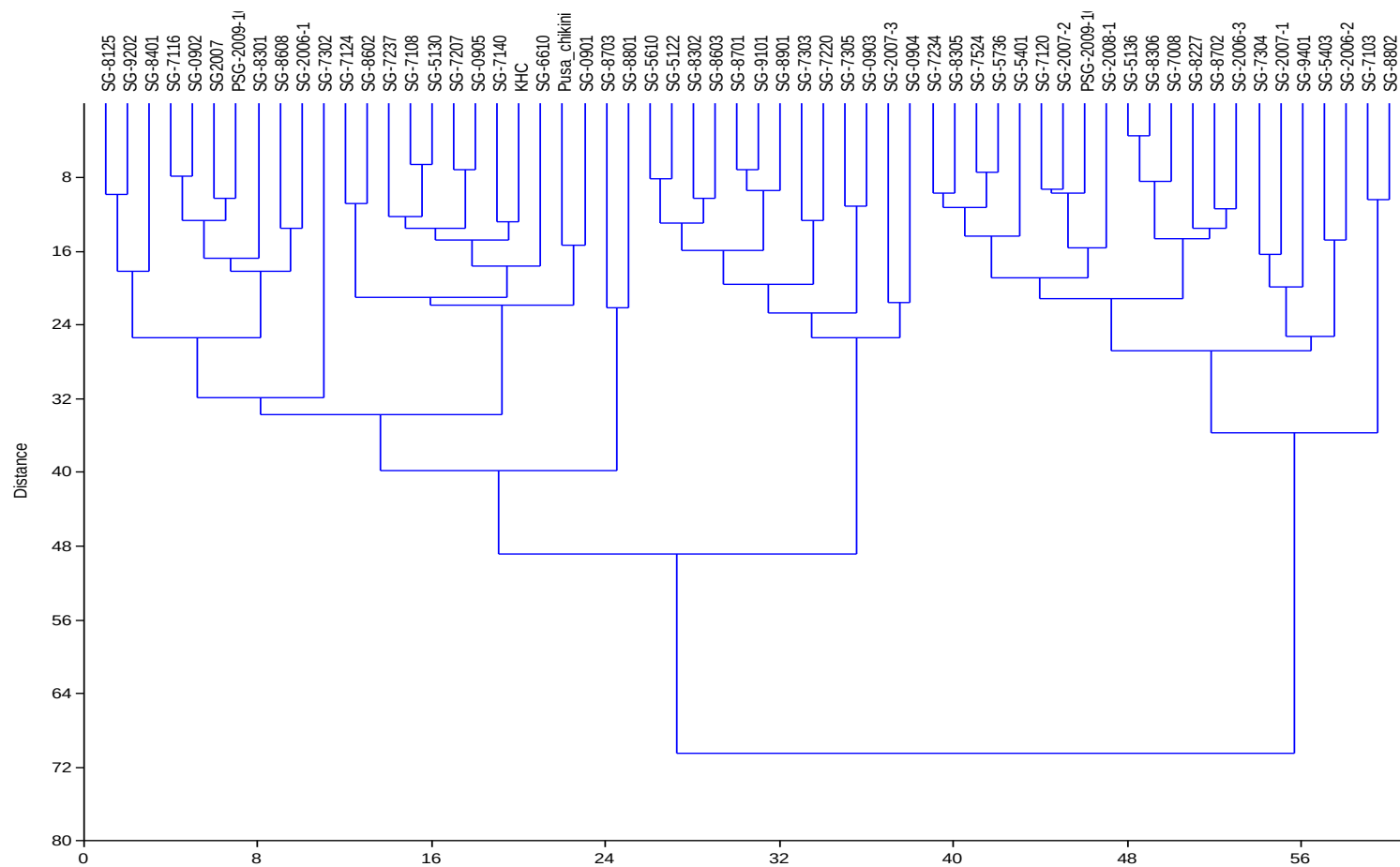
Table No. 4.6.2 Inter and intra distances

Clusters	I	II	III
I	2.382		
II	3.544	2.329	
III	3.403	3.994	2.265

Table No. 4.6.3 Cluster mean MAHALANOBIS D2 analysis

Clusters		Days To First Male Flower	Days To First Female Flower	Days To 1st Picking	Average Fruit Weight (gm)	Fruit Length (cm)	Internode Length (cm)	Fruit Diameter (cm)	Vine length (cm)	No of fruit/plant	Fruit Yield per plant (kg)
I	Mean	36.08	40.82	53.84	121.24	18.59	15.39	2.70	294.20	20.94	2.67
	SE$\pm$	2.04	2.06	2.64	10.62	2.17	2.75	0.38	31.59	4.68	0.56
II	Mean	38.41	43.30	56.40	137.69	25.31	15.48	3.26	344.05	29.02	3.59
	SE$\pm$	3.04	3.00	3.53	10.26	3.06	2.11	0.38	23.02	3.60	0.29
III	Mean	42.99	48.08	61.63	127.04	20.23	15.00	2.66	288.86	19.83	2.51
	SE$\pm$	1.52	1.41	2.34	12.52	2.74	2.45	0.41	31.40	4.11	0.46





Ward's Minimum Variance Dendrogram

ecologically distinct peripheral environment can exhibit genetic divergence from the remainder of a population, especially where the range of a population is very large.

The study of genetic diversity is important because it helps to maintain the health of a population, by including allele that may be valuable in resisting diseases, pests, and other stress. Maintain diversity gives the population a buffer against change, providing the flexibility to adapt. It is also useful in selecting the desirable parents for breeding programme, since it is known that exploitation of heterosis and success in obtaining desirable recombinants depend upon the degree of divergence of the parents. This study was done by **Mahalanobis D^2 statistics**. The 60 genotypes under study were classified into 3 clusters. Out of them, cluster 2 had maximum number of genotype (25), followed by cluster 1 and 3.

4.6.1 Intra cluster distance

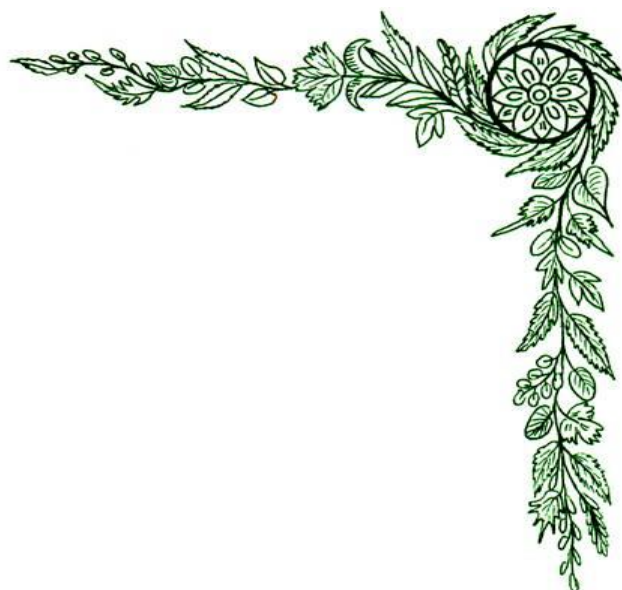
Intra cluster distance for cluster 1 was 2.382. It was 2.329 for cluster 2, and it was 2.265 for cluster 3.

4.6.2 Inter cluster distance

Cluster 1 has shown maximum inter cluster distance with cluster 2 (3.544) followed by cluster 3 (3.403). The minimum cluster distance with cluster 1 (2.382). it shows highest value for vine length(294.20) and lowest value for fruit diameter(2.70)

Cluster 2 has shown maximum inter cluster distance with cluster 3 (3.994) and minimum cluster distance with cluster 2 (2.329). it shows highest value for vine length(344.05) and lowest value for fruit diameter(3.26).

Cluster 3 has shown highest value for vine length (288.86), average fruit weight (127.04) days to first picking (61.63) and days to first female flower(48.08).



RESULTS AND DISCUSSION



The experimental findings of the present investigation “**Studies on genetic diversity, correlation and path coefficient analysis in sponge gourd (*Luffa cylindrica* (L.) Roem.)**” have been discussed in the following heads on the basis of the available literature.

- ❖ Analysis of variance
- ❖ Mean performance of genotypes
- ❖ Genetic variability, heritability and genetic advance
- ❖ Correlation coefficient
- ❖ Path coefficient analysis
- ❖ Genetic divergence
- ❖ Other qualitative characters
- ❖ Identification of better genotype

5.1 Analysis of variance

The main objective of the present investigation was to study the variability present in sixty genotypes of sponge gourd. The estimation of mean sum of square due to genotypes were highly significant for all the characters indicating the presence of genetic diversity in the existing material Singh *et al.* (2018), Kumar *et al.* (2019), Rathor *et al.* (2017), Manoj *et al.* (2018) and Koppad *et al.* (2015) also reported the high genetic variability among the traits.

5.2 Mean performance of genotype

The mean performance of the genotypes revealed a wide range of variability for all the traits. The variation was highest for days to first male

flower (32.44-46.22), days to first female flower (37.32-50.44), days to first picking (50.10-65.22), average fruit weight (110-165gm), fruit length (15.16-29.83cm), internode length (10.00-20.50cm), fruit diameter (2.10-3.85cm), vine length (240-380cm), number of fruit per plant (8.33-36.80) and fruit yield per plant (1.04-3.97kg).

5.3 Genetic variability, Heritability and Genetic advance

5.3 Genetic variability

In the present findings phenotypic coefficient of variation were observed to be higher than the corresponding genotypic coefficient of variation for all the characters studied, however, the difference was narrow which implied their relative resistance to environmental variation. It also described that genetic factor were predominantly responsible for expression of those attributes and selection could be made effective on the basis on the basis of phenotypic performance. The finding was quite similar to as reported by Sharma et al.(2017), Kumar et al. (2013), Pandey et al.(2012), Sanandia (2010) and Singh et al. (2009) were similar to that of the present findings.

5.3.1.1 Phenotypic coefficient of variation

The phenotypic coefficient of variation ranges from 7.47% for days to first picking to 25.15% for number of fruit per plant. The PCV was found to be high for the number of fruit per plant (25.15%), followed by fruit yield per plant (23.05%), fruit length(18.65%). Other characters like, fruit diameter(16.88%),internode length(16.55%), vine length (12.16%) and average fruit weight (10.06%)also show moderate value of PCV, which indicating that selection of these character can be predicated to improve sponge gourd genotype. And days to first male flower (9.28%), days to first female flower (8.42%), days to first picking (7.47%) also shows lower value of PCV. Which indicate that there is limited scope for

improvement. The findings close harmony with Sharma *et al.* (2017), Kumar *et al.*(2013), Pandey *et al.*(2012) and Khule *et al.*(2011).

5.3.1.2 Genotypic coefficient of variation

The genotypic coefficient of variation was range from 7.36 % for days to first picking to 24.19% for number of fruit per plant. The genotypic coefficient of variation was found to be high for the number of fruit per plant (24.19%), fruit yield per plant (21.30%) . other character like fruit length (18.49%), fruit diameter (16.12%) and internode length (15.06%) shows moderate value of GCV which indicating that selection of these character can be predicated to improve the sponge gourd genotype. And days to first male flower (9.17%), days to first female flower (8.32%) and days to first picking (7.36%) shows lower value of GCV which indicate that there is limited scope for improvement. This findings close harmony with the result of Sharma *et al.* (2017), Kumar *et al.*(2013), Pandey *et al.*(2012) and Khule *et al.*(2011).

5.3.2 Heritability

Heritability in broad sense of a character is important to the breeder since it indicates the possibility and extent to which improvement is possible through selection. It also indicates direction of selection pressure to be applied for the traits during selection because it measures relationship between parent and their progeny, widely used in determining the degree to which a character may be transmitted from parent to offspring. However, high heritability alone is not enough to make efficient selection in advanced generations unless accompanied by substantial amount of genetic advance (Burton, 1952). The estimate value of heritability in broad sense were classified as very high (more than 90%), high (70-90%), medium (50-70%) and lows (less than 50%). Very high estimates of heritability (>90%) were recorded for all characters *viz.* vine length (99.77%), average fruit weight

(99.04%), fruit length (98.34%), days to first female flower (97.81%), days to first male flower (97.60%), days to first picking (96.93%), number of fruit per plant (92.56%) and fruit diameter (91.25%) . The results were in close proximate to that of Kumar et al.(2019), Singh et al.(2018), Kumar et al.(2013), Pandey et al.(2012), Sanandia(2010) high values of broad sense heritability for the above characters expressed that they were least influenced by environmental modification. It reflected that the phenotypes were the true representative of their genotypes and selection based on phenotypic performance would be reliable. It was moderate for fruiting span, plant height, number of branches per plant, days to first picking which indicated that selection based on phenotypic performance would be rewarding.

5.3.3 Genetic advance

Heritability indicates only the effectiveness with which selection of a genotypes can be based on phenotypic performance, but fails to indicate the genetic progress. Heritability estimate along with genetic gains are more effective and reliable in predicting the improvement through selection (Johnson *et al.*1995).

Estimate of genetic advance help to predict the extent of improvement that can be achieved for improving the different characters. The estimate value of genetic advance as per cent of mean were classified as high (more than 50%), moderate (20-50%) and low (less than 20%). The genetic advance value higher in fruit yield per plant (40.54%), fruit length (37.78%), fruit diameter (31.72%), internode length (28.24%), vine length (24.99%) and average fruit weight (20.53%). The results were in close proximate to that of Kumar et al.(2019), Singh et al.(2018), Kumar et al.(2013), Pandey et al.(2012) and Khule *et al.*(2011), Sanandia(2010).

5.4 Correlation coefficient

Genetic correlations between characters could be due to linkage and

pleiotropic effect of genes. Therefore, selection made for one trait influenced by the other linked or pleiotropically affected traits. The fruit yield or economic yield, in almost all the crops, is referred as super character, which resulted from multiple interactions of several other component characters that are termed as yield components. Thus, identification of important yield components and information about their inter relationship with each other will be very useful for developing efficient breeding strategy (Johanson *et al.* 1955, Robinson *et al.* 1951).

In this respect, the correlation coefficient, which provides symmetrical measurement of degree of association between two variables or characters help in understanding the nature and magnitude of association among yield and yield components.

5.4.1 Days to first male flower

Exhibited highly significant positive correlation with days to first female flower and days to first picking. it also exhibited non-significant positive correlation with average fruit weight, while significant negative correlation with vine length, fruit yield per plant and number of fruit per plant. Non-significant negative correlation seen with internode length and fruit length. These findings corroborated the earlier finding of Kumar *et al.*(2019), Singh *et al.*(2018) ,Chauhan *et al.*(2018).

5.4.2 Days to first female flower

Exhibited significant positive correlation with days to first picking. it also exhibited non-significant positive correlation with average fruit weight. while significant negative correlation with vine length, fruit yield per plant. Non-significant negative correlation with number of fruit per plant, fruit diameter, internode length. These findings corroborated the earlier finding of Kannan *et al.*(2019), Manoj *et al.*(2018), Rathor *et*

al.(2017).

5.4.3 Days to first picking

Exhibited non-significant positive correlation with fruit length, average fruit weight. while significant negative correlation with vine length, fruit yield per plant. Non-significant negative correlation seen with number of fruit per plant, fruit diameter, internode length. These findings corroborated the earlier finding of Singh *et al.*(2018), Islam *et al.*(2009)

5.4.4 Average fruit weight

Exhibited highly significant positive correlation with vine length, fruit length, fruit yield per plant and fruit diameter. Non-significant negative correlation seen with internode length. These findings corroborated the earlier finding of Singh *et al.*(2018), Sharma *et al.*(2017)

5.4.5 Fruit length

Exhibited highly significant positive correlation with fruit yield per plant, number of fruit per plant, vine length and fruit diameter. it also exhibited non-significant positive correlation with internode length. These findings corroborated the earlier finding of Som *et al.*(2018), Sharma *et al.*(2017).

5.4.6 Internode length

Exhibited non-significant positive correlation with vine length, number of fruit per plant and fruit yield per plant. Non-significant negative correlation seen with fruit diameter. These findings corroborated the earlier finding of Ahirwar and Singh *et al.*(2018), Deepa *et al.*(2017).

5.4.7 Fruit diameter

Exhibited highly significant positive correlation with vine length, fruit yield per plant and number of fruit per plant. These findings

corroborated the earlier finding of Kumar *et al.*(2019), Singh *et al.*(2018), Kumar *et al.*(2013).

5.4.8 Vine length

Exhibited highly significant positive correlation with fruit yield per plant and number of fruit per plant. These findings corroborated the earlier finding of Kumar *et al.*(2013), Moshin *et al.*(2017).

5.4.9 Number of fruit per plant

Exhibited highly significant positive correlation with fruit yield per plant. . These findings corroborated the earlier finding of Kumar *et al.*(2019), Sharma *et al.*(2017).

5.5 Path Coefficient Analysis

Path coefficient analysis is a power full tool, which enable portioning of the given relationships in its further components. In other words, it considers notonly the relationship of component characters with the dependent character, but simultaneously takes care of its relationship with another component also. Thus,it helps in understanding the causal system in a better way because it enables portioning the total correlations coefficient into direct and indirect effects of various characters.

In the present investigation path coefficient analysis was carried out for characters under study using genotypic and phenotypic correlation coefficient andtaking fruit yield per plant as dependable variable, in order to see the causal factor and so as to identify the components which are responsible for producing fruit yield per plant. In general, the genotypic direct as well as indirect effects were slightly higher in magnitude as compared to corresponding phenotypic direct and indirect effects indicating that the masking effect of the environment.

Present study revealed that some characters possess direct positive effects while other showed direct negative effects. The positive direct effects on fruit yield per plant were shown by days to first female flower, days to first picking, average fruit weight, fruit diameter and vine length and number of fruit per plant. it also possesses direct negative effects on days to first male flower, fruit length and internode length. The results are in propinquity with Kumar *et al.* (2019); Kumar *et al.* (2013); Panday *et al.* (2012); Khule *et al.* (2011) and Singh *et al.* (2011) in sponge gourd. In ridge gourd also, similar results were reported by Ananthan and Krishnamoorthy (2017); Varalakshmi *et al.* (2015); Dubey *et al.* (2013); Rabbani *et al.* (2012); Prasana *et al.* (2002) and Rao *et al.* (2000).

5.6 Genetic divergence

The study of genetic diversity is important because it helps to maintain the health of a population, by including allele that may be valuable in resisting diseases, pests, and other stresses. Maintaining diversity gives the population a buffer against change, providing the flexibility to adapt. It is also useful in selecting the desirable parents for breeding programme, since it is known that exploitation of heterosis and success in obtaining desirable recombinants depend upon the degree of divergence of the parents. This study was done by **Mahalanobis D² statistics**. The 60 genotypes under study were classified into 3 clusters. Out of them, clusters 2 had maximum number of genotype (25), followed by cluster 1 and 3.

5.6.1 Intra cluster distance

Intra cluster distance for cluster 1 was 2.382. It was 2.329 for cluster 2, and it was 2.265 for cluster 3.

5.6.2 Inter cluster distance

Cluster 1 has shown maximum inter cluster distance with cluster 2 followed by cluster 3 . The minimum cluster distance with cluster

1 . it shows highest value for vine length and lowest value for fruit diameter.

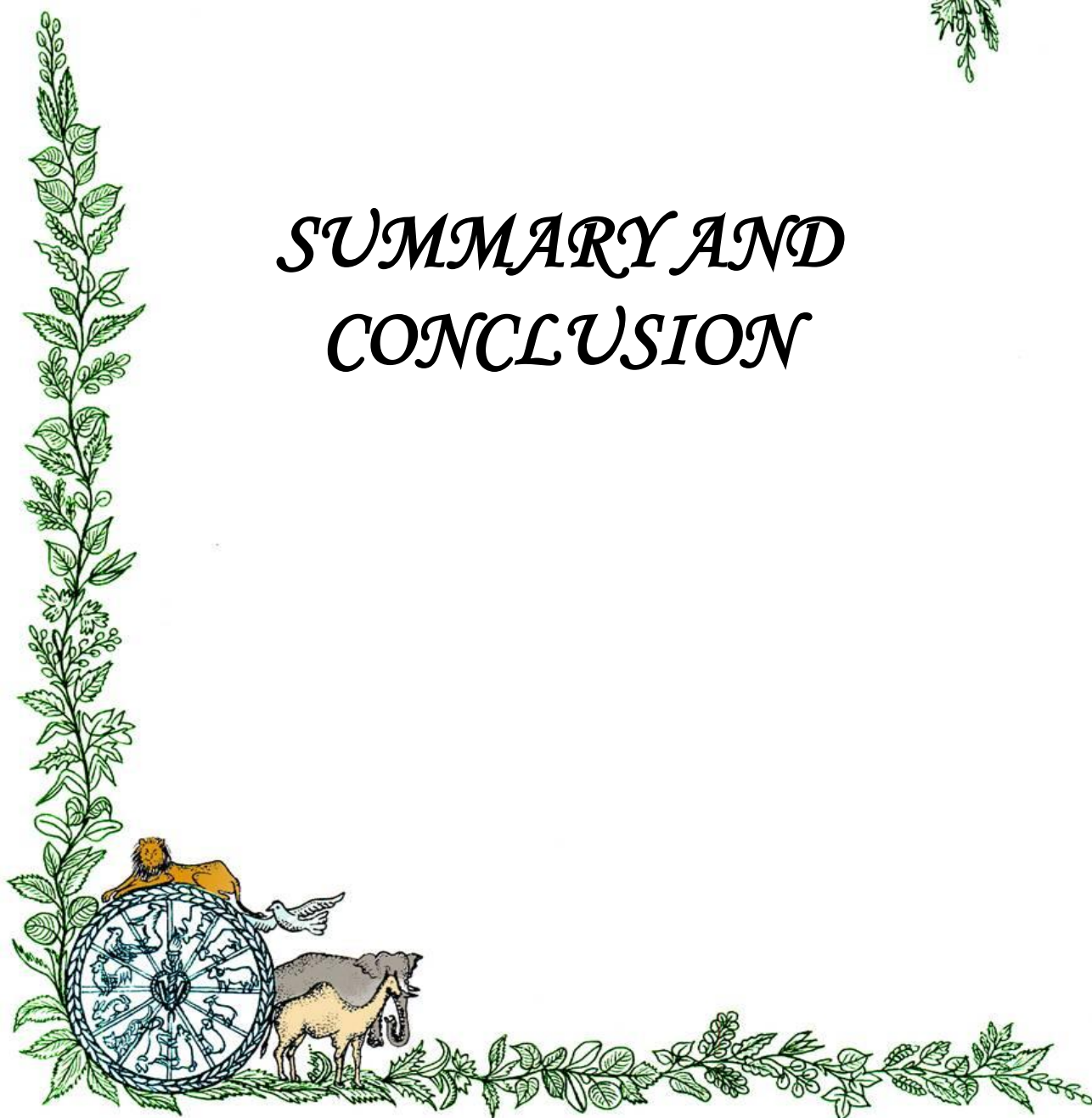
Cluster 2 has shown maximum inter cluster distance with cluster 3 and minimum cluster distance with cluster 2. it shows highest value for vine length and lowest value for fruit diameter.

Cluster 3 has shown highest value for vine length , average fruit weight , days to first picking and days to first female flower.

These findings corroborated the earlier finding of Kumar *et al.*(2019), Gaffar *et al.*(2015), Devi *et al.*(2013) and Rabbani *et al.*(2012).



SUMMARY AND CONCLUSION



SUMMARY AND CONCLUSION

Present investigation named, “**Studies on genetic diversity, correlation and path coefficient analysis in sponge gourd [*Luffa cylindrica* (Roem) L.]**” was taken in Vegetable Research Farm, Department of Vegetable Science of Chandra Shekhar Azad University of Agriculture and Technology, Kalyanpur, Kanpur during *kharif* season of 2022-23. The equipment exploits and the process engaged in studying varied plant traits and genetic parameters have been narrated in the antecedent chapter. The limitation of genetic variability, association between yield and related traits, path analysis and genetic divergence were studied.

The observation was based on ten characters viz., days to first male flower, days to first female flower, days to first picking, average fruit weight, fruit length, internode length, fruit diameter, vine length, number of fruit per plant, fruit yield per plant. The analysis of variance revealed that estimates of mean sum of square due to genotypes were highly significant for all the characters, indicating the presence of genetic diversity in the existing material.

The phenotypic coefficient of variation was higher than genotypic coefficient of variation. The PCV was found to be high for the number of fruit per plant, followed by fruit yield per plant and fruit length. Other characters like, fruit diameter, internode length, vine length and average fruit weight also show moderate value of PCV. And days to first male flower, days to first female flower, days to first picking also shows lower value of PCV.

The genotypic coefficient of variation was found to be high for the number of fruit per plant, fruit yield per plant. other characters like fruit length, fruit diameter and internode length shows moderate value of GCV. And days

to first male flower, days to first female flower and days to first picking shows lower value of GCV .

All the characters under study showed the high value of heritability viz., vine length, average fruit weight, fruit length, days to first female flower, days to first male flower, days to first picking, number of fruit per plant and fruit diameter.

Characters like average fruit weight, fruit length, fruit diameter, vine length, number of fruit per plant showed highly significant positive correlation with fruit yield per plant while, with days to first male flower, days to first female flower and days to first picking showed significant negative correlation with it. Study of path coefficient analysis reported that all the characters like days to first female flower, days to first picking, average fruit weight, fruit diameter and vine length and number of fruit per plant exhibited positive direct effect on fruit yield per plant. It also possesses direct negative effects on days to first male flower, fruit length and internode length.

Analysis of genetic divergence by D^2 statistics grouped the 60 genotypes under study were classified into three clusters. Out of them, clusters II had maximum number of genotype (25), followed by cluster I(19) and III(16). Cluster 1 has shown maximum inter cluster distance with cluster II followed by cluster III and cluster II has shown maximum inter cluster distance with cluster III. The maximum intra-cluster distance was shown by cluster I followed by cluster II.

conclusion

Based on above findings, following conclusions can be made in respective of objectives-

Present material comprising 60 genotypes were evaluated for different characters and variability among them was significantly proved with the confirmation of ANOVA. Also, some characters showed high heritability along with high genetic advance.

Characters like average fruit weight, fruit length, fruit diameter, vine length, number of fruit per plant showed highly significant positive correlation with fruit yield per plant which conclude that these characters are yield contributing characters and should be considered in any selection programme.

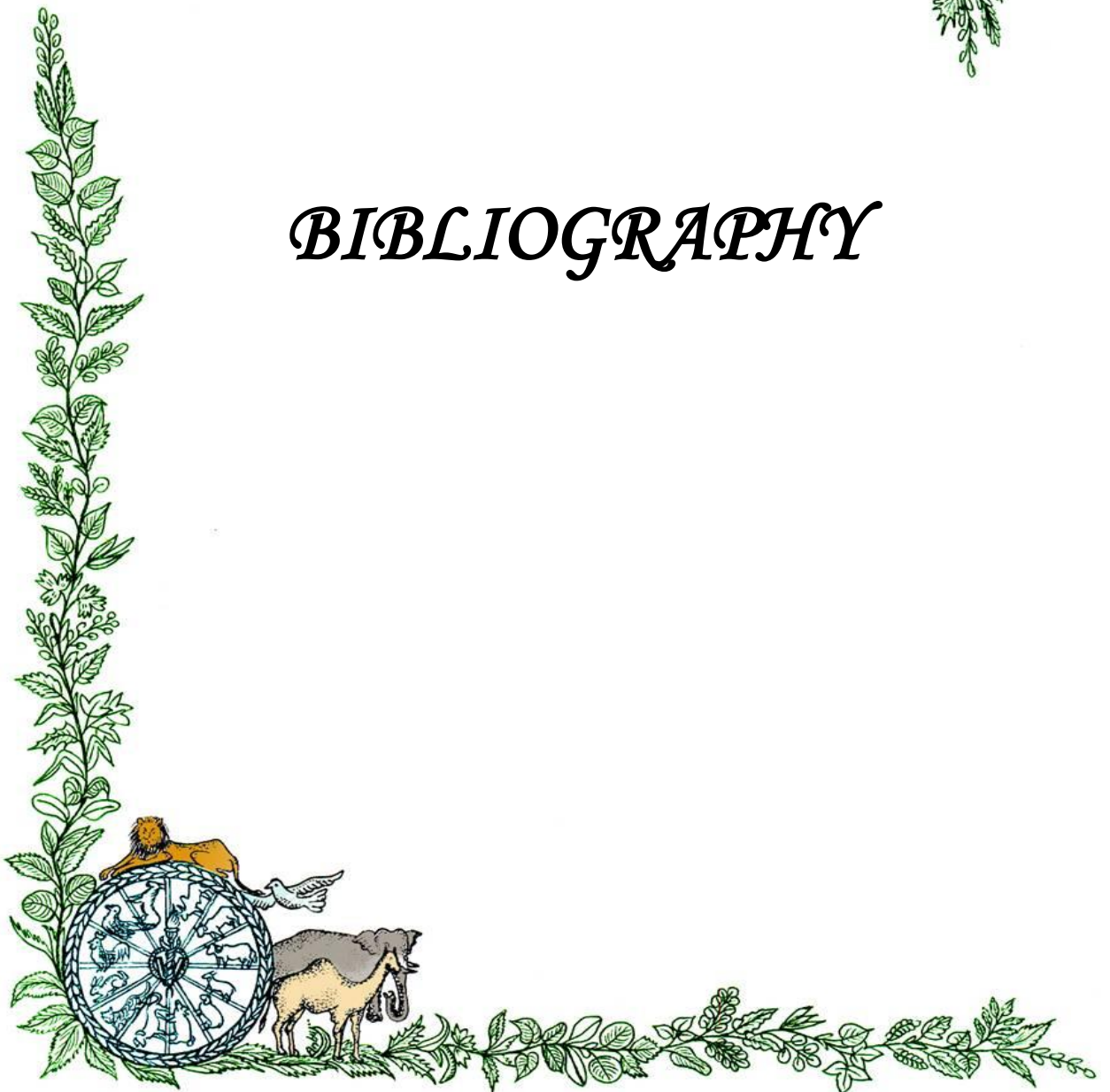
Number of fruits per plant and average fruit weight also showed high positive direct effect along with highly significant positive correlation with fruit yield, indicating that these are yield contributing traits.

Analysis of genetic divergence by D^2 statistics grouped the 60 genotypes into three clusters. Out of them, clusters II had 25 genotypes making it the largest cluster. The inter-cluster distance between cluster I and cluster II is maximum which indicates the presence of maximum divergence among the genotypes of these clusters. Hence, these genotypes can be used in any hybridization programme.

An overall observation of quantitative characters, the genotype SG-7302 recorded highest fruit yield per plant of 3.97 kg followed by SG-2007(3.95kg/plant) and SG-8603, SG-8401, SG-8123(3.90 kg/plant) and these were identified as best genotypes for cultivation in central plain zone of Uttar Pradesh.



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