

**STUDIES ON GENETIC VARIABILITY IN
RIDGE GOURD [*Luffa acutangula* (L.) Roxb]
GENOTYPES**

HARSHITHA, S.

UHS14PGM536

**DEPARTMENT OF VEGETABLE SCIENCE
COLLEGE OF HORTICULTURE,
UHS CAMPUS, GKVK, BENGALURU - 560 065
UNIVERSITY OF HORTICULTURAL SCIENCES
BAGALKOT - 587 104**

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**STUDIES ON GENETIC VARIABILITY IN
RIDGE GOURD [*Luffa acutangula* (L.) Roxb]
GENOTYPES**

*Thesis submitted to the
University of Horticultural Sciences, Bagalkot
in partial fulfilment of the requirements for the
Degree of
MASTER OF SCIENCE (Horticulture)
IN
VEGETABLE SCIENCE*

By
HARSHITHA, S.

**DEPARTMENT OF VEGETABLE SCIENCE
COLLEGE OF HORTICULTURE,
UHS CAMPUS, GKVK, BENGALURU - 560 065
UNIVERSITY OF HORTICULTURAL SCIENCES
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APRIL, 2017**



*Affectionately
Dedicated to
My Beloved Parents
& Friends*

DEPARTMENT OF VEGETABLE SCIENCE
COLLEGE OF HORTICULTURE, UHS CAMPUS, GKVK,
BENGALURU-65
UNIVERSITY OF HORTICULTURAL SCIENCES, BAGALKOT - 587 102

CERTIFICATE

This is to certify that the thesis entitled “**STUDIES ON GENETIC VARIABILITY IN RIDGE GOURD [*Luffa acutangula* (L.) Roxb.] GENOTYPES**” submitted by **HARSHITHA, S. ID No. UHS14PGM536** in partial fulfilment of the requirements for the award degree of **MASTER OF SCIENCE (HORTICULTURE) in VEGETABLE SCIENCE** to the University of Horticultural Sciences, Bagalkot is a record of bonafide research work carried out by her during the period of her study in this University, under my guidance and supervision, and no part of the thesis has been previously submitted for the award of any degree, diploma, associate ship, fellowship or other similar titles.

Place: Bengaluru

Date: April, 2017

(Dr. Indires, K. M)

Chairman, Dean & campus head,
College of Horticulture, Mysuru.

Approved by

Chairman: _____
(Indires, K. M.)

Members: 1. _____
(M. Anjanappa)

2. _____
(B. G. Prakash)

3. _____
(Meenakshi Sood)

4. _____
(H. S.Surendra)

5. _____
(Sangeetha, C. G.)

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Bengaluru

April, 2017

(HARSHITHA, S.)

“STUDIES ON GENETIC VARIABILITY IN RIDGE GOURD [*Luffa acutangula* (L.) Roxb] GENOTYPES.”

HARSHITHA, S.

ABSTRACT

A study on genetic variability in ridge gourd genotypes was under taken during the year 2015-16 at COH, Mysuru where 25 genotypes were evaluated and significant differences were observed among genotypes for all the characters studied except for 100 seed weight. High PCV, GCV and heritability coupled with high GAM were recorded for most of the parameters viz., number of primary branches per plant, vine length, number of nodes per main vine, internodal length, number of nodes to first male and female flower, number of fruits per plant, fruit yield per plant, vitamin C, crude protein, total chlorophyll content, seed yield per plant and number of seeds per fruit. Character association and path analysis studies revealed that number of fruits per plant and average fruit weight are the important contributing traits influencing yield through direct effect coupled with high positive correlation and selection based on these characters can be effective for developing high yielding varieties. Fruit yield per plant ranged from 1825.2 g per plant (IC-92638) to 297.03 g per plant (IC-335912) and was found highest in IC-92638 (1825.2 g per plant) and Arka Sumeeth (1802.37 g per plant) followed by Arka Sujat (1593.54% g per plant). Deepthi (9.9% PDI) and IC-92638 (8.66% PDI) showed resistant to downy mildew under artificial screening and hence these genotypes may be used for further resistant breeding programme.

Signature of Student
(Harshitha, S.)

Signature of Chairperson
(Indiresh, K.M.)

ಹೀರೆಕಾಯಿ ತಳಿಗಳಲ್ಲಿ ಅನುವಂಶೀಯತೆಯಲ್ಲಿನ ವೈವಿಧ್ಯತೆಯ ಅಧ್ಯಯನ

ಹರ್ಷಿತ, ಎಸ್

ಸಾರಾಂಶ

ಹೀರೆಕಾಯಿ ಒಂದು ಬಹು ಮುಖ್ಯ ತರಕಾರಿ ಬೆಳೆಯಾಗಿದ್ದು, ಇದನ್ನು ಸಾಮಾನ್ಯವಾಗಿ ಹಿತ್ತಲ ತೋಟದಲ್ಲಿ ಬೆಳೆಯುತ್ತಾರೆ. ಪ್ರಸ್ತುತ ಅಧ್ಯಯನದಲ್ಲಿ 25 ತಳಿಗಳ ಗುಣಲಕ್ಷಣಗಳನ್ನು 2015-16ರ ಸಾಲಿನಲ್ಲಿ ತೋಟಗಾರಿಕೆ ಮಹಾವಿದ್ಯಾಲಯ, ಮೈಸೂರಿನಲ್ಲಿ ಪ್ರಯೋಗಕ್ಕೊಳಪಡಿಸಿದಾಗ, 100 ಬೀಜಗಳ ತೂಕವನ್ನು ಬಿಟ್ಟು ಉಳಿದ ಎಲ್ಲಾ ಗುಣಲಕ್ಷಣಗಳಲ್ಲಿ ಗಮನಾರ್ಹ ವ್ಯತ್ಯಾಸ ಕಾಣಬಹುದಾಗಿದೆ. ಪ್ರತಿ ಪ್ರಾಥಮಿಕ ರೆಂಬೆ ಸಂಖ್ಯೆ, ಬಳ್ಳಿಯ ಉದ್ದ, ಮುಖ್ಯ ಬಳ್ಳಿಯಲ್ಲಿ ಬರುವ ಗೇಣುಗಳ ಸಂಖ್ಯೆ, ಎರಡು ಗೇಣುಗಳ ನಡುವಿನ ಅಂತರ, ಮೊದಲ ಗಂಡು ಮತ್ತು ಹೆಣ್ಣು ಹೂವು ಉತ್ಪತ್ತಿಯಾಗುವ ಗೇಣಿನ ಸಂಖ್ಯೆ, ಪ್ರತಿ ಬಳ್ಳಿಗೆ ಬಿಡುವ ಕಾಯಿಗಳ ಸಂಖ್ಯೆ, ಪ್ರತಿ ಬಳ್ಳಿಯ ಇಳುವರಿ, ಸಿ ಜೀವಸತ್ವ, ಕಚ್ಚಾ ಪಿಷ್ಟ, ಒಟ್ಟು ಪತ್ರಹರಿತ್ತಿನ ಸಾಂದ್ರತೆ, ಪ್ರತಿ ಬಳ್ಳಿಯ ಬೀಜದ ಇಳುವರಿ, ಪ್ರತಿ ಕಾಯಿಯಲ್ಲಿನ ಬೀಜಗಳ ಸಂಖ್ಯೆ ಗುಣಲಕ್ಷಣಗಳಲ್ಲಿ ಅತಿ ಹೆಚ್ಚು ವ್ಯತ್ಯಾಸದ ಹೊರನೋಟದ ಗುಣಾಂಕ, ವ್ಯತ್ಯಾಸದ ವಂಶವಾಹಿ ಗುಣಾಂಕ ಮತ್ತು ಅನುವಂಶೀಯತೆ ಜೊತೆಗೆ ಶೇಕಡ ಸರಾಸರಿ ಮೇಲೆ ಅನುವಂಶೀಯತೆ ಅಭಿವ್ಯಕ್ತಿಯನ್ನು ಕಾಣಬಹುದಾಗಿದೆ. ಗುಣಲಕ್ಷಣ ಹೊಂದಾಣಿಕೆ ಮತ್ತು ದಾರಿ ವಿಶ್ಲೇಷಣೆಯ ಪ್ರಯೋಗಕ್ಕೆ ಸಂಬಂಧಿಸಿದಂತೆ, ಪ್ರತಿ ಬಳ್ಳಿಗೆ ಬಿಡುವ ಕಾಯಿಗಳ ಸಂಖ್ಯೆ ಮತ್ತು ಸರಾಸರಿ ಕಾಯಿಯ ತೂಕವು ಬಹು ಮುಖ್ಯವಾಗಿ ಇಳುವರಿಯ ಮೇಲೆ ನೇರ ಹಾಗೂ ಹೆಚ್ಚು ಪರಸ್ಪರ ಧನಾತ್ಮಕ ಪ್ರಭಾವ ಬೀರುವುದಲ್ಲದೆ, ಹೆಚ್ಚಿನ ಇಳುವರಿ ಕೊಡುವ ತಳಿಗಳನ್ನು ಆಯ್ಕೆ ಮಾಡಲು ಸಹಕಾರಿಯಾಗಿದೆ. ಪ್ರತಿ ಹೀರೆಕಾಯಿ ಗಿಡದ ಇಳುವರಿಯು 297.03 ಗ್ರಾಂ (I೮-335912) ರಿಂದ 1825.2 ಗ್ರಾಂ (I೮-92638) ರಷ್ಟಿದೆ. ನಂತರ I೮-92638 (1825.2 ಗ್ರಾಂ ಪ್ರತಿ ಗಿಡಕ್ಕೆ) ಮತ್ತು ಅರ್ಕಾ ಸುಮಿತ್ (1802.37 ಪ್ರತಿ ಗಿಡಕ್ಕೆ) ತದನಂತರ ಅರ್ಕಾ ಸುಜಾತ್ (1593.54 ಗ್ರಾಂ ಪ್ರತಿ ಗಿಡಕ್ಕೆ) ಅತಿ ಹೆಚ್ಚಾಗಿ ಇಳುವರಿ ನೀಡುವ ತಳಿಯಾಗಿದೆ ಹಾಗೂ ಇಳುವರಿಯನ್ನು ನೀಡುವುದರ ಜೊತೆಗೆ ಉತ್ತಮ ಬೆಳವಣಿಗೆ ತೋರಿವೆ. ದೀಪ್ತಿ (9.9% ಪಿಡಿಐ) ಮತ್ತು I೮-92638 (8.66 ಗ್ರಾಂ ಪಿಡಿಐ) ಎಂಬ ತಳಿಗಳು ಕೃತಕ ತಪಾಸಣೆ ಅಡಿಯಲ್ಲಿ ಬೂಜು ತುಪ್ಪಟ ರೋಗ ನಿರೋಧಕ ಶಕ್ತಿಯನ್ನು ಹೊಂದಿದ್ದು, ಅವುಗಳನ್ನು ರೋಗ ಪ್ರತಿರೋಧದ ಮೂಲಗಳನ್ನಾಗಿ ಹೀರೆಕಾಯಿ ತಳಿ ಅಭಿವ್ಯಕ್ತಿಯಲ್ಲಿ ಉಪಯೋಗಿಸಬಹುದಾಗಿದೆ.

ವಿದ್ಯಾರ್ಥಿಯ ಸಹಿ

ಪ್ರಧಾನ ಮಾರ್ಗದರ್ಶಕರು

(ಹರ್ಷಿತ, ಎಸ್.)

(ಇಂದ್ರೇಶ್, ಕೆ.ಎಂ.)

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LIST OF ABBREVIATIONS

Symbols	Abbreviations
PCV	Phenotypic co-efficient of variation
GCV	Genotypic co-efficient of variation
h^2	Heritability in broad sense
GA	Genetic advance
GAM	Genetic advance over per cent mean
DAT	Days after transplanting
%	Per cent
°C	Degree Celsius
Cm	Centimeter
mm	Millimeter
ml	Millilitre
g	Gram
Kg	Kilogram
mg	Milligram
<i>viz.</i>	As follows
Fig.	Figure
<i>et al</i>	Et alii (and others)
S.Em.±	Standard error mean
CD	Critical difference
CV	Co-efficient of variation

I. INTRODUCTION

The family cucurbitaceae is one of the most diverse group of the plants in the plant kingdom. It is moderately a large family comprising of 118 genera and 825 species (Jeffrey,1990). India is having about 37 genera and 100 species. Some of the genera are *Momordica* (about 45 species), *Trichosanthes* (44 species), *Cucumis* (25 species), *Cucurbita* (15 species), *Lagenaria* (6 species), *Luffa* (6 species) and *Echinocystis* (15 species).

Most of the cucurbitaceous vegetables are usually cultivated in relatively small areas for local consumption and hence the statistical data on area and production are lacking. Nevertheless, squashes and gourds as a group of vegetables occupy an area of 3521 hectares in Karnataka with a production of 32,182 tonnes and productivity of 9.14 tonnes per hectare (Anonymous, 2009).

Ridge gourd [*Luffa acutangula* (L.) Roxb.] known as Kalitori and it is also called as angled gourd, angled loofah, chinese okra, silky gourd and ribbed gourd. It belongs to family cucurbitaceae with a chromosome number $2n=26$. The genus *Luffa* is derived from the product "loofah" which is used in manufacture of bathing sponges, scrubber pads, door mats, pillows, mattresses and also for cleaning utensils.

Ridge gourd has originated in India and cultivated in the tropics and sub-tropics for its tender edible fruits both on commercial scale and kitchen gardens throughout India and some parts of Indonesia, Myanmar, Malaysia, Phillipines, Srilanka and Taiwan. Broad genetic variation for various growth, morphology and fruit characteristics is observed in different parts of India. It can be grown as spring or summer crop as well as rainy season crop.

This crop is grown for its tender fruits which are used in curries or as cooked vegetable. Fruit contains moisture (92.5g), protein (0.5g), fat (0.5g), carbohydrate (3.4g), energy (17k calories), calcium (18mg), vitamin C (5mg), riboflavin (0.01mg), phosphorous (26mg), iron (0.5mg) and carotene (33µg) per 100 g of edible portion (Sheshadri and Parthasarthy, 1980). Besides their use as vegetables, it is also used for other purposes. The fiber obtained from the mature dry fruit is used in industry for filters of various sorts, good pot holders, table mats, bath room mats, slipper and shoe soles. The fiber is also proved to be a good insulator for various purposes. Sometimes the dry fruits which gave good storability are used for ornamental purposes also. It is emetic and traditionally used for the treatment of stomach ailment and fever (Chakravarthy, 1959). Seeds are also reported to be possessing purgative, emetic and antihelmintic properties due to the secondary metabolite *cucurbitacin* (Robinson and Decker-Walters, 1997). Isolation of Ribosome Inactivating Proteins (RIPs) and luffaculin from ridge gourd seeds have received wide attention for their potential applications in medicine as they possess various pharmacological activities including abortifacient, antifungal, antitumor, antiviral and HIV-1 integrase inhibitory properties (Hou *et al.*, 2006).

Ridge gourd is a cross pollinated crop and monoecious in nature, sometimes hermaphrodite, androecious, andromonecious, gynoecious and gynomonoecious types of flowers are also exist (Choudhary and Thakur, 1965). The plant is dicotyledonous annual climber with long tap root system and tendrils. Leaves are pale green, simple and ovate with 6-7 lobes. In reproductive phase the nodes have potential of bearing six organs viz., leaf tendrils, branch, bract, solitary pistillate flower, androecious raceme and adventitious root. Flowers are light yellow in colour and borne on axil of leaves. Staminate flowers are arranged in raceme, while pistillate flowers are solitary, short or long peduncle and fragrant (Plate 1). Anthesis starts between 4-6pm in the evening and remain throughout the night and are ready for selfing and pollination in the early morning or afternoon. Anthesis and dehiscence are governed by temperature and humidity.



Plate 1: View of male and female flowers of ridge gourd

Anthers are free and pistil has three placenta with many ovules. Stigma is three and bilobate seeded. Fruits are club shaped and angled with ten prominent ridges and many seeded. Over matured fruits are inedible as they become hard and ridged. Seeds are black, flattened and wrinkled. One thousand seeds weigh about 150-170g (Doijode 2002).

Noticeable variability is observed among the genotypes with respect to staminate and pistillate flower sex ratio. Great variability is recorded in ridge gourd for fruit shape, size and colour. The fruit shape may be categorized as very long, long, oblong or short as that of sponge gourd. Very little variability is recorded in colour of seeds. Ridge gourd genotypes vary with respect to their earliness, fruit bearing capacity and the degree of resistance against biotic and abiotic stresses.

In spite of its economical and medicinal importance, adaptability and uses, the research priority given to this crop was less in crop improvement programmes when compared to other cucurbits. But in recent days, cultivation of ridge gourd is fast increasing because of improved awareness of its anti-biotic property and nutritive values among the consumers. There is a necessity to assess the genetic variability and its exploitation for the crop improvement. As many vegetable breeders made an effort in crop improvement, good number of new varieties and hybrids has been developed.

The crop improvement work should be focused on selection of elite genotypes for better yield, superior quality and resistance to biotic stress. For an effective selection, nature and magnitude of variation available in the material should be studied with regard to traits that are contributing to yield and effect of the environment in the expression of these characters. Generally selection depends upon the total variability and transmissibility of characters from parents to offsprings. Therefore on selecting any plant or any genotype one should be sure of the superiority of the selection being inherited by the progenies. Thus, knowledge of both genetic and environmental factors are essential for effective breeding programme.

Downy mildew caused by *Pseudoperonospora cubensis* Rostow is the major constraint in ridge gourd cultivation. The disease occurs severely in high temperature and high humidity. There are very few resistant varieties available in India and most of them are becoming more susceptible to downy mildew. Hence it is necessary to find out resistant sources which can be further exploited for developing downy mildew disease resistant types without compromising on yield and quality of fruits.

Hence the present investigation is formulated with the following objectives:

1. To study the nature and extent of genetic variability in ridge gourd [*Luffa acutangula* (L.) Roxb] for
 - a) Morphological and growth parameters
 - b) Yield and quality parameters
2. Screening of ridge gourd genotypes for downy mildew resistance under artificial condition.

II. REVIEW OF LITERATURE

Ridge gourd is one of the most important *Cucurbitaceous* vegetables grown in our country. This crop has gained significance with respect to area, production and its contribution to human nutrition. The main aim of the vegetable breeder is to improve both quantitative and qualitative characters of the plant. In order to achieve the above goals, there is a necessity to understand the genetic architecture of the important characters and inter relationship among them. In the present study an attempt was made to study genetic variability, heritability, genetic advance, characters association, path co-efficient and sources of resistance for downy mildew disease in collected ridge gourd genotypes. The available literatures pertaining to the investigation are reviewed under the following heading. As literature pertaining to ridge gourd alone was scanty, efforts were made to collect reviews on related cucurbits crops.

2.1 Genetic variability:

- Phenotypic co-efficient of variation (%)
- Genotypic co-efficient of variation (%)

2.2 Heritability in broad sense (%)

2.3 Genetic advances (% of mean)

2.4 Genotypic and Phenotypic correlation co-efficient

2.5 Path analysis

2.6 Resistance screening for downy mildew disease

2.1 Genetic variability

The success of breeding programme depends upon the magnitude of variability existing in the germplasm. Variability may be defined as the amount of variation present among the members of a population or species for one or more characters at genotypic or phenotypic levels.

A comprehensive summary of methods for estimating genetic variance is presented by Cockerham (1963). Phenotypic variability is observable and includes both genotypic and environmental variation and therefore called total variation. Genotypic variation refers to genetic or inherent variability, which remains unaltered by environmental conditions. It is measured in terms of genotypic variance and consists of additive, dominance and epistatic components. Environmental variance is measured in terms of error mean variance. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are derived from standard deviation divided by mean and are used to assess the extent of variation. Variability for growth, earliness, yield and yield components in ridge gourd has been reported by several workers. The review of literature on variance and its components for various characters have been presented below.

The estimates of genotypic coefficient of variation were found to be low as compared to phenotypic coefficient of variation for all the characters under study (Singh *et al.* 2002). High PCV and GCV were observed for node number for appearance of first male flower, sex ratio on whole plant, main axis and branches, fruits/plant, fruit weight, seeds/fruit and yield/plant. Values of GCV and PCV were almost equal for most of the characters of ridge gourd.

Narayanankutty *et al.* (2006) estimated the values for different genetical parameters for thirty six snake gourd genotypes. The seeds/fruit, fruit yield, fruit weight and fruits/plant showed the highest phenotypic and genotypic coefficient of variation. High values of GCV are an indication of high genetic variability among the genotypes and the scope for improvement of these characters through simple selection.

The highest phenotypic and genotypic coefficients of variability were found for number of seeds per fruit (8.59) by Ram *et al.* (2006). The PCV of moderate magnitude was observed for number of fruits per plant. Moderate values were recorded for days to edible maturity from fruit set, number of fruits per plant, length of fruit and diameter of full-grown ridge gourd fruit.

The field experiment was conducted by Kumar *et al.* (2007) with 20 bottle gourd genotypes that indicated the presence of wide variability among the genotypes as PCV were higher than GCV. The PCV expressed in term of percentage were comparatively high for fruit yield/vine followed by other traits and GCV were comparatively high for fruit yield/vine followed by number of fruits/vine, vine length, number of branches/vine, node number of first female flower, 100-seed weight and node number of first male flower.

The extent of variability present in 46 germplasm accessions of bitter gourd was estimated and the result revealed that the higher values of GCV were observed for number of primary branches per plant and fruit weight. Days to first female flowering, days to first fruit harvesting, 100-seed weight and node to first female flower appears exhibited the moderate values of GCV. Fruit diameter exhibited low values of GCV, indicating the least scope for improvement through selection (Raja *et al.* 2007).

The higher PCV than GCV indicated the predominant role of environment in the expression of the ridge gourd traits. The genotypic and phenotypic coefficient of variation were highest for fruit weight (38.75 and 38.28, respectively), yield per plant (135.68 and 35.56, respectively), fruit length (25.89 and 24.44, respectively), node at which first female flower appears (25.39 and 23.41, respectively) and fruits per plant (22.00 and 20.26, respectively) as per the result obtained by Choudhary *et al.* (2008).

Wide genetic variation was observed for twenty genotypes of bitter gourd (Islam *et al.* 2009). The highest genotypic and phenotypic variance was observed for vine length followed by weight per fruit, branches per vine and days to first male flowering. High GCV was observed for branches per vine, yield per plant and number of fruit per plant where as low GCV was observed for days to first male and female flowering. The differences between GCV and PCV were high fruit diameter, number of fruit per plant and weight per fruit. High GCV and PCV was observed fruit diameter, number of fruit per plant and weight per fruit. In all cases, phenotypic variances were higher than the genotypic variance.

Khan *et al.* (2009) conducted an experiment with 24 accessions of pointed gourd. The result revealed that genotypic variance was maximum in fruits per plant (13141) followed by fruit yield (104) and fruit weight (73.41). However, high phenotypic variance was recorded in fruit number (13646), yield (105), fruit weight (73.84) and pulp weight per fruit (79.14). Minimum PV was recorded in fruit length (0.76) and fruit breadth (1.01). Moderately high GCV was evident in fruit number (5415%), yield (410%), fruit weight (172%) and fruit weight per plant (162%). This indicated the presence of maximum amount of genetic variability. High PCV was observed in fruit number (5623%), yield (411%), fruit weight (173%) and fruit weight per plant (161%).

In ridge gourd, the highest GCV (29.40) was recorded in node at which first female flower appeared followed by number of marketable fruits per plant (25.48) and PCV (32.29) was highest for node at which first female flower appeared (Choudhary and Suresh Kumar, 2011).

A Wide range of bottle gourd genotypes were evaluated for genetic parameters. High GCV and PCV was observed for yield per plant, fruit weight and number of fruit per plants whereas low genotypic co-efficient of variation was observed for fruit breadth (Husna *et al.* 2011). However PCV was more than GCV for all characters as always. In all cases, phenotypic variances were higher than the genotypic variance.

In ridge gourd fruit yield/plant, fruit weight and fruit length exhibited the highest PCV and GCV estimates as observed by Samadia (2011). Differences between phenotypic and genotypic coefficient of variations were low which showed the low impact of environment on the expression of characters. High values of GCV are an indication of high genetic variability among the genotypes and thus the scope for improvement of these characters through simple selection would be better.

Rabbani *et al.* (2012) evaluated 60 ridge gourd landraces and result showed that the GCV was smaller than PCV for all the characters indicating the effect of environment to some extent in the expression of the characters and also observed low difference between the GCV (58.0%) and the PCV (59.67%). The highest GCV and PCV were observed in fruit yield per plant.

Radha Rani (2012) evaluated 14 genotypes of ridge gourd and her study revealed that the phenotypic coefficient of variation was greater than genotypic coefficient of variation for most of the traits under study. Relatively high phenotypic and genotypic coefficients of variation were recorded for fruit length, number of fruits per vine and fruit yield. The GCV estimates were maximum for fruit length (18.25 cm) followed by fruit yield per vine (15.54 kg), number of fruits per vine (12.32). High PCV was observed for yield per vine (20.31) followed by fruit length (19.54cm) and number of nodes at first harvest (13.35).

Dubey *et al.* (2013) reported that the PCV was highest (27.91%) in ridge gourd vine length followed by fruit length (26.12%), fruit yield per plant (21.91%) and fruit diameter (19.38%) in that order. A comparatively moderate PCV observed for days to first female flower anthesis (10.81%), fruit weight (11.46%), number of branches per plant (12.05%) and days to first male flower (12.37%). The highest estimates of GCV were observed for fruit length (23.79%) followed by vine length (22.89%) and fruit yield per plant (20.52%).

Dubey *et al.* (2013a) reported that the PCV and GCV was highest in fruit length (28.03 and 24.18, respectively) followed by fruit yield per plant (19.56 and 14.35, respectively), vine length (17.06 and 14.33, respectively), fruit diameter (19.38 and 16.12, respectively), and number of fruits/plant (18.65 and 16.07, respectively). A comparatively low PCV and GCV was observed for days to first harvest (5.06 and 4.02, respectively), days to first male flower anthesis (7.10 and 5.76, respectively) and days to first female flower anthesis (7.15 and 5.83, respectively) is indicative of less possibility for ridge gourd improvement

The performance of 20 genotypes of sponge gourd was evaluated by Kumar *et al.* (2013). High values of PCV as well as GCV were recorded for total yield per vine, number of seeds per fruit and average weight of fruit. The high magnitude of GCV further revealed the greater extent of variability present for the characters, suggesting good scope for improvement through selection of this crop.

A field experiment was conducted by Basumatary *et al.* (2014) for 15 local germplasm of spine gourd. Highest GCV was observed in number of primary branches (27.65%) followed by node at which first female flower appeared (20.77%), fruit yield per plant (20.37%) and fruit length (19.71%) respectively, whereas high PCV was recorded in number of primary branches (27.88%), node at which first female flower appeared (20.92 %), fruit yield per plant (20.90%) and fruit length (20.45%).

Choudhary *et al.* (2014) reported on ridge gourd that the PCV were invariably higher than their corresponding GCV due to environmental influence. They recorded fairly high magnitude of PCV and GCV in fruit length (25.39 and 24.56 respectively) and node at which first hermaphrodite flower appeared (24.70 and 21.83 respectively). The difference between PCV and GCV was narrow for days to first fruit harvest and number of fruits per plant, indicating less influence of environment on the expression of these traits.

Singh *et al.* (2014) reported that the higher degree of variation was observed in phenotypic and genotypic variance among the characters studied in case of bitter gourd. Maximum variation was shown by fruit yield per plant followed by fruit length. Low variance was observed for branches per plant, plant height, fruit diameter, fruits per plant, fruit weight and seeds per fruit. In their study, all the characters except weight of fruit showed narrow differences between the values of GCV and PCV indicating variability due to genetic constitution.

The PCV invariably increased for all the traits of ridge gourd and the genetic variability did not show any consistent pattern of change. Days to first female flowering, days to 50% flowering, days to first harvest and days to last harvest had low PCV and GCV. Fruit diameter had moderate PCV and GCV. Number of branches at 45 DAS had higher PCV and moderate GCV. High variability availability for biochemical characters like chlorophyll, number of branches at 90 DAS and fruit yield per vine in the present materials would be quite useful for selection. This result was observed by Koppad *et al.* (2015).

Khatoon *et al.* (2016) reported in ridge gourd that the phenotypic and genotypic variances were highest for vine length (5682.80 and 3769.73 respectively) and lowest for fruit yield per plant (0.73 and 0.49 respectively). The highest estimates of PCV and GCV were observed for fruit yield per plant (27.62 and 22.52%). However, the lowest estimates were recorded for crop duration (8.79 and 5.92%).

2.2 Heritability

Heritability is the transmissibility of characters from parent to off-spring. Effectiveness of selection of genotypes depends on heritability. In crop improvement, the genetic component of variation is important since only this component is transmitted to the next generation. Heritability is expressed as the ratio of genotypic variance to phenotypic variance. The heritability is termed as broad sense heritability and serves as useful tool in the process of selection by the breeder. Heritability for growth, quality, yield and yield components in ridge gourd has been reported by several workers. The review of literature on heritability for various characters has been presented below.

Singh *et al.* (2002) reported high heritability for node number for appearance of first male and female flower (90.48 and 93.5 respectively), length of main axis (98.98), number of primary branches (83.87), sex ratio (94.39), fruit set (67.57%), fruit length (88.10), fruit weight (94.18), seeds/fruit (98.89), 100-seed weight and yield/plant (86.64) indicating the presence of additive gene action in ridge gourd.

High heritability was observed for days to first male flower opening (91.80), node at which first female flower was formed (80.30), days to first female flower opening (89.90), node at which first female flower formed (82.60), days to first harvest (83.40) and hundred seeds weight (98.90) (Narayanankutty *et al.* 2006). These characters are governed by non-additive gene action and hence hybridization followed by selection may be used for the sponge gourd improvement of these traits.

In Luffa, the highest value of heritability was reported by Ram *et al.* (2006) for number of seeds per fruit (96.8) followed by fruit yield per ha (95.1) and average fruit weight (94.0) while lowest value was recorded for 100-seed weight (62.6). High heritability suggested that characters might be governed by additive gene action and phenotypic value could provide fair and reliable measure of genotypic variance in ridge gourd crop improvement.

Kumar *et al.* (2007) conducted field experiment with twenty diverse bottle gourd genotypes. Heritability estimates were high of >90% for days to 1st male flower anthesis, days to 1st female flower anthesis, number of branches/vine, vine length, nodes number of 1st male

flower, nodes number of 1st female flower, days to 1st fruit harvest, length of edible fruit and fruit yield/vine. Moderate heritability (70-80%) was observed for number of fruits/vine, number of seeds/fruit and 100-seed weight.

The study was undertaken with 46 genotypes of bitter gourd (Raja *et al.* 2007). The results revealed that the magnitude of heritability were quite higher for all the characters except for fruit girth. The characters viz., fruit weight yield per plot, fruit length, number of fruits per plot and number of female flowers per plant showed high heritability percent.

In ridge gourd, the high estimates of heritability in broad sense were obtained by Choudhary *et al.* (2008) for all the characters except internodal length, vine length and number of primary branches per plant. The high heritability were obtained for fruit weight (97.6), days to first fruit harvest (91.0) fruit length (89.1) and yield per plant (88.51).

Choudhary and Suresh Kumar (2011) reported in ridge gourd that the heritability estimate in broad sense were high for all the traits excepted number of branches/ plant, days to first female flower and days to first fruit harvest. While, in bitter gourd Islam *et al.* (2009) estimated the high heritability for days to first male flowering, days to first female flowering and Vine length which indicated the presence of additive genes effect.

Broad sense heritability among different characters of 33 bottle gourd genotypes was studied by Husna *et al.* (2011). High heritability estimates were recorded for yield per plant and fruit weight (91.6%) followed by sex ratio (89.39), fruit length (88.71%) and fruit weight (87.97%) which in fact demonstrate the presence of additive genes effect and selection for genetic improvement for this trait would be effective and remaining traits shows moderate heritability.

In the this study, high heritability was observed for fruit length, fruit weight, fruit yield/plant, mature fruit length, days to anthesis of first male and female flower, days to first harvest and number of seeds/fruit whereas it is moderate for number of fruits/plant on ridge gourd (Samadia 2011).

The heritability estimates were high (>90%) for plant height, fruit weight, fruit length, fruit circumference and number of seeds per plant. Other characteristics of bottle gourd, such as fruit length and seed length, showed heritability values ranging between 83.55% and 86.43%. Whereas a somewhat lower heritability was observed for 100-seed weight (78.29%) (Mladenovic *et al.* 2012).

Sixty genotypes of ridge gourd were evaluated by Rabbani *et al.* (2012) and the result revealed that the high heritability (94.16%) indicated a little contribution of environment to the phenotype. Out of 14 characters studied, five were found to be highly heritable (above 80%) the characters like sex ratio, 100 seed weight, number of fruit per plant, average fruit weight and fruit yield per plant and the rest had medium heritability (50-80%).

Dubey *et al.* (2013) reported high heritability (broad sense) estimates for fruit yield per plant (87.7%), fruit length (82.95%), days to first male flower anthesis (81.55%), days to first harvest (81.50%), days to first female flower anthesis (77.88 %), number of fruits per plant (71.27%) and fruit diameter (69.22%,) were indicator of minimal environmental influence in the expressions of these characters. These characters can be accorded significant attention in selections aimed at ridge gourd improvement.

High heritability (in broad sense) estimates for fruit length (74.45%), number of fruit, per plant (74.32%), number of branches per plant (70.06%) and fruit diameter (69.22%) indicated minimal environmental influence in expressions of these characters in ridge gourd. Lower heritability was observed for fruit yield per plant (53.80) followed by average fruit weight (55.29).

(Dubey *et al.* 2013a). High heritability estimates indicated that the characters would exhibit a high response to selection. Similar result was also reported by Panwar *et al.* (1977) in sponge gourd.

The field experiment was conducted in sponge gourd to estimate heritability (Kumar *et al.* 2013). All the 14 traits studied, high heritability ranging from 78.72% (days to maturity) to 98.17% (number of seeds per fruit). Out of 14 characters studied, number of seeds per fruit (98.17%) and average weight of fruit (97.60) showed high heritability which indicated that these two characters had additive gene effect and therefore, they are more reliable for effective selection.

Choudhary *et al.* (2014) found that heritability (in broad sense) was high (>70%) for ridge gourd fruit length (93.5%) and node at which first hermaphrodite flower appeared (78.0%) which provides ample scope for varietal improvement through selection.

Singh *et al.* (2014) evaluated 25 bitter gourd genotypes for estimation of broad sense heritability. The heritability was very high for all the traits studied indicating less influence of environment in the expression of these traits which suggested the presence of additive gene effects. The higher estimates of heritability were observed for days to first male and female flower anthesis (95.5 and 91.85 respectively) followed by fruit yield per plant (84.50%), branches per plant (82.17%), fruit diameter (77.82%), fruit length (71.19%), fruits per plant (77.708%) and low heritability was observed in average fruit weight (31.39%).

The heritability was low for the number of branches at 45 DAS (7%). High heritability was observed for the characters like number of fruits per vine (73%). Days to 50% flowering (100%), days to harvest (87 %), vine length (88 %), number of branches at 90 DAS (90%). The yield component like fruit yield per vine (62%), average fruit weight (58 %), days to last harvest (56 %) and fruit length (67%) had moderate heritability. The biochemical trait like chlorophyll (98 %) had the high heritability indicating that the characters are under control of additive gene action in case of ridge gourd (Koppad *et al.* 2015).

Khatoon *et al.* (2016) reported high heritability estimates was recorded for vine length, number of nodes per vine, number of nodes to first pistillate flower appearance, days to first staminate flower anthesis, days to first pistillate flower anthesis, days to first fruit harvest, fruit length, fruit diameter, number of fruits per plant and fruit yield per plant in ridge gourd.

2.3 Genetic advance

Genetic advance is the measure of the improvement that can be achieved by practicing selection in a population. Since, the estimates of heritability give no indication of the amount of progress expected from the selection; they are most meaningful when accompanied by estimates of genetic advance. High genetic advance coupled with high heritability is an indication of more additive gene action (Panse and Sukhatme, 1967).

Genetic advance for growth, morphological, quality, yield and yield components in ridge gourd and related crops has been reported by several workers. The reviews of literature on genetic advance as per cent of mean for various characters have been presented below.

High heritability coupled with high genetic advance (% mean) was observed for node number for appearance of first male and female flower, length of main axis, number of primary branches, sex ratio on whole plant, fruits/ plant, fruit set (%), fruit length, fruit weight, seeds/fruit, 100-seed weight and yield/plant indicating greater scope of improvement in ridge gourd through selection (Singh *et al.* 2002).

Estimates of genetic advance of thirty-six snake gourd genotypes indicated that heritability estimates in conjunction with estimates of genetic advance are more useful in selecting superior genotypes. Narayankutty *et al.*, (2006) reported high heritability with high genetic advance was observed for fruit yield, fruit weight and seeds/fruit.

Twenty-four accessions of *Luffa hermaphrodita* were evaluated for 12 economic characters to study genetic advance. The result showed that genetic advance values varied from 0.64 for diameter of full grown fruit to 65.22 for number of seeds per fruit. The GAM ranges from 15.78 for 100 seed weight to 89.38 for number of seeds per fruit (Ram *et al.* 2006).

High heritability estimates associate with fairly high estimates of genetic advance for days to first male flowering, days to first female flowering and vine length in bitter gourd (Islam *et al.*, 2009). Whereas, in another study on ridge gourd (Choudhary *et al.*, 2008) fruit weight showed maximum genetic advance (63.47) followed by fruit length (8.65), days to first fruit harvest (7.96) and fruits per plant (7.661). High heritability along with high genetic advance was observed for fruit weight and fruit length.

Choudhary and Suresh Kumar (2011) reported that high genetic advance and high genetic advance as per cent of mean for node at which first female flower appeared (8.04 and 55.14 respectively), fruit length (8.93 and 42.84 respectively), marketable fruits/plant (10.17 and 47.54 respectively) and fruit weight (38.12 and 45.27 respectively) indicating the presence of additive gene action among ridge gourd genotypes.

High genetic advance as percentage of mean was observed for fruit length, fruit weight, fruit yield/plant, mature fruit length and number of seeds/fruit whereas it is moderate for number of fruits/plant. Low genetic advance was observed for days to anthesis of first male and female flower and days to first harvest (Samadia 2011). Since, these characters are governed by non-additive gene action hybridization followed by selection may be used for ridge gourd crop improvement.

Estimates of expected genetic advance as per cent of mean ranged from 9.03 for vine length to 35.11 for fruit length of ridge gourd (Radha Rani, 2012). High heritability values were associated with high values of expected genetic advance as per cent of mean for fruit length, number of fruits/vine, node number at 1st fruit harvested and moderate values for fruit girth.

Ten ridge gourd accessions were evaluated to estimate genetic advance (Dubey *et al.* 2013). High GAM was observed for fruit length (44.63) followed by fruit yield per plant (39.58) and vine length (38.66). In sponge gourd Kumar *et al.* (2013) revealed that out of 14 characters studied, number of seeds per fruit and average weight of fruit showed high heritability coupled with high genetic advance.

Dubey *et al.* (2013a) reported high GA for vine length (43.25) followed by mean fruit weight (40.62) and low GA was observed for number of branches (0.98) and fruit yield per plant (0.76) in ridge gourd genotypes.

A study was carried out by Choudhary *et al.* (2014) to determine genetic advance in ridge gourd. The result showed high genetic advance and GAM for fruit weight (6.39 and 23.59, respectively) followed by fruit length (5.91 and 48.88).

High heritability coupled with high genetic advance as percent of mean was observed for fruit length (93.53), yield per plant (81.25), fruit diameter (67.36), fruit weight (65.07), branch per plant (62.04) and seeds per fruit (53.77) indicating the possible role of additive gene action in bitter gourd (Singh *et al.* 2014).

In ridge gourd, Koppad *et al.* (2015a) reported that the genetic advance (GA) was the high for fruit yield per vine (515.39%) and the lowest for flesh thickness (0.23%) followed by average fruit weight (0.26%). The GAM was highest for fruit yield per vine (41.30) and lowest was observed for fruit diameter (6.42).

Khatoon *et al.* (2016) reported high genetic advance for vine length (103.01%). However, a low value was observed in fruit yield per plant (1.17%). From this study on mean performance revealed that the characters *viz.*, vine length, pedicel length, number of fruits per plant, fruit length, fruit diameter and average fruit weight were the most important traits for improving the genotypes for higher yield and may be applied for selection in ridge gourd.

2.4 Genotypic and phenotypic correlation co-efficient

Yield is a complex character and is governed by polygenic system. Moreover, it is highly influenced by environmental fluctuations. Correlation study measures the natural relationship between various characters and helps in determining the component characters on which selection can be based for yield improvement. Correlation coefficient measures the degree of association either in positive or negative direction. Phenotypic correlation is the observable correlation between two variables, which includes both genotypic and environmental effects. On the other hand genotypic correlation is the inherent association between two variables and it may be either due to pleiotropic action of genes or linkage or both.

The expression of characters in a plant is the consequence of a chain of inter-relationship between characters either directly or through other events. The correlation of characters may be due to genetic linkage (Harland, 1939). Correlation co-efficient analysis measures the mutual relationship between various plant characters and determines the components on which selection can be based for improvement. Review of literature on correlation studies at both phenotypic and genotypic level are presented below

Shah and Kale (2002) conducted an experiment on correlation co-efficient analysis of yield components of 55 genotypes of ridge gourd. The fruit weight per vine was positively and significantly correlated with number of fruits per vine, average fruit weight and vine length indicating the close association and dependency of yield on these characters. Among 15 quantitative traits in ridge gourd, The magnitude of genotypic correlation coefficients exhibited higher than the phenotypic ones for all the traits studied (Prasanna *et al.* 2002).

Dey *et al.* (2005) revealed that the genotypic values were higher than the phenotypic values. The yield had the highest positive correlation with fruit weight followed by fruits per plant, fruit length and fruit diameter.

Narayanankutty *et al.* (2006) reported that yield/plant showed significant positive correlation with fruit weight, fruits/ plant, fruit girth, fruit length, days to first harvest, and days to first female flower opening both at the genotypic and phenotypic levels. The significant positive association of number of fruits/plant, fruit length, fruit girth and fruit weight with yield of snake gourd. Seeds/fruit showed significant and positive correlation with days to first male flower opening, days to first female flower opening, fruit girth and fruit weight of sponge gourd.

Twenty-four accessions of *Luffa hermaphrodita* were evaluated by Ram *et al.* (2006) who revealed that fruit weight and number of fruits per plant was positively and significantly associated with yield whereas days to first harvesting was positively and significantly associated with vine length and individual fruit weight while diameter of fruit, 100-seed weight were positive. Length of fruit was positively associated with number of fruit per plant, number of seed per fruit and seed weight per fruit, positively. The fruit diameter did not exhibit positive and significant correlation with any of the traits studied.

In bottle gourd, Suchitra and Haribabu (2006) reported that the relationship between fruit length, fruit weight, number of fruits per vine and number of seeds per fruit is positive and significant at both phenotypic and genotypic levels i.e., as the length of the fruit increases fruit weight and number of seeds also increases significantly. Vine length showed a positive and significant correlation with most of the characters except for fruit length and number of fruits per vine.

Genotypic correlation coefficient was found higher than their corresponding phenotypic correlation coefficient for most of the characters in ridge gourd except vine length, inter-nodal length and fruits per plant by Choudhary *et al.* (2008) and the yield had positive and significant correlation with fruit length (0.513, 0.436) and fruit weight (0.875, 0.845) at both genotypic and phenotypic level, respectively.

In bitter gourd Islam *et al.* (2009) showed that genotypic correlation appeared to be higher than the corresponding phenotypic correlation. Days to first male flowering were highly significant and positively correlated with the number of nodes per vine and weight per fruit. Positively significant correlations were also noticed for vine length, branches per vine, fruit diameter and weight per fruit both at phenotypic and genotypic level. Highly positively significant correlation was noticed for fruit length both at genotypic and phenotypic level with positively correlated on yield per plant.

Khan *et al.* (2009) evaluated for 24 accessions of pointed gourd. Correlation coefficient revealed that number of node at first harvest had positive association with single fruit weight, number of fruits per plant and yield of fruits per hectare. On the other hand number of node at first harvest had negative correlation with fruit length and weight of fruits per plant. Days to first flowering had positive association with fruit breadth, number of fruits per plant, weight of fruit per plant and yield of fruit. Number of fruits per plant had positive significant correlation with weight of fruits per plant (0.915**) and yield of fruit (0.813**).

The genotypic and phenotypic correlation co-efficient were determined to obtain information on the relationship among 14 quantitative characters in ridge gourd (Hanumegowda *et al.* 2011). The result revealed that fruit yield per plant showed positive and significant correlation with number of fruits per plant (0.889), average fruit weight (0.871), fruit yield per hectare (0.821), fruit length (0.795), fruit diameter (0.726), per cent fruit set (0.702), 100 seed weight (0.652) and seed yield per fruit (0.547) at genotypic level. Whereas number of fruits per plant (0.862), average fruit weight (0.858), fruit yield per hectare (0.807), fruit length (0.784), fruit diameter (0.683), number of seeds per fruit (0.630), seed yield per fruit (0.643), per cent fruit set (0.540) and 100 seed weight (0.480) at phenotypic level.

In bottle gourd correlation studies revealed that the highest significant association of yield per plant with reproductive characters number of fruit per plant followed by fruit weight at genotypic and phenotypic level (Husna *et al.* 2011). But number of male flowers had significant and negative correlation with ratio of male & female flower and fruit length at both genotypic and phenotypic level.

Choudhary and Suresh Kumar (2011) reported that the magnitude of genotypic correlation coefficients was higher than respective phenotypic correlation coefficients where in ridge gourd the marketable fruits yield per plant had positive and significant correlation with fruit weight (0.786) and fruit length (0.448) at phenotypic level. Days to first fruit harvest exhibited positive and highly significant correlation with days to first female flowering opening (0.850) and node at which first female flower appeared (0.469) at phenotypic level.

In bottle gourd Mladenovic *et al.* (2012) reported that the existence of a positive correlation between plant height and fruit length ($r = 0.33$). The correlation between fruit weight

and all other variables was positive ($r = 0.22$ to 0.59). The correlation between fruit weight and 100-seed mass was also positive.

Correlation coefficient study indicated that the 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 of ridge gourd (Rabbani *et al.* 2012).

Radha Rani (2012) studied correlation on ridge gourd and found that yield per vine was significantly and positively correlated with number of fruits per vine both at genotypic and phenotypic levels. Vine length was positively and significantly correlated with node number at first fruit harvested and number of fruits per vine at genotypic level. Vine length, average fruit weight and fruit length showed non-significant but positive correlated with yield at both genotypic and phenotypic levels.

Correlation co-efficient analysis in ridge gourd revealed that fruit yield per plant showed positive and significant correlation with number of fruits per plant (0.963), fruit length (0.892), fruit weight (0.835) and vine length (0.614) at genotypic level and with number of fruits per plant (0.854), fruit length (0.721), fruit weight (0.577) and vine length (0.349) at phenotypic level (Dubey *et al.* 2013).

In ridge gourd, Dubey *et al.* (2013a) reported that the genotypic coefficient of variation was high for fruit length, fruit diameter, number of fruits per plant, and number of branches per plant. Genotypic coefficients of variation was low for days to first male flower anthesis, days to first female flower anthesis, and days to first harvest. Vine length, number of branches per plant, fruit diameter and number of fruits per plant were positively correlated with fruit yield per plant.

The estimates of genotypic correlation were slightly higher than their corresponding phenotypic correlations for all the characters of sponge gourd. Total yield per vine exhibited significant and positive correlation with number of fruit per vine, average weight of fruit and number of seeds per fruit both at genotypic and phenotypic levels. Further, average weight of fruit was significantly and positively correlated with number of seeds per fruit, total yield per vine, average length of fruit, number of fruits per vine (Kumar *et al.* 2013).

Significantly positive correlation was found between fruit yield per plant and fruit weight (0.877), number of fruits per cluster (0.590) and fruit length (0.356) at phenotypic level, while significantly negative and desirable correlation at phenotypic level was observed between fruit yield per plant and days to first fruit harvest (-0.403), days to first hermaphrodite flower (-0.337) and node at which first hermaphrodite flower appeared (-0.315) (Choudhary *et al.* 2014) in ridge gourd.

In ridge gourd the marketable yield/ plant had positive and highly significant correlation with fruit weight (0.834) and number of marketable fruits/ plant (0.624) at phenotypic level (Choudhary *et al.* 2014a).

Basumatary *et al.* (2014) revealed highly significant and positive correlation of yield per plant with number of primary branches, internode length, fruits per plant, fruit diameter and single fruit weight. Days to 50 % flowering exhibited significant positive correlation with total soluble sugar (%). The association between single fruit weight, fruit yield, 100 seed weight and vitamin C content was highly positive in spine gourd.

In ridge gourd, Narasannavar *et al.* (2014) reported that fruit yield per vine had highly significant and positive association with number of fruits per vine ($G=0.951$, $P=0.450$), fruit length

($G=0.600$, $P=0.547$) and significant and positive correlation with number of branches at 90 DAS ($G=0.407$, $P=0.362$). Whereas, average fruit weight ($G=0.425$) and vine length at 90 DAS ($G=0.332$) are found to be significant at genotypic level.

Singh *et al.* (2014) reported that the genotypic correlation were higher than their corresponding phenotypes for all the traits of bitter gourd studied. Yield per plant showed significant positive association with plant height, fruit diameter, fruit length and seeds per fruit. Fruit weight had a positive significant correlation with fruit diameter, fruit length and fruits per plant. Fruit length showed significant positive association with plant height and fruit diameter, whereas fruit diameter showed significant positive correlation with days to first flower anthesis and plant height. Plant height had a significant positive correlation with only for days to first flower anthesis whereas edible maturity had positive significant correlation with days to first flower anthesis.

The field experiment was conducted to determine the association between the various characters of ridge gourd by Koppad *et al.* (2015a) which revealed that fruit yield per vine had positive and significant correlation with the number of fruits (0.9650), average fruit weight (0.9298), fruit length (0.7422) and fruit diameter (0.6288).

In ridge gourd, Khatoon *et al.* (2016) reported that the correlation in the study indicated that fruit yield per plant was positively and significantly correlated with vine length, number of nodes per vine, inter nodal length, crop duration, fruit length, fruit diameter, number of fruits per plant and average fruit weight. However, negative and significant association of fruit yield per plant was seen with days to 1st staminate and pistillate flower anthesis and days to first fruit harvest at both phenotypic and genotypic level.

2.5 Path co-efficient analysis

When correlation co-efficient alone considered as the criterion for selection for high yield would be misleading. As such a character may directly correlate with yield but may further depend on other characters. Yield is a complex character and it is dependent upon number of components. A correlation study gives the amount of association between any pair of characters. However, the direct and indirect effect of the components of yield are however, not revealed by this study. Especially, when more and more variables are included in the study, the indirect contribution becomes more complex and para mixing. Path co-efficient analysis developed by Wright (1921) helps in partitioning the correlation co-efficient into direct and indirect effects, thereby, providing relative importance of each of the causal factors. Dewey and Lu (1957) used this technique first time for plant selection in crested wheat grass. The implication of correlation studies becomes more evident when magnitude of various attributes contributing to correlation.

Path analysis is simply standardized partial regression co-efficient, which splits the correlation co-efficient into the measures of direct and indirect effects of a set of independent variables on the dependent variable. Partitioning of the total correlation into direct and indirect effects would be worthwhile for an effective selection programme. If the correlation co-efficient between causal factor and the effect is almost equal to its direct effect, then correlation explains the true relationship and a direct selection through this trait will be effective. If the correlation co-efficient is positive, but the direct effect is negative or negligible, the indirect effects seem to be cause of correlation. In such situations, the indirect causal factors need to be considered simultaneously for selection. Correlation co-efficient may be negative but the direct effect can be positive and high, under such circumstances, a restricted simultaneous selection model is to be followed, i.e., restrictions are to be imposed to nullify the undesirable indirect effects in order to make use of the direct effects.

Dey *et al.* (2005) revealed that fruit weight exhibiting maximum positive direct effect towards yield followed by fruits per plant and fruit length. Ascorbic acid and total carotenoids exhibited very low insignificant direct effect but they gave strong negative indirect effect through traits such as fruit weight, fruit length and fruit diameter also and they can be utilized for the improvement of nutritional qualities in bitter gourd.

In bottle gourd Suchitra and Haribabu (2006) reported that the characters like fruit weight, number of fruits per vine and vine length exhibited positive direct effects on yield revealing that there are major yield contributing traits in bottle gourd. The characters namely fruit length, fruit diameter, fruit flesh thickness and number of fruits per vine showed highest positive indirect effects on fruit yield. Similarly positive indirect effects of other characters viz., fruit length and fruit weight through number of fruits per vine were also observed.

High positive direct effects were noticed by fruit weight, fruit number, days to first harvest, seeds/fruit and hundred seeds weight. Fruit weight showed that the highest positive direct effect with yield/plant. Fruits/plant showed the next highest positive effect on yield of snake gourd. Hence the higher positive value of direct effect was nullified through negative indirect effect of fruit weight and fruit number (Narayanankutty *et al.* 2006).

In ridge gourd, Choudhary *et al.* (2008) reported that the characters like fruit weight (1.136), fruits per plant (0.575) and days taken to initiation of first female flower (0.557) had maximum direct effect on yield followed by number of primary branches per plant (0.015). These characters should be considered for yield improvement in ridge gourd breeding programme.

The results of the path analysis revealed (Islam *et al.* 2009) that in bitter gourd the number of fruit per plant had the maximum direct (1.789) followed by vine length (1.134), number of nodes per vine (0.583) and days to first flowering male (0.044). The direct effect of number of fruit per plant on yield was diluted mainly due to negative indirect effect via days to first male flowering (-0.008), Vine length (-0.105), Number of nodes per vine (-0.510), branches per vine (-0.052) and fruit diameter (-1.141).

The results of the path analysis revealed that in bottle gourd the number of fruit per plant had the maximum direct effect (0.680) followed by weight per fruit (0.453), fruit length (0.087) and ratio of male and female flower (0.042) (Husna *et al.* 2011).

Radha Rani (2012) studied on path coefficient analysis and the result showed that at genotypic level number of fruits per vine (1.427) had highest direct effect on yield followed by fruit girth (1.407) and average fruit weight (0.869). Also maximum positive direct effect was observed on yield via number of fruits/vine. At phenotypic level, maximum positive direct effects were exhibited by average fruit weight (0.607) followed by number of fruits/vine (0.580), and vine length (0.201) whereas maximum positive indirect effect was shown by vine length upon yield (0.238) through number of fruits/vine in case of ridge gourd. Rabbani *et al.* (2012) also revealed that yield improvement could be achieved by direct selection for days to 50% flowering, girth of fruit, fruits per plant or vine, fruit per branch and length of the vine of ridge gourd.

Path analysis indicated that number of fruit per plant and fruit weight had the highest positive direct effect on fruit yield per plant at the genotypic level. Days to first male flower anthesis had the most negative direct effect on fruit yield per plant. Low residual effect at the genotypic level indicated that more than 99.99% of variability could be explained through component characters of ridge gourd (Dubey *et al.* 2013a).

According to Kumar *et al.* (2013), path analysis implied that among 14 traits of bitter gourd, few traits namely, average diameter of fruit (5.93), number of primary branches (2.46), average weight of fruits (0.97) and number of fruits per vine (0.81) exhibited positive direct effects

on fruit yield per vine. Days to maturity (-2.97), number of seeds per fruit (-2.22), node number at which first female flower appeared (-2.17) and days to anthesis of first female flower (-2.16) were found to be negatively associated with total yield per vine.

In *Luffa*, path coefficient analysis exhibited that number of fruits per plant and fruit weight had the highest positive direct effect on fruit yield per plant at genotypic level. Days to first male flower anthesis had maximum negative direct effect on fruit yield per plant (Dubey *et al.* 2013).

Thirty five genotypes of ridge gourd were evaluated by Choudhary *et al.* (2014). The results revealed that fruit weight (0.850) and number of fruits per plant (0.334) exerted maximum direct effect on fruit yield per plant at phenotypic level. Days to first fruit harvest (-0.057) had negative direct effect on fruit yield per plant. Fruit weight exerted negative direct effect on fruit yield per plant but had positive and significant correlation with fruit yield per plant through positive indirect that is days to first fruit harvest (0.001) and number of fruits per cluster (0.003)..

Path analysis for fruit yield per vine revealed that, fruit yield per plot ($G=0.760$, $P=0.390$), fruit length ($G=0.669$, $P=0.558$) and number of branches ($G=0.163$, $P=0.424$) exhibited maximum positive and direct effects on fruit yield per vine at both genotypic and phenotypic level indicating their true positive significant association with fruit yield per vine. This result was reported by Narasannavar *et al.* (2014) in ridge gourd.

In ridge gourd, Khatoon *et al.* (2016) revealed maximum positive direct effect on fruits yield per plant was imposed by average fruit weight, fruit length and days to 1st staminate flower anthesis. Path co-efficient analysis showed that number of fruits per plant and average fruit weight (0.4656) exhibited the highest positive direct effect (0.7192) on yield.

Fruit quality parameter

Eight genetically divergent parental lines of cucumber and their hybrids evaluated for TSS, total carotenoids, vitamin C, total mineral matter, reaction to downy mildew, bitterness and shelf life of fruit. Hybrid Long Green x Bhari Mansa registered best overall performance for studied quality traits (Brar *et al.* 2011).

Proximate analysis of pumpkin and bottle gourd was analyzed by Hegazy and Kinawy (2011). The results showed that the value of crude protein content was ranged between 35-22.48%. Pumpkin kernels contained a high percentage of crude protein (35%) than bottle gourd (22.48%).

Lisa *et al.* (2011) studied the provitamin A and vitamin C contents of 6 California grown and 4 imported melon varieties and compared that to the nutrient data published in USDA nutrient database. The results indicated that the California grown and imported melons had higher vitamin A activity than the values reported in USDA database.

Ullah *et al.* (2011) evaluated 4 varieties (Charantia C. B. Clerke, Muricata, Hybrid green and Hybrid white) of bitter gourd. The result revealed that the presence of protein and Vitamin C constituent among the varieties comprising $1.17 \pm 0.01\%$ to $2.4 \pm 0.02\%$ and 9.41 ± 0.26 to $13 \pm 0.57\text{mg}\%$ respectively. Muricata and Charantia C. B. Clerke are moderate sources of protein. The vitamin C content of four varieties ranges from 9.41 to 16 mg%. Among the 4 varieties the highest amount of vitamin c was recorded from hybrid green ($16.2\text{mg} \pm 0.24/100\text{g}$) followed by Muricata ($13.0 \pm 0.57\text{mg} \%$).

The values of ascorbic acid, varied significantly in varieties of ridge gourd used as parental lines and hybrids which were higher in hybrids over their parents. The average value of

21 F₁ hybrids for ascorbic acid was higher than the average value of the seven parents. Narrow sense heritability being 17.15 % for ascorbic acid (Karmakar *et al.* 2013).

Alli and Jansirani (2014) evaluated thirty five entries of ridge gourd germplasm for protein content. There were significant differences in protein content among the genotypes. CO 1 recorded the highest protein content. This most promising genotype can be used as common parent and other entries with special characters as partners to develop character specific hybrids with maximum yield.

Bello *et al.* (2014) evaluated four species of gourd fruits which were characterized for dietary values and anti-nutrient constituents. Proximate analysis revealed that the crude protein content is highest in ash gourd (7.88 g/100g) and lowest (1.87 g/100g) in oriental gourd. The level of vitamin C varied from 21.82 mg/100g in cucumber to 60.00 mg/100g in ash gourd. Ash gourd has the highest amount of Vitamin C (60.00 mg/100g) while cucumber has the lowest value (21.82 mg/100g) among the four gourd fruits analyzed.

Koppad *et al.* (2015) evaluated eighteen genotypes of ridge gourd for chlorophyll content. The chlorophyll content was high in the leaves of the genotype Arabhavi Local which recorded 2.47 mg⁻¹fresh weight. Whereas, the lines Chintamani Local and Arka Sujat showed less (0.30 and 0.46 mg⁻¹) fresh weight respectively. Lowest chlorophyll content was recorded in the line Deepthi and Selection 4-12 (2.32 and 12.08µ.g⁻¹fresh weight) respectively.

2.6 Screening of ridge gourd genotypes for downy mildew resistance under artificial condition

Downy mildew, a foliar disease caused by the oomycete *Pseudoperonospora cubensis* Rostow. is one of the most destructive pathogens of cucurbits. Cucurbit downy mildew is an obligate parasite and, with the rare exception of oospore production, can only survive and reproduce on living host tissue. *Pseudoperonospora* species produce asexual spores called sporangia which germinate and release zoospores. The zoospores are biflagellate and motile in water, once they encyst they will produce a germ tube that enters host stomatal pores. *Peronospora* species produce asexual spores that germinate by means of a germ tube, these spores are commonly called conidia. The germ tube from the conidia directly enters the host through stomatal pores (Palti and Cohen, 1980; Thakur and Kusum, 2001).

Resistant cultivars are available but nevertheless yield losses are high if fungicides are not used. Higher levels of resistance are needed to reduce the use of pesticides while maintaining adequate yields. The objective of this experiment was to identify new sources of resistance to downy mildew among plant introduction accessions

Based on Disease Index (DI), PI 124112 was highly resistant (DI = 3.7), and PIs 124111, 122847, 124210, 145594, and 165525 were resistant (DI = 3.0, 2.8, 2.6, 2.7, and 2.5, respectively). PIs 124111 and 124112 had exhibited a highly resistant to downy mildew of melon (Thomas and Jourdain, 1992).

In this study Fugro *et al.* (1997) grouped ridge gourd genotypes as follows Highly susceptible: Bombay special, Samurapur, Mysore, Solapur, Sathadol, Saswad, Torai, Wardha, Kasegaon, Tendoli Sel. 5, Sel. 4-12, RG-104, RG- 108, RG-113 and RTN-3. (51-100 % downy mildew infection). Susceptible : Poona, Panvel, Konkan Harita, Hatargi, Pusa Nasdar, Tendoli Sel. I, Co-I, Pali, GBGN, Kapali, Vani Sel, Green long, Kawalapur, Vengurla-I, Goteswar, Pangari, Sagaon, Punjab Sadabahar, Save local, RG Long, Konkani, AEC- 90, AEC-91, RG-107, RG-IIO, RG Round, Tendoli Sel-3, Tendoli Sel 6., Surekha (Hybrid), RTN-1, RTN-2 and Kerala type (21-50% of infection). Moderately resistant: DPL-RG-16 (11-20 % infection). Resistant: DPL-RG-29 and DPL-RG-33 (0-10% infection).

In ridge gourd Jamadar and Desai (1999) reported that none of the cultivars showed immune or highly resistant reaction to downy mildew infection. But among the cultivars screened Raichur Local-1, Raichur Local -2 and Jumna Local showed moderate resistance with an average PDI of 30.9, 32.4 and 35 per cent respectively. The other cultivars were showing susceptibility with a PDI range between 39 to 67 per cent whereas maximum infection was noticed on Hittinhalli Local (67% PDI).

Artificial inoculation of the pathogen on bitter melon revealed that out of 148 germplasm lines of bitter melon screened against *Pseudoperonospora cubensis*, NIC-12285 and VRBT-39 were moderately resistant with high degree of tolerance. IC-50524A, Wild-27, VRBT-1, IC-68250B, IC-68313, IC-85618, VRBT-21 were found moderately susceptible to the disease. Slow mildew resistance (SMR) was observed in IC-50520B, Wild-27, IC-68250B and IC-68314 (Pandey *et al.* 2005).

The seventy cultivars of cucumber were evaluated in greenhouse condition (Adam *et al.* 2008). The result showed that the most resistant 10 cultivars were Ames 2353, Ames 2354, PI 197085, PI 197088, PI 234517, PI 321008, PI 330628, PI 432878, PI 605996 and PI 618931. The most susceptible cultivars over locations were PI 137848, PI 169328, PI 169385 and PI 172846.

Pandey *et al.* (2008) reported that out of 29 genotypes of cucumber, only one genotype DC-I was rated as resistant. The genotypes B-184 and B-157 were observed to be highly resistant. But, in case of B-184 genotype, there was no disease appearance till last stage of the crop. Six genotypes were observed to be moderately resistant viz., VRC-112, CHC-2, DR/NKV/02-13, PCUC-8, Sel.-75-2-1 and EC-362927 and about 28-30% leaf area infection appeared in these genotypes. Four genotypes of cucumber viz., DRINKV/02-91, CH-20, FZCU-4, VRC-7, were observed to be susceptible.

Resistance to downy mildew appeared to be controlled mainly by dominance effects. Therefore the inbred lines IIHR 121 and IIHR 122 could be used strategically to exploit heterotic effects in muskmelon (Shashikumar *et al.*, 2010).

Call *et al.* (2012) reported that the most resistant cultivars of cucumber were WI 2238, Wellington, Moxie, LJ 90430, Atlantis, Fancipak, Picklet, and Vlaspek. Moderately resistant cultivar was observed in Line M 21. The cultivars Coolgreen, Wis. SMR 18, and Straight 8 were identified as moderately to highly susceptible.

Cucumber cultivars have been found that significantly outperform checks in all resistance traits. The mean combined ratings for these cultivars ranged from 2.8 to 3.0. Call *et al.* (2012a) reported that the highest performing checks were Slice and M 21. The most resistant accessions were PI 605996, PI 618893, PI 330628, PI 605924, PI 605928, PI 197086 and PI 197088.

The genotypes of bottle gourd viz., Gutkha, Sarika and Kaveri were found to show resistant reaction (disease score of 1.0) against downy mildew, while Arka Bahar, INDAM-204, NS-421, NBOH-1, Bio Gaurav, US-15, Reena, Super Dhana, Anand and Sharada were found to exhibit moderately resistant reaction (disease score of 2.0). The genotypes INDAM-320, NS-443, Anand Bottlegourd-1, Gaja, NBBL-12, Warad, NBBL-52, Elina, Krushi Sampada and Louki exhibited moderately susceptible reaction (disease score of 3.0). Thar Samridhi and Champion were found to show susceptible reaction (disease score of 4.0) against downy mildew (Harika *et al.*, 2012).

Pitchaimuthu *et al.* 2012 revealed that wild species *Cucumis hardiwickii*-14 and 15, *Cucumis sativus* var *sativus* and SM 12735 exhibited a high level of resistance to downy mildew

diseases with 0-25 % PDI. Five accessions namely (IIHR-27, IIHR-35, IIHR-303, IIHR-64 and IIHR 82) had < 40 % PDI exhibited moderately resistance to DM disease of cucumber.

Santhosh Reddy *et al.* (2012) screened fourteen genotypes of Gherkin against *P. cubensis* under artificial epiphytotic condition. The results revealed that out of 14 genotypes evaluated none of them was found to be resistant. However, genotypes viz., Sparta (20.05PDI) was moderately resistant, and genotypes Vertina (35.08PDI), Nun-5508 (43.07PDI) and Shakthi-RZ (25.20 PDI) showed moderate susceptibility.

Varalakshmi *et al* (2014) evaluated 24 selections of ridge gourd for artificial screening against downy mildew disease resistance. Out of twelve lines evaluated, four advanced selections showed least incidence of downy mildew compared to susceptible checks and commercial varieties/ hybrids. Out of the four selections, IIHR-17-2-1 was moderately resistant (16.25 PDI) and the rest three selections viz., IIHR-17-1-7-4 (29.09 PDI), IIHR-7-5-1 (21.4 PDI), IIHR-17-1-7-3(21.6 PDI) showed moderate susceptibility, whereas the susceptible checks, IIHR-52-1-30 (92.18 PDI) and IIHR-23-8-10 (91.85 PDI) were highly susceptible.

Seven cucumber varieties were screened for resistance against downy mildew (Waris *et al.* 2014). The result showed that Super green special variety was graded 3 and the other varieties Beithoalfa, Marketmore-76, Cucumber 363, Anmol, Marketmore and Desi graded 6,6,6,7,7 and 8 respectively which revealed that these varieties were highly resistant.

Lebeda *et al* (2016) reported that two accessions of *C. melo* subsp. *agrestis* (PI 614174 and PI 614442) were incompletely resistant. The accession with resistance to *P. cubensis* is PI 315410 belongs to the *C. melo* subsp. *melo*. Two of the three accessions of *C. melo* subsp. *agrestis* were also incompletely resistant.

III. MATERIALS AND METHODS

The present investigation on “Studies on genetic variability in ridge gourd [*Luffa acutangula* (L.) Roxb] genotypes” was conducted at the PG research block, Experimental farm of College of Horticulture, Mysuru, Karnataka during the period between June -2015 to April-2016. The materials used and the methods followed during the course of investigation are presented in this chapter.

3.1 Experimental site

The experiment was conducted at the PG research block, Experimental farm of College of Horticulture, Mysuru, Yelachanalli, Mysuru district, Karnataka. The soil of the experimental site comprised of red sandy loam soil.

3.2 Location and climate

Mysuru is located at 12 °18'N latitude 74.65° E longitude at an average altitude of 770 meters above mean sea level and it has spread across an area of 128.42 km². Mysuru district receives an average annual rainfall of 776.7mm with the highest temperature 39°C. During the experimental period, the meteorological data recorded is presented in Appendix I.

3.3 Details of the experiment

3.3.1 Entries

Twenty five ridge gourd genotypes collected from different sources were used for the study. The list of the genotypes along with their source of supply is presented in Table 1. These genotypes were open pollinated at the time of study and also they were selfed to maintain the germplasm.

Table 1. List of ridge gourd [*Luffa acutangula* (L.) Roxb] genotypes used and their sources of supply

Sl. No.	Genotypes	Source of Supply	Sl. No.	Genotypes	Source of Supply
1.	Deepti	KAU, Kerala	14.	IC-201145	NBPGR, New Delhi
2.	Kolar Local	Collection from Kolar	15.	Gokak Local	Collection from Gokak
3.	IC-344512	NBPGR, New Delhi	16.	IC-92618	NBPGR, New Delhi
4.	IC-344605	NBPGR, New Delhi	17.	Green Long	KRCCH, Arabhavi
5.	IC-126249	NBPGR, New Delhi	18.	Mysuru Local	Local collection
6.	Thovinkere Local	Collection from Tumkur	19.	IC-385912	NBPGR, New Delhi
7.	IC-92675	NBPGR, New Delhi	20.	IC-146606	NBPGR, New Delhi
8.	Arka Sujat	IIHR, Bengaluru	21.	Jaipur long	Private sector
9.	IC-144613	NBPGR, New Delhi	22.	Arka Sumeet	IIHR, Bengaluru
10.	IC-92638	NBPGR, New Delhi	23.	Yaderanghalli Local	Local collection
11.	IC-124268	NBPGR, New Delhi	24.	Pusa Nasdar	IARI, New Delhi
12.	IC-335912	NBPGR, New Delhi	25.	Ghataprabha Local	Collection from Ghataprabha
13.	IC-344652	NBPGR, New Delhi			

3.3.2 Layout of the experiment

Location	:	College of Horticulture, Mysuru.
Experiment design	:	Completely Randomized Block Design (CRBD)
Total number of genotypes	:	25
Replication	:	2
Season	:	<i>Kharif</i>
Spacing	:	1.2 m X 0.9 m
Number of plants per plot	:	10
Plot size	:	540 sq.m
Date of transplanting	:	12-07- 2015

The experiment was laid out in a Completely Randomized Block Design (CRBD) with two replications (Plate 2).

3.4 Cultivation practices

The ridge gourd seeds were sown on pro trays containing cocopeat. Seedlings were transplanted at the age of eighteen days to the main field.

Experimental plot was divided into different plots of required size. Those plots were leveled and beds were prepared with dimension of 1.2m width, 1m height and 12m length, provided with mulching sheet (Plate 3).

Soil was incorporated with FYM at 25 t ha⁻¹ along with neem cake. The recommended fertilizers are N:P:K – 50:50:50 kg ha⁻¹ where of 50% of nitrogen, full dose of phosphorus and potassium are applied at the stage of transplanting and remaining 50% of nitrogen was applied 45 DAT as top dressing.

Regular irrigation, weeding and other cultural practices were followed as per the package of practices of University of Horticultural Sciences, Bagalkot (Anon.,2008).



Plate 2: General view of main plot



Plate 3: Morphological growth stages of ridge gourd plant

The vines were trained uniformly using iron rods for facilitating the cultural practices and for easy harvesting. The recommended plant protection measures were taken up against insect pests and diseases.

3.5 Observations recorded

Observations were recorded at different stages of crop growth viz., 45 and 90 DAT. Various growth and morphological parameters were recorded at their respective stages and yield parameters were recorded at the time of harvest on five randomly selected plants. The data recorded on five plants from each treatment was averaged and used for statistical analysis. The details of observations recorded and techniques for recording observations are given below.

3.5.1 Morphological and growth parameters

- 3.5.1.1 Number of primary branches:** The number of primary branches that had emerged from the main vine was counted from five labeled plants. The observations were recorded at 45 and 90 days after transplanting (DAT).
- 3.5.1.2 Vine length:** The vine length was measured using measuring tape from the base to the growing tip of the vine and was expressed in centimeters. The observations were recorded at 45 and 90 DAT.
- 3.5.1.3 Number of nodes per main vine:** The numbers of nodes were counted from the main vine. The observations were recorded at 45 and 90 DAT.
- 3.5.1.4 Internodal length:** The ratio of total vine length to the number of nodes per vine in all the five representative plants in each treatment was calculated and expressed in centimetres. The observations were recorded at 45 and 90 DAT.
- 3.5.1.5 Days to anthesis of first male flower:** Number of days taken from day of transplanting to the anthesis of first male flower on any one of the vines in each treatment was recorded.
- 3.5.1.6 Days to anthesis of first female flower:** Number of days taken from day of transplanting to the anthesis of first female flower on any one of the vines in each treatment was recorded.
- 3.5.1.7 Number of nodes to first male flower:** Number of nodes was counted from the base of vine up to the appearance of first male flower.
- 3.5.1.8 Number of nodes to first female flower:** Number of nodes was counted from the base of vine up to the appearance of first female flower.
- 3.5.1.9 Days to 50 per cent flowering:** The number of days taken by 50 per cent of plants to produce female flowers in each treatment was recorded.
- 3.5.1.10 Days to first harvest:** Number of days taken from the day of transplanting to day of first harvesting was recorded as days to first harvest.
- 3.5.1.11 Days to last harvest:** Number of days taken from the day of transplanting to day of last harvesting was recorded as days to last harvest.

- 3.5.1.12 Sex ratio (Male: Female):** Total number of female and male flowers was counted. Observations were recorded daily in the evening when the flowers start blooming. Sex ratio was calculated by using the formula

$$\text{Sex Ratio} = \frac{\text{Number of male flowers}}{\text{Number of female flowers}}$$

3.5.2 Yield and yield components

- 3.5.2.1 Fruit set (%):** Per cent fruit set was calculated by the ratio of number of fruits to the number of female flowers produced by vine and expressed in percent basis.
- 3.5.2.2 Number of fruits per plant:** Total number of fruits obtained in each treatment was recorded from five labeled plants and mean value per treatment was calculated.
- 3.5.2.3 Fruit yield per plant (kg):** The total weight of fruit obtained in each harvest was recorded from the five labeled plants and the mean value per plant was calculated and expressed in grams per plant.
- 3.5.2.4 Average fruit weight (g):** The five randomly selected fruits were weighed and their mean fresh weight was recorded from fruits.
- 3.5.2.5 Fruit length (cm):** The five fruits were selected for measuring the fruit length using meter scale and the average was worked out and was expressed in centimeters.
- 3.5.2.6 Fruit diameter (mm):** The same five fruits were selected for measuring the fruit diameter using vernier caliper and the average was worked out. The measurement was expressed in millimeters.
- 3.5.2.7 Seed yield per fruit (g):** The seeds obtained from five randomly selected fruits were weighed and average value is taken and expressed in grams.
- 3.5.2.8 100 seed weight (g):** 100 seed from each treatment were counted separately and mean seed weight was recorded and expressed in grams.
- 3.5.2.9 Number of seeds per fruit:** Number of Seeds per fruit was counted for five fruits and the mean number of seeds per fruit was worked out.

3.5.3. Quality parameter (Biochemical traits)

- 3.5.3.1 Estimation of Vitamin C:** Amount of Vitamin C (ascorbic acid) present in the fruit sample was analyzed by using DCIP titration given by Sadasivam and Manickam 1997. Procedure is as follows:

Stock standard solution: Ascorbic acid (100 mg) was dissolved in 100 ml of 4% metaphosphoric acid (1 mg/ml).

Working standard: The stock solution (10 ml) was diluted to 100 ml with 4% metaphosphoric acid. The concentration of working standard was 100 mcg/ml

To 5 ml of working standard, 10 ml of 4% metaphosphoric acid was added and titrated against the dye (V_1 ml) till the appearance of pink color which persisted for few minutes. 5 gm sample was extracted in 4% metaphosphoric acid. Volume was made 100 ml and centrifuged. 5 ml of the supernatant was pipetted to which 10 ml of 4% metaphosphoric acid was added and titrated against the dye (V_2 ml).

Calculation

$$\text{Ascorbic acid (mg) in 100g sample} = \frac{0.5 \text{ mg}}{V_1 \text{ ml}} \times \frac{V_2}{5 \text{ ml}} \times \frac{100 \text{ ml}}{\text{Wt. of sample}} \times 100$$

3.5.3.2 Estimation of protein: Amount of protein present in the fruit sample was assessed by using Microkjeldahl method. This method works with the principle that the nitrogen in protein is converted to ammonium sulfate by H_2SO_4 during digestion. This salt on steam distillation liberates ammonia which is collected in boric acid solution and titrated against H_2SO_4 .

Firstly the sample was weighed (0.5 g) and transferred to digestion flasks. Each of the catalyst (1 mg) was added and the samples were digested with 10 ml of concentrated sulphuric acid till the solution became colourless. After digestion the volume was made to 100 ml with distilled water. From this 10 ml of digested and diluted sample(s) was taken in Kjeldahl flask along with 10 ml of 50% NaOH and heated to liberate ammonia. The liberated ammonia was collected in a 100 ml conical flask containing 5 ml of boric acid solution with a few drops of mixed indicator. The flask was placed with the tip of the condenser dipping below the surface of the solution. The solution was titrated against the standard acid until the first appearance of violet color, the end point. A reagent blank was run with an equal volume of distilled water and the titration volume was subtracted from that of sample titre volume.

$$\text{Protein (\%)} = \frac{\text{Titre reading}}{1} \times \frac{\text{Normality of } \text{H}_2\text{SO}_4}{0.02} \times \frac{0.28}{\text{Aliquot taken}} \times \frac{\text{Volume made up}}{\text{ample taken}} \times \frac{100}{1000} \times 6.25$$

3.5.3.3 Determination of chlorophyll: Amount of chlorophyll present in leaves was assessed by using DMSO (Dimethyl Sulphoxide). This procedure was given by Hiscox and Israelstom (1979). 100mg of freshly harvested and cleaned leaves was taken and cut into small pieces. These pieces were transferred in to the test tube containing 7ml of DMSO and kept overnight. In the next morning extract morning extract was collected by discarding the leaf sample. Then volume was made upto 10ml with DMSO. Optical density of the extract was measured @ 645 and 663 nm using DMSO as blank through Spectrophotometer.

Calculated using the equation of Arnon (1949),

$$\text{mg total chlorophyll/g tissue} = 12.7(A_{645}) + 8.02(A_{663}) \times \frac{V}{1000 \times w \times a}$$

3.6 STATISTICAL AND BIOMETRICAL ANALYSIS

The biometrical analysis of the data was carried out using OPSTAT programmes at online statistical analysis, Hisar Agricultural University. The following statistical methods were employed for analysis of data.

3.6.1 Analysis of variance (ANOVA)

Analysis of variance was carried out as per the procedure given by Panse and Sukahtme (1967) using the mean values of random plants in each replication from all treatments to find out the significance of treatment effects.

3.6.2 Estimation of genetic variability parameters

3.6.2.1. Genotypic and phenotypic variances

Phenotypic and genotypic components of variance were estimated by applying the formula as suggested by Cochran and Cox (1959).

The Variances due to genotype, phenotype and environment were computed as follows.

$$\text{Genotypic variance (GV}/\sigma_g^2) = \frac{\text{MS due to genotypes (adj)} - \text{MS due to error (intra block)}}{r \text{ (replication)}}$$

Environmental variance (EV/σ_e^2) = Error mean sum of squares

Phenotypic variance (PV/σ_p^2) = $\sigma_g^2 + \sigma_e^2$ (MS due to error)

Where, 'r' is number of replications.

3.6.2.2 Genotypic and phenotypic co-efficient of variation

Phenotypic and genotypic co-efficients of variation were calculated by using the following formulae suggested by Cockerham (1963).

3.6.2.2.1 Genotypic co-efficient of variation (GCV)

$$\text{GCV (\%)} = \frac{\sigma_g}{\bar{X}} \times 100$$

3.6.2.2.2. Phenotypic co-efficient of variation (PCV)

$$\text{PCV (\%)} = \frac{\sigma_p}{\bar{X}} \times 100$$

Where, $\bar{X}$ = General mean
R = Number of replications

σ_g = Genotypic standard deviation
 σ_p = Phenotypic standard deviation

GCV and PCV were classified as suggested by Burton and Devane (1953)

0-10%: Low, 10-20%: Moderate and 20% and above: High

3.6.3 Heritability (h^2)

The broad sense heritability was estimated by following the procedure suggested by Webber and Moorthy (1952) as indicated here below.

$$h^2 = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

Where, h^2 (%) = Heritability (Broad sense)

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

The calculated heritability was classified into three groups as suggested by Johnson *et al.* (1955)

Low (0.30%), moderate (31- 60%) and high (>60%).

3.6.4 Expected genetic advance

Genetic advance for each character was predicted by the formula given by Johnson *et al.* (1955).

$$GA = h^2 \times \sigma_p \times k$$

Where k = selection differential (2.06) at 5 per cent selection intensity

h^2 = Heritability in broad sense

σ_p = Phenotypic standard deviation

3.6.5 Genetic advance over per cent of mean (GAM)

Genetic advance as percentage over mean was worked out as suggested by Johnson *et al.* (1955).

$$\text{Genetic advance over mean (GAM)} = \frac{GA}{\bar{X}} \times 100$$

Where, GA = Genetic advance

$\bar{X}$ = General mean

The genetic advance as per cent of mean was categorized as suggested by Johnson *et al.* (1955) and the same is given below.

0-10%: Low, 11-20%: Moderate, 21% and above: High

3.6.6 Correlation analysis

The correlation co-efficient among all possible character combinations at phenotypic r_{xy} (p) and genotypic r_{xy} (g) level were estimated employing formula (Al-Jibouri *et al.*, 1958).

$$\text{Phenotypic correlation} = r_{xy} (p) = \frac{\text{Cov}_{xy} (p)}{\sqrt{V_x (p) \times V_y (p)}}$$

$$\text{Genotypic correlation} = r_{xy} (g) = \frac{\text{Cov}_{xy} (g)}{\sqrt{V_x (g) \times V_y (g)}}$$

Where,

$\text{Cov}_{xy} (g)$	=	Genotypic covariance between x and y
$\text{Cov}_{xy} (p)$	=	Phenotypic covariance between x and y
$V_x (g)$	=	Genotypic variance of character 'x'
$V_x (p)$	=	Phenotypic variance of character 'x'
$V_y (g)$	=	Genotypic variance of character 'y'
$V_y (p)$	=	Phenotypic variance of character 'y'

The test of significance for association between characters was done by comparing table 'r' values at n-2 error degrees of freedom for phenotypic and genotypic correlations with estimated values, respectively.

3.6.7 Path co-efficient analysis

Path co-efficient analysis suggested by Wright (1921) and Dewey and Lu (1957) was carried out to know the direct and indirect effect of the morphological traits on plant yield. The following set of simultaneous equations were formed and solved for estimating various direct and indirect effects.

$$\begin{aligned} r_{1y} &= a + r_{12}b + r_{13}c + \dots + r_{1li} \\ r_{2y} &= a + r_{21}a + b + r_{23}c + \dots + r_{2li} \\ r_{3y} &= r_{31}a + r_{32}b + c + \dots + r_{3li} \\ r_{1y} &= r_{11}a + r_{12}b + r_{13}c + \dots + l \end{aligned}$$

Where,

r_{1y} to 1_{1y} = Co-efficient of correlation between causal factors 1 to l with dependent characters y.

r_{12} to r_{li} = Co-efficient of correlation among causal factors

a, b, c,.....i = Direct effects of characters 'a' to 'l' on the dependent character 'y'

Residual effect (R) was computed as follows.

$$\text{Residual effect (R)} = 1 - \sqrt{a^2 + b^2 + c^2 + \dots + i^2 + 2abr_{12} + 2acr_{13} + \dots}$$

3.7 Screening of ridge gourd genotypes for downy mildew disease resistance under artificial condition.

3.7.1 Material

All the Genotypes used for genetic variability and studies were used for screening against downy mildew with an additional resistant check (Sirsi Local) and susceptible check (Pusa Nutan).

- Method : Artificial inoculation (Spraying)
- Genotypes : 25+2 (checks)
- Date of sowing : 29-12-2015
- Date of inoculation : 22-01-2016

3.7.2 Methods

Experiment was undertaken in *Rabi* 2015 at polyhouse PG research block, Experimental farm of College of Horticulture, Mysuru (Plate 4) under artificial inoculum condition. Cultural operations are similar to that of genetic variability studies excluding the spraying of fungicides.



Plate 4: General view of poly house for screening of genotypes against downy mildew disease

The genotypes were sown in earthen pots inside the polyhouse. Susceptible and resistant genotypes were raised in between the test rows to facilitate the spread of the fungal inoculum and no fungicides were sprayed since sowing to end of the crop season and artificially inoculated at twenty-five days after germination. Since this pathogen is an obligate parasite and cannot be cultured on artificial media. Hence sporangia were harvested directly from the naturally infected leaves. The artificial screening was carried out in January 2016. Congenial condition of disease development was already established prior to artificial inoculation so that natural infection in field could be coincided with artificial screening. Diseased leaves at initial stage of infection were collected and brought to the laboratory. Care was taken while selecting the leaves that pathogen must be in its reproductive phase.

Inoculum preparation: Infected leaves collected from plants in open field were kept in a tray along with cotton swab which was used as absorbant and tightly covered with polyethelene cover and kept overnight so that it was ready for secondary inoculum with sufficient sporangiophores and sporangia (Plate 5). In the next morning, infected leaves were gently washed in sterilized distilled water so that sporangia could disperse easily. Later in the early morning inoculum was sprayed using hand pumped spray to the plants as stomata will open in the early morning and which helps in easy penetration of spores. (Plate 5a).

3.7.3 Observations recorded

The per cent downy mildew intensity was recorded by randomly selecting five plants in each genotype by referring the following 0-5 scale given by Mayee and Datar (1986).

Sl. No.	Percent Disease severity	Score
1	0 (No infection)	0
2	0.1-10 %	1
3	10.1-15 %	2
4	15.1-25 %	3
5	25.1-50 %	4
6	>50 %	5

Percent Disease Index (PDI) was calculated by using formula by Wheeler (1969).

$$\text{PDI} = \frac{\text{Sum of numerical values}}{\text{Number of leaves graded} \times \text{Maximum rating}} \times 100$$

Furthur the genotypes were grouped into following categories based on the Percent Disease Index as given by Jamadar and Desai (1999):

Reaction	PDI (%)
Immune	: 0
Resistant	: 1-10
Moderately resistant	: 11-25
Moderately susceptible	: 26- 50
Susceptible	: 51-75
Highly susceptible	: >75



Plate 5: Infected ridge gourd leaves were collected from the farms around the campus and were kept closed overnight to increase the sporulation



Plate 5a: Water suspension collected after washing leaves with sterilized water and sprayed to plants

IV. EXPERIMENTAL RESULTS

The present investigation was carried out to study the nature and extent of genetic variability in ridge gourd in the PG research block, College of Horticulture, Mysuru with a view to study the extent of genetic variability, correlation co-efficient, path co-efficient analysis and sources of resistance for downy mildew disease in different genotypes of ridge gourd during June-2015 to April -2016, (*Rabi and Kharif* season). The results of the experiment are presented under the following heading.

4.1 Analysis of variance

4.2 Genetic variability

4.3 Character association

4.4 Path co-efficient analysis

4.5 Screening of ridge gourd genotypes for downy mildew resistance

4.1 Analysis of variance

Twenty five ridge gourd genotypes were analyzed for 16 growth and morphological parameters, six parameters related to yield, three quality and three seed parameters is presented in Table 2. The results indicated significant variation among the genotypes for most of the characters studied viz., number of branches 45 and 90 DAT, vine length 45 and 90 DAT, number of nodes per main vine 45 and 90 DAT, internodal length 45 and 90 DAT, days to anthesis of first male and female flower, number of nodes to first male flower and female flower, days to 50 per cent flowering, days to first harvest, fruit set per cent, number of fruits per plant, fruit yield per plant, average fruit weight, fruit length and diameter, vitamin C, crude protein, total chlorophyll, seed yield per fruit, 100 seed weight number of seeds per fruit, days to last harvest and sex ratio. However, variation for 100 seed weight indicated non-significant variation among the genotypes under study.

4.2 Genetic variability

The Range, Mean, Phenotypic variance (PV), Genotypic variance (GV) Phenotypic co-efficient of variation (PCV), Genotypic co-efficient of variation (GCV), broad sense heritability (h^2) and Genetic advance as per cent of mean (GAM) with respect to morphological and growth, yield, seed and quality parameters are presented in Tables 3 to 5, respectively. Variability observed among the genotypes for fruit presented in Plate 6 and *per se* performances for all parameters are presented in Appendix II-IV.

4.2.1 Variability in morphological and growth parameters of ridge gourd

The results pertaining to the genetic variability observed in 25 ridge gourd genotypes for growth and morphological parameters are presented in Table 3 and Figure 1.

4.2.1.1 Number of primary branches 45 DAT and 90 DAT

Maximum number of branches at 45 DAT was observed in Green long (3.3) and IC-124268 (3.3) followed by IC-144613 (2.9), IC-358912 (2.9), Jaipur Long (2.9) and Arka Sumeet (2.9) and minimum was recorded in IC-344512 (2.05). The mean value of this trait was 2.65. A narrow difference between PCV and GCV (12.71 and 8.79, respectively) was observed. Moderate

broad sense heritability (47.84%) associated with moderate genetic advance over per cent mean (12.53%) was recorded. While, the number of branches per plant at 90 DAT ranged from 3.0 (IC-201145) to 7.40 (Arka Sumeet) with a mean value of 4.09. It was recorded high GCV (23.96) and PCV (25.50). High broad sense heritability (88.23%) and high GAM (46.89) was observed with a genetic advance of 1.89.

4.2.1.2 Vine length 45 DAT and 90 DAT

Vine length at 45 DAT among the genotypes ranged from 118cm (IC-201145) to 291cm (Yaderanghalli Local) with a mean of 212.25 cm. The phenotypic and genotypic coefficients were high with 21.4 and 18.43 per cent respectively. The broad sense heritability (74.17 %) and GAM (32.69%) were also high with genetic advance of 69.69. However, the mean value of vine length at 90 DAT was 438.68 with a range of 219.96 cm to 818.94 cm. High GCV and PCV were observed with a value of 38.4 and 38.67 per cent respectively. High heritability (98.64%) coupled with high GAM (78.57%). Maximum vine length was recorded in Arka Sumeet (818.94cm) followed by Yaderanghalli Local (798.19cm) and minimum was observed in IC-335912 (219.96cm) and Ghatapraba Local (223.27cm).



Plate 6: Variability observed among the genotypes for fruit characteristics

Plate 6: continued



Plate 6: continued



4.2.1.3 Number of nodes per vine 45 DAT and 90 DAT

Maximum number of nodes per vine at 45 DAT was observed in Arka Sumeet (24.60) and IC-146606 (20.34) and minimum number of nodes per vine was recorded in IC-92638 (7.70). It has recorded a genetic advance of 6.11 with high GCV (21.27%) and PCV (23.33%), high heritability (83.12%) and GAM (39.94) whereas number of nodes per vine 90 DAT ranged from 17.40 to 49.57 with a mean of 29.79. The difference between GCV and PCV was narrow for this trait (27.74 and 28.61, respectively) with high heritability (94.03) and high GAM (55.41). Maximum value was observed in Arka Sumeet (49.57) followed by IC-385912 (43.42) and minimum number was observed in IC-344652 (17.4) and Green Long (17.04).

4.2.1.4 Internodal length 45 DAT and 90 DAT

The mean value of internodal length at 45 DAT was 14.58, ranged from 8.69 (Arka Sumeet) to 30.63 (IC-92638). The GCV and PCV were high with 29.26% and 33.37% respectively. High heritability (76.91%) coupled high GAM (52.87%) associated with genetic advance of 7.1 was observed for this trait. While, internodal length at 90 DAT exhibited high variability ranging from 8.92cm (Mysuru Local) to 19.45 cm (Yaderanghalli Local) with a mean of 14.56. The genotypic and phenotypic coefficients were 15.16% and 18.77%, respectively. High estimates of broad sense heritability (65.28%) coupled with high GAM 25.24% was observed for internodal length at 90 DAT.

4.2.1.5 Days to anthesis of first male flower

The genotype IC-335912 was earliest to open first male flower (21 days) followed by Green long (21.77 days) and Mysuru Local (21.74 days) while genotype Yaderanghalli Local took maximum number of days (42.78days) for first male flower to open with a mean of 25.85 days was observed. The difference between GCV and PCV (18.46 and 20.65%, respectively) was relatively low. High broad sense heritability (79.90%) associated with high GAM (33.99%) was recorded.

Table 3. Estimates of mean, range, components of variance, heritability and genetic advance for morphological and growth parameters in ridge gourd [*Luffa acutangula* (L.) Roxb] genotypes.

Sl. No.	Characters	Range	Mean	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
1.	Number of branches 45 DAT	2.05-3.30	2.65	0.05	0.11	8.79	12.71	47.84	0.33	12.53
2.	Number of branches 90 DAT	3.00-7.40	4.09	0.96	1.09	23.96	25.50	88.23	1.89	46.89
3.	Vine length 45DAT (cm)	118.0-291.0	212.25	1529.76	2062.50	18.43	21.40	74.17	69.39	32.69
4.	Vine length 90 DAT (cm)	219.96-818.84	438.68	28379.47	28770.17	38.40	38.67	98.64	344.67	78.57
5.	Number of nodes per vine 45DAT	7.70-24.60	15.29	10.57	12.72	21.27	23.33	83.12	6.11	39.94
6.	Number of nodes per vine 90 DAT	17.40-49.57	29.79	68.28	72.62	27.74	28.61	94.03	16.51	55.41
7.	Internodal length 45 DAT (cm)	8.69-30.63	14.58	18.21	23.68	29.26	33.37	76.91	7.1	52.87
8.	Internodal length 90 DAT (cm)	8.92-19.45	14.56	4.88	7.47	15.16	18.77	65.28	3.67	25.24
9.	Days to anthesis of first male flower	21-42.78	25.85	22.77	28.5	18.46	20.65	79.90	8.7	33.99
10.	Days to anthesis of first female flower	23.8-47.34	34.59	12.79	27.23	10.34	15.09	46.98	5.05	14.60
11.	Number of nodes at which first male flower appear	2.05-6.40	4.01	0.79	1.27	22.16	28.11	62.11	1.44	35.97
12.	Number of nodes at which female flower appear	4.40-21.54	9.18	10.45	12.99	35.19	39.25	80.42	5.97	65.01
13.	Days to 50 per cent flowering	36.12-56.42	44.50	21.39	43.31	10.39	14.79	49.38	6.69	15.04
14.	Days to first harvest	39.55-58.58	47.98	10.15	20.57	6.64	9.45	49.37	4.61	9.61
15.	Days to last harvest	84.5-114	98.2	43.55	105.66	6.72	10.47	41.22	8.73	8.89
16.	Sex ratio	18.28-28.36	24.19	3.17	8.46	7.36	12.02	37.52	2.25	9.29

GCV = Genotypic coefficient of variation
PCV = Phenotypic coefficient of variation
GAM = Genetic advance over per cent of mean

GA = Expected genetic advance
PV= Phenotypic variance

h^2 (%) = Heritability (broad sense)
GV= Genotypic variance

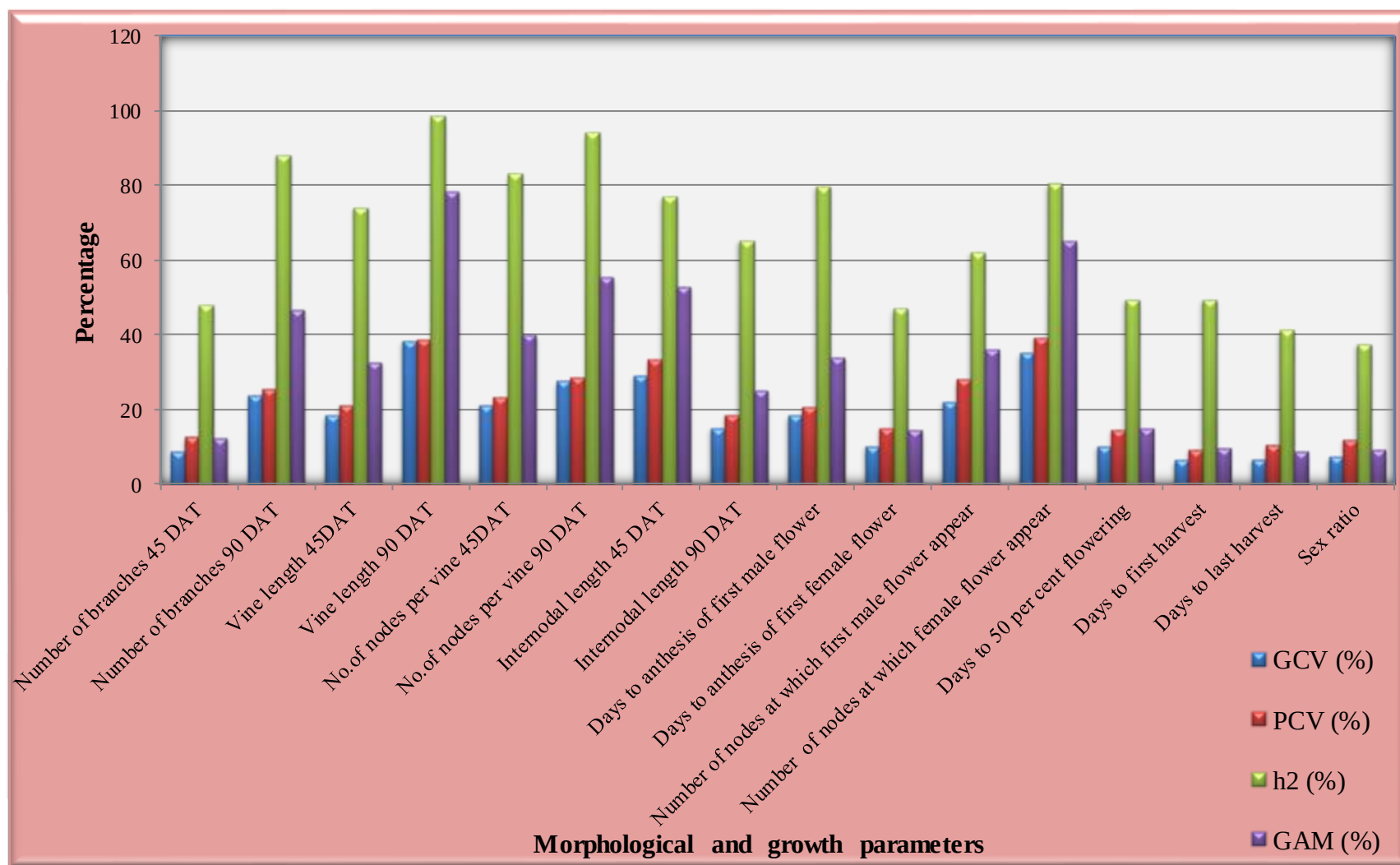


Fig. 1: PCV, GCV, h² and GAM for morphological and growth parameters in ridge gourd.

4.2.1.6 Days to anthesis of first female flower

Genotype IC-144613 took minimum number of days (23.80 days) for appearance of first female flower followed by Green long (27.97 days). Genotype Yaderanghalli Local took 47.34 days for first female flower appearance. Days to appearance of first female flower ranged from 23.80 to 47.34 with a mean of 34.59 days. GCV and PCV were moderate with 10.34% and 15.09%, respectively. The broad sense heritability and GAM recorded moderate magnitude of 46.98% and 14.6%, respectively.

4.2.1.7 Number of nodes to first male flower

The mean number of nodes to first male flower was 4.01 and ranged from 2.05 (Thovinkere Local) to 6.40 (IC-92638). It recorded high GCV (22.16%) and PCV (28.11%). The heritability (62.11%) and GAM (35.97%) were also high with genetic advance of 1.44.

4.2.1.8 Number of nodes to first female flower

The first female flower appeared at different nodes in different genotypes with highest value of 21.54 in Yaderanghalli Local and lowest value of 4.40 in IC-335912 followed by Green long (5.5), IC-201145 (6.0) and IC-92618 (6.0). The genotypes varied among themselves from 4.40-21.54 with average mean of 9.18. A relatively high GCV (35.19%) and PCV (39.25%) were recorded. High broad sense heritability (80.42%) coupled with high genetic advance as per cent of mean (65.01%) was observed.

4.2.1.9 Days to 50% flowering

The genotype Mysuru Local took minimum number of days (36.12days) for 50% plants to produce flower followed by IC-335912 (36.66 days), IC-92618 (36.95days) and IC-144613 (37.1days) whereas genotype Yaderanghalli Local took maximum number of days (56.42 days) for 50% of plants produce female flowers. GCV (10.39) and PCV (14.79) were observed to be moderate. Moderate broad sense heritability (49.38%) associated with moderate GAM (15.04) was recorded.

4.2.1.10 Days to first harvest

Minimum number of days (39.55days) for first fruit harvest were recorded in IC-92638 while Yaderanghalli Local took maximum number of days (58.58) for first harvest with a mean of 47.98. The difference between GCV (6.64%) and PCV (9.45%) was relatively narrow. Moderate broad sense heritability (49.37%) associated with low genetic advance over per cent mean (9.61%) was recorded for this trait.

4.2.1.11 Days to last harvest

Maximum number of days to last harvest was recorded in IC-92638 (114.0) followed by Deepti (109.5days), IC-344512 (103.5days) and IC-92675 (103.5days) and minimum number of days taken by Ghataprabha Local (84.5days) followed by IC-124268 (87.5days). The observed GCV and PCV were 6.72 and 10.47 and moderate heritability (41.22%) coupled with low GAM (8.89%) which is associated with GA (8.73).

4.2.1.12 Sex Ratio

Lowest sex ratio (Male: Female flowers) was observed in IC-92638 (18.28) followed by IC-126249 (20.07), Arka Sujat (20.57) and Jaipur Long (21.89) and highest was observed in Ghatapraba Local (28.36). Sex ratio (male flowers to one female flower) ranged from 18.28-28.36 with a mean of 24.19. A relatively narrow difference was noticed for PCV and GCV (12.02 %) and 7.36 %). Moderate broad sense heritability (37.52%) coupled with low GAM (9.29).

4.2.2 Variability in yield, quality and seed parameters of ridge gourd

The results pertaining to the genetic variability observed 25 ridge gourd genotypes for yield, quality and seed parameters are presented in Table 4 and 5, respectively and Figure 3.

4.2.2.1 Per cent fruit set

Among the genotypes studies, maximum per cent fruit set was observed in Yaderanghalli Local (78.16%) followed by Arka Sumeet (77.46%), IC-126248 (76.98%) and Arka Sujat (75.73%) and minimum was observed in Ghatapraba Local (51.41). Per cent fruit set ranged from 51.41 to 78.16 with a mean value of 65.94. The genotypic and phenotypic co-efficient of variation for per cent fruit set were 9.97% and 14.32%, respectively. Moderate broad sense heritability (48.44%) with moderate GAM (14.29%) was recorded for this trait.

4.2.2.2 Number of fruits per plant

Maximum number of fruits per plant was harvested from IC-92638 (8.0) followed by Arka Sumeet (6.75) and Thovinkere Local (6.69) and minimum number of fruits were seen in Ghataprabha Local (1.6). The number of fruits per plant ranged from 1.60 to 8.00 with a mean of 4.47. High broad sense heritability (82.78%) coupled with high genetic advance over per cent mean (65.64%) associated with genetic advance 2.93.

4.2.2.3 Average fruit weight

Average fruit weight was found to be maximum in IC-124268 (267.9g) followed by Arka Sumeet (266.8g), Gokak Local (264.7g) and minimum was observed in IC-335912 (141.40g). Mean fruit weight ranged from 141.4g to 267.9 g with a mean value of 208.75g. The recorded phenotypic and genotypic coefficients of variability were moderate for this trait with 16.12 and 19.10%, respectively. High broad sense heritability (71.25 %) coupled with high genetic advance over per cent mean (58.52 %) was recorded for this trait.

4.2.2.4 Fruit yield per plant

The genotype IC-92638 (1825.2 g) gave the highest fruit yield per plant followed by Arka Sujat (1593.54 g), IC-126249 (1330.52 g) and minimum yield per plant was observed in IC-335912 (297.04 g) with a mean value of 848.39 g. The GCV and PCV for this trait were 40.12 % and 44.29 %. High broad sense heritability (82.07%) coupled with high GAM (74.87%) was recorded for this trait.

Table 4. Estimates of mean, range, components of variance, heritability and genetic advance for yield and yield parameters in ridge gourd [*Luffa acutangula* (L.) Roxb] genotypes

Sl. No.	Characters	Range	Mean	GV	PV	GCV (%)	PCV (%)	h ² (%)	GA	GAM (%)
1.	Per cent fruit set (%)	51.41-78.16	65.94	43.22	89.22	9.97	14.32	48.44	9.42	14.29
2.	Number of fruits per plant	1.60-8.00	4.47	2.45	2.96	35.02	38.50	82.78	2.93	65.64
3.	Average fruit weight (g)	141.40-267.90	208.75	1132.67	1589.63	16.12	19.10	71.25	58.52	28.03
4	Fruit yield per plant (g)	297.04-1825.20	948.49	144803.2	176442.1	40.12	44.29	82.07	710.14	74.87
5.	Fruit length (cm)	18.1-39.80	27.07	20.61	35.34	16.77	21.96	58.33	7.14	26.39
6.	Fruit diameter (mm)	37.72-56.10	46.26	11.67	28.29	7.38	11.50	41.23	4.52	9.76

GCV = Genotypic coefficient of variation

GA = Expected genetic advance

h² (%) = Heritability (broad sense)

PCV = Phenotypic coefficient of variation

PV= Phenotypic variance

GV= Genotypic variance

GAM = Genetic advance over per cent of mean

4.2.2.5 Fruit length

The maximum fruit length was recorded in Arka Sujat (39.80cm) followed by Arka Sumeet (37.85cm) and IC-146606 (31.15cm) whereas minimum fruit length was recorded in IC-335912 (18.1cm) and IC-344605 (18.10cm). High magnitude of genetic components viz., GCV (16.77%), PCV (21.96%) and GAM (26.39%) were recorded with genetic advance of 7.14.

4.2.2.6 Fruit diameter

The mean diameter of fruit was 46.26mm with a range of 37.72 (IC-335912) to 56.10 (IC-344652). The observed genotypic and phenotypic co-efficient of variability were 7.38% and 11.50%, respectively. High heritability was recorded for this trait (41.23%) coupled with high GAM (9.76 %) and the genetic advance of 4.52.

4.2.2.7 Vitamin C

The mean value of Vitamin C was observed to be 16.42 mg and ranged from 4.95 mg (Kolar Local) to 39.15 (IC-201145). The observed genotypic and phenotypic co-efficient of variability were high with values of 35.25 % and 38.33%, respectively. The high heritability was recorded (84.57%) coupled with high GAM (66.78%) and genetic advance of 10.97.

4.2.2.8 Crude protein

The crude protein content among the genotypes ranged from 4.06-22.09% with a mean of 12.58%. Maximum crude protein was observed for IC-201145 (22.09%) and IC-385912 (17.99%) and minimum was observed for Arka Sumeet (4.06%) and Arka Sujat (4.83%). The phenotypic and genotypic coefficients were high with the value of 35.72% and 35.08%, respectively. The broad sense heritability (96.44 %) and GAM (70.97%) were also observed high with genetic advance of 8.93.

4.2.2.9 Total chlorophyll

The mean total chlorophyll content of leaves was 1.92mg with a range of 0.91-3.03mg. The maximum total chlorophyll content was observed in Ghataprabha Local (3.03) and minimum was observed in Arka Sujat (0.91). The estimated genetic components viz., GCV(24.95%), PCV(26.56%), heritability (88.24%) and GAM (48.27%) were recorded to be of higher magnitude with genetic advance of 0.93.

Table 5. Estimates of mean, range, components of variance, heritability and genetic advance for quality and seed parameters in ridge gourd [*Luffa acutangula* (L.) Roxb] genotypes

Sl. No.	Characters	Range	Mean	GV	PV	GCV (%)	PCV (%)	h ² (%)	GA	GAM (%)
1.	Vitamin C (mg)	4.95-39.15	16.42	33.50	39.62	35.25	38.33	84.57	10.97	66.78
2.	Crude protein (%)	4.06-22.09	12.58	19.48	20.20	35.08	35.72	96.44	8.93	70.97
3.	Chlorophyll (mg)	0.91-3.03	1.92	0.23	0.26	24.95	26.56	88.24	0.93	48.27
4	Seed yield per fruit (g)	8.42-32.67	18.13	38.85	52.28	34.38	39.88	74.33	11.07	61.06
5.	100 seed weight (g)	10.48-24.21	15.12	3.07	11.97	11.59	22.88	25.63	1.83	12.08
6.	Number of seeds per fruit	55.09-198.32	121.37	1296.27	1972.22	29.66	36.59	65.73	60.13	49.54

GCV = Genotypic coefficient of variation

PCV = Phenotypic coefficient of variation

GAM = Genetic advance over per cent of mean

GA = Expected genetic advance

PV= Phenotypic variance

h² (%) = Heritability (broad sense)

GV= Genotypic variance

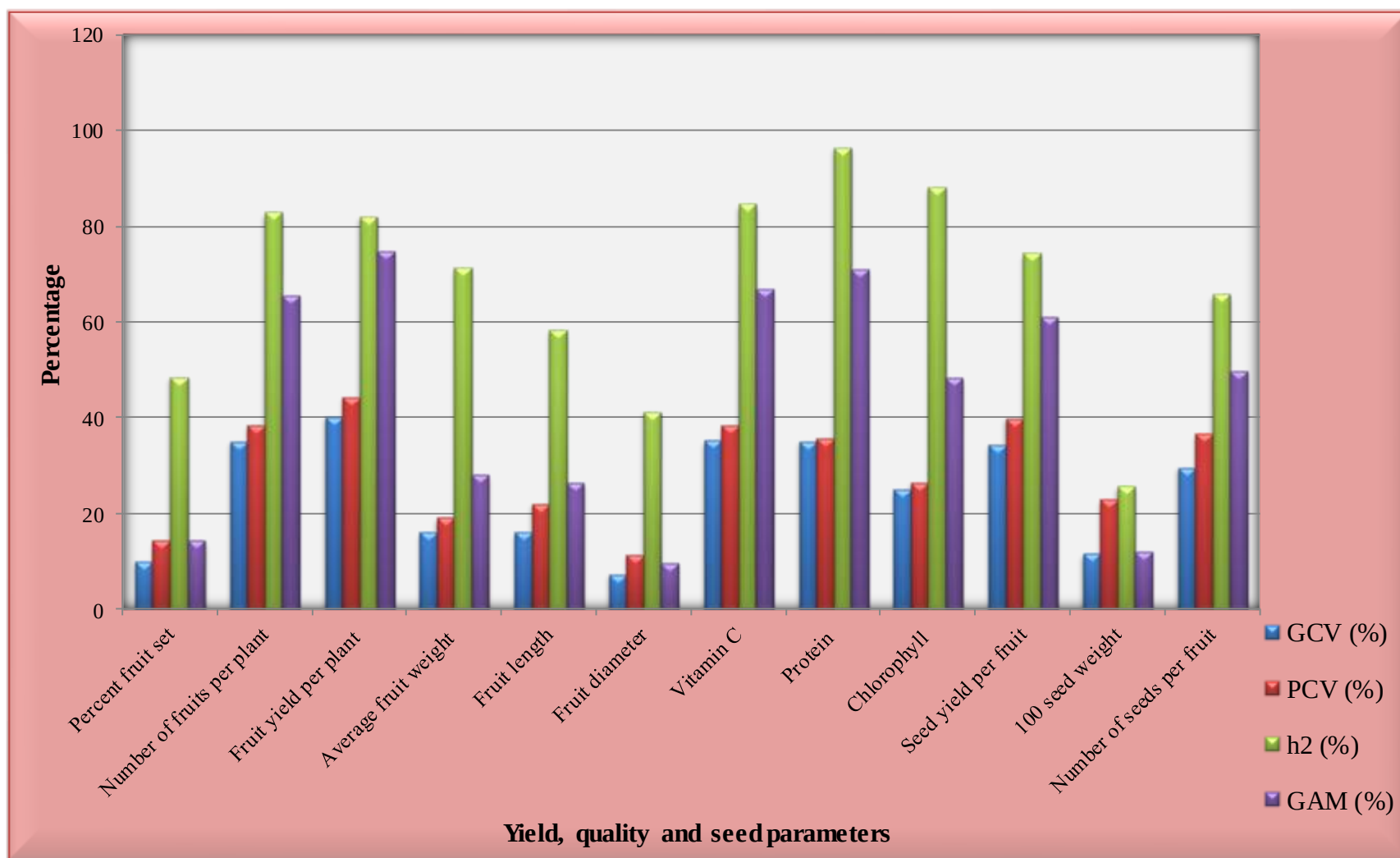


Fig. 2: PCV, GCV, h² and GAM for yield, quality and seed parameters in ridge gourd.

4.2.2.10 Seed yield per fruit

The seed yield per fruit was recorded maximum in IC-126249 (32.67g) followed by Thovinkere Local (27.84g) and IC-146606 (27.01g) and minimum was observed in Gokak Locak (8.42g) followed by Pusa Nasdar (8.58g). The mean value for this trait was 18.13. High values of GCV and PCV were 34.38% and 39.88%, respectively with high heritability (74.33%) coupled with GAM (61.06%) and GA (11.07) was observed for this trait.

4.2.2.11 100 seed weight

100 seed weight was maximum in Green Long (24.21g) and minimum was observed in IC-92618(10.48) with a mean of 15.12. The GCV and PCV were observed to be 11.59% and 22.88% respectively. Low broad sense heritability (25.63 %) coupled with moderate genetic advance over per cent mean (12.08 %) associated with GA (1.83) was recorded for this character.

4.2.2.12 Number of seeds per fruit.

Maximum number of seeds per fruit was recorded in IC-126249 (198.32) followed by Thovinkere Local (183.84) and IC-344605 (173.52) and minimum were observed in Green Long (55.09) and Pusa Nasdar (64.17). The mean value was 121.37 varied from 55.09-198.32. High GCV (29.66%) and PCV (36.59%) were recorded with higher heritability (65.73%) coupled with high GAM (49.54%) associated with GA (60.13%).

4.3 Character association

The genotypic and phenotypic correlation co-efficient were determined to obtain information on the relationship among 12 quantitative characters in ridge gourd and are presented in Tables 6 and 7, respectively. The present study reveals that phenotypic correlation co-efficient was always higher than genotypic correlation co-efficient for all the characters indicating maximum variability existing in the genotypes for all the characters and offers good scope for improvement by simple selection through those characters which are under study (Figure 3).

4.3.1 Genotypic correlation

4.3.1.1 Number of branches at 90 DAT

The genotypic correlation co-efficient presented in the Table 6 revealed that the number of branches at 90 DAT had highly significant ($p=0.01$) and positive association with vine length at 90 DAT (0.475), number of nodes per plant at 90 DAT (0.456), days to first harvest (0.417), per cent fruit set (0.548), number of fruits per plant (0.492), fruit length (0.518), fruit yield per plant (0.629). Days to anthesis of first female flower (0.284), number of nodes to first female flower (0.341) had also significant ($p=0.05$) and positive association with this trait. However sex ratio (-0.385) had negative significant association with the same trait.

4.3.1.2 Vine length at 90 DAT

Vine length at 90 DAT had highly significant and negative correlation was recorded for sex ratio (-0.429). Positive and highly significant correlation was observed for number of nodes at 90 DAT (0.931), days to anthesis of first female flower to appear (0.536), number of nodes to first female flower to appear (0.740), days to last harvest (0.435), per cent fruit set (0.666), number of fruits per

plant (0.574), average fruit weight (0.458) and fruit yield per plant (0.641). Days to first harvest (0.295) and fruit length (0.353) had positive and significant association with the trait.

4.3.1.3 Number of nodes per vine at 90 DAT

Number of nodes per vine at 90 DAT exhibited highly significant and positive correlation for days to anthesis of first female flower (0.475), number of nodes to first female flower (0.643), days to last harvest (0.417), per cent fruit set (0.718), number of fruits per plant (0.567), fruit weight (0.372) and fruit yield (0.591) whereas fruit length (0.340) had positive and significant correlation with the trait ($p=0.05$).

4.3.1.4 Days to anthesis for first female flower

Days to anthesis for first female flower had highly significant and positive association with number of nodes at which first female flower appeared (0.793), days to first harvest (0.487) and significantly positive association with per cent fruit set (0.334). This trait showed non-significant correlation with remaining traits studied.

4.3.1.5 Number of nodes to first female flower

Number of nodes to first female flower was highly significant and positively associated with days to first harvest (0.577), per cent fruit set (0.582), number of fruits per plant (0.433), average fruit weight (0.423) and fruit yield/plant (0.505). However, negative and significant association was observed with sex ratio (-0.298).

4.3.1.6 Days to first harvest

Days to first harvest had highly significant and negative association with days to last harvest (-0.408) where as highly significant and positively associated with average fruit weight (0.390). Fruit length (0.318) was positive and significantly ($p=0.05$) correlated with this trait.

4.3.1.7 Days to last harvest

Days to last harvest exhibited highly significant and positive association with fruit set (0.538) and fruit yield/plant (0.422). Number of fruits per plant (0.439) was also significantly and positively correlated with the trait.

4.3.1.8 Sex ratio

Sex ratio highly significant and negatively correlated with per cent fruit set (-0.628), number of fruits per plant (-0.798), fruit length (-0.445) and fruit yield/plant (-0.796). Average fruit weight (-0.229) had non-significant and negative association with the trait.

Table 6. Genotypic correlation coefficients among morphological, growth, yield and yield components in ridge gourd [*Luffa acutangula* (L.) Roxb] genotypes.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.000	0.475**	0.456**	0.284*	0.341*	0.417**	-0.048 ^{NS}	-0.385**	0.548**	0.492**	0.276 ^{NS}	0.518**	0.629**
2		1.000	0.931**	0.536**	0.740**	0.295*	0.435**	-0.429**	0.666**	0.576**	0.458**	0.353*	0.641**
3			1.000	0.475**	0.643**	0.192 ^{NS}	0.417**	-0.514**	0.718**	0.567**	0.372**	0.340*	0.591**
4				1.000	0.793**	0.487**	-0.070 ^{NS}	-0.075 ^{NS}	0.334*	0.229 ^{NS}	0.093 ^{NS}	-0.093 ^{NS}	0.219 ^{NS}
5					1.000	0.577**	0.198 ^{NS}	-0.298*	0.582**	0.433**	0.423**	0.218 ^{NS}	0.505**
6						1.000	0.408**	0.155 ^{NS}	0.131 ^{NS}	-0.164 ^{NS}	0.390**	0.318*	0.025 ^{NS}
7							1.000	-0.187 ^{NS}	0.538**	0.439*	0.165 ^{NS}	0.052 ^{NS}	0.422**
8								1.000	-0.628**	-0.798**	-0.229 ^{NS}	-0.445**	-0.796**
9									1.000	0.825**	0.224 ^{NS}	0.224 ^{NS}	0.806**
10										1.000	0.120 ^{NS}	0.245 ^{NS}	0.937**
11											1.000	0.691**	0.412**
12												1.000	0.471**
13													1.000

* and ** Indicate significant at 5 and 1 per cent probability level, respectively.

NS: Non significant

1. Number of branches per plant 90 DAT

2. Vine length 90 DAT

3. Number of nodes per plant 90 DAT

4. Days to anthesis of first female flower

5. Number of nodes to first female flower

6. Days to first harvest

7. Days to last harvest

8. Sex ratio

9. Per cent fruit set

10. Number of fruits per plant

11. Fruit weight

12. Fruit length

13. Fruit yield per plant

4.3.1.9 Per cent fruit set

Per cent fruit set had highly significant and positive correlation with number of fruits per plant (0.825) and fruit yield/plant (0.806). Average fruit weight (0.224) and fruit length (0.224) had no significant association with the trait.

4.3.1.10 Number of fruits per plant

Number of fruits per plant was highly significant and positively associated with fruit yield per plant (0.937).

4.3.1.11 Average fruit weight

Average fruit weight had exhibited highly significant and positive association with fruit length (0.691) and fruit yield (0.412).

4.3.1.12 Fruit length

Fruit length was highly significant and positively associated with fruit yield per plant (0.471). This trait showed non-significant correlation with all other remaining traits studied.

4.3.2 Phenotypic correlation

4.3.2.1 Number of primary branches at 90 DAT

The phenotypic correlation co-efficient presented in the Table 7 revealed that the trait number of primary branches at 90 DAT had highly significant and positive association with vine length at 90 DAT (0.461), number of nodes per vine at 90 DAT (0.447), per cent fruit set (0.500), number of fruits per plant (0.464), fruit length (0.464) and fruit yield/plant (0.610) and significantly positively association with number of nodes to first male flower (0.284), number of nodes to first female flower (0.307) and days to first harvest (0.281).

4.3.2.2 Vine length at 90 DAT

Negative and significant ($p=0.05$) association was observed with vine length at 90 DAT for sex ratio (-0.302). Number of nodes per vine at 90DAT (0.916), days to anthesis of first female flower (0.467), number of nodes to first female flower (0.699), days to last harvest (0.372), per cent fruit set (0.625), number of fruits per plant (0.547), average fruit weight (0.449) and fruit yield/plant (0.652) had highly significant and positive association with the trait. But fruit length (0.331) had positive and significant association with the trait.

4.3.2.3 Number of nodes per main vine at 90 DAT

Number of nodes per main vine at 90 DAT had positive and highly significant association was recorded with days to anthesis of first female flower (0.378), number of nodes to first female flower (0.592), per cent fruit set (0.660), number of fruits per plant (0.508), average fruit weight (0.367) and fruit yield/plant (0.573), whereas days to last harvest (0.335) and fruit length (0.320) had significant and positively correlated with the trait under consideration. Negative and significant association was observed for sex ratio(-0.320).

4.3.2.4 Days to anthesis of first female flower

Days to anthesis of first female flower had positive and highly significant association with the number of nodes to first female flower (0.679) and days to first harvest (0.437). This trait showed non-significant correlation with all other traits studied.

4.3.2.5 Number of nodes to first female flower

The trait number of nodes to first female flower was highly significant and positively associated with days to first harvest (0.447), per cent fruit set (0.515), fruit number (0.402), average fruit weight (0.361) and fruit yield/plant (0.463).

4.3.2.6 Days to first harvest

The trait days to first harvest had no significant association with all characters which are under study.

Table 7. Phenotypic correlation coefficients among morphological, growth, yield and yield components in ridge gourd [*Luffa acutangula* (L.) Roxb] genotypes.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.000	0.461**	0.447**	0.220 ^{NS}	0.307*	0.281*	-0.100 ^{NS}	-0.227 ^{NS}	0.500**	0.464**	0.275 ^{NS}	0.207 ^{NS}	0.610**
2		1.000	0.916**	0.467**	0.699**	0.218 ^{NS}	0.372**	-0.302*	0.625**	0.547**	0.449**	0.018 ^{NS}	0.632**
3			1.000	0.378**	0.592**	0.138 ^{NS}	0.335*	-0.320*	0.660**	0.508**	0.367**	-0.079 ^{NS}	0.573**
4				1.000	0.679**	0.437**	0.002 ^{NS}	-0.019 ^{NS}	0.239 ^{NS}	0.179 ^{NS}	0.057 ^{NS}	-0.183 ^{NS}	0.160 ^{NS}
5					1.000	0.447**	0.194 ^{NS}	-0.249 ^{NS}	0.515**	0.402**	0.361**	0.026 ^{NS}	0.463**
6						1.000	-0.174 ^{NS}	0.177 ^{NS}	0.102 ^{NS}	-0.133 ^{NS}	0.229 ^{NS}	0.032 ^{NS}	-0.036 ^{NS}
7							1.000	-0.192 ^{NS}	0.371**	0.344*	0.115 ^{NS}	0.286*	0.334*
8								1.000	-0.511**	-0.694**	-0.160 ^{NS}	0.061 ^{NS}	-0.588**
9									1.000	0.809**	0.202 ^{NS}	0.110 ^{NS}	0.774**
10										1.000	0.113 ^{NS}	0.143 ^{NS}	0.903**
11											1.000	-0.005 ^{NS}	0.406**
12												1.000	0.237 ^{NS}
13													1.000

* and ** Indicate significant at 5 and 1 per cent probability level, respectively.

NS: Non significant

1. Number of branches per plant 90DAT

2. Vine length 90DAT

3. Number of nodes per plant 90DAT

4. Days to anthesis of first female flower

5. Number of nodes to first female flower

6. Days to first harvest

7. Days to last harvest

8. Sex ratio

9. Per cent fruit set

10. Number of fruits per plant

11. Fruit weight

12. Fruit length

13. Fruit yield per plant

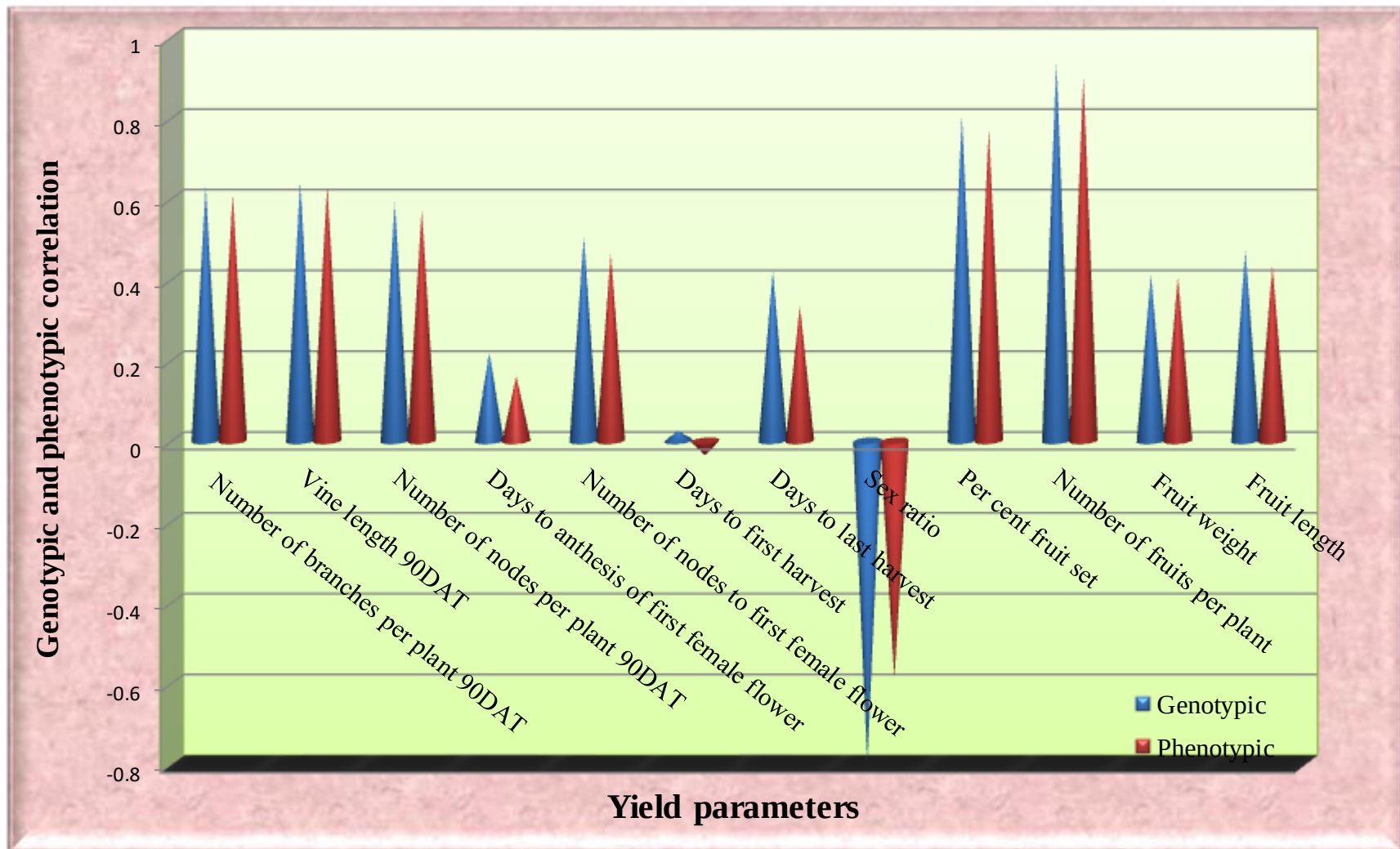


Fig. 3: Genotypic and phenotypic correlation of different characters with yield per vine in ridge gourd.

4.3.2.7 Days to last harvest

The trait days to last harvest exhibits a strong positively and significant association with number of fruits per plant (0.344), 100 seed weight (0.286) and fruit yield/plant (0.334). Per cent fruit set (0.371) had highly significant and positively correlated with the trait.

4.3.2.8 Sex ratio

Sex ratio had highly significant and negative association with per cent fruit set (-0.511), fruit number (-0.694) and fruit yield/plant (-0.588) whereas seed yield/fruit (-0.286) was observed to be significant and negative association with the trait.

4.3.2.9 Per cent fruit set

The trait per cent fruit set had highly significant and positive association with the number of fruits per plant (0.809) and fruit yield/plant (0.774).

4.3.2.10 Number of fruits per plant

Number of fruits per plant exhibited highly significant and positive correlation with seed yield/fruit (0.534) and fruit yield/plant (0.903).

4.3.2.11 Average fruit weight

A strong positively and highly significant association of average fruit weight was observed with fruit length (0.661) and fruit yield/plant (0.406).

4.3.2.12 Fruit length

Fruit length was highly significant and positive correlated with fruit yield/plant (0.434).

4.4 Path co-efficient analysis

The correlation would only indicate the overall relationship of independent trait with dependent trait but does not provide cause and effect of relationship. Using path analysis, it is possible to resolve the correlations, which provide clue about such relationship. In ridge gourd 12 parameters were subjected to genotypic and phenotypic path coefficient analysis and are presented in Table 8 and 9, respectively and Figure 4.

The total fruit yield per plant was considered as dependent on 12 independent variables, which were considered as cause. The independent characters were number of branches per plant at 90 DAT, vine length at 90 DAT, number of nodes per main vine at 90DAT, days to anthesis of first female flower, number of nodes to first female flower, days to first and last harvest, sex ratio, fruit set per cent, number of fruits per plant, average fruit weight and fruit length.

4.4.1 Genotypic path coefficient

4.4.1.1 Number of branches per vine

The Genotypic path coefficient presented in the Table 8 revealed that the number of branches per vine had high positive direct effect (0.528) on yield. Positive indirect effect was observed through vine length (0.194), days to anthesis of first female flower (0.071), number of nodes to first female flower (0.071), number of fruits per plant (0.286), average fruit weight (0.158) and fruit length (0.195) whereas, negative indirect effect was observed for number of nodes per vine (-0.045), days to first harvest (-0.025), days to last harvest (-0.016), sex ratio(-0.341) and per cent fruit set (-0.558).

4.4.1.2 Vine length

Vine length had high positive direct effect (0.409) along with negative indirect effect through number of nodes per vine (-0.092), days to first harvest (-0.018), sex ratio (-0.379) and per cent fruit set (-0.677). Positive indirect effect was observed through number of primary branches per plant (0.251), days to anthesis first female flower (0.134), number of nodes to first female flower to appear (0.156), days to last harvest (0.143), number of fruits per plant (0.335), fruit weight (0.262) and average fruit weight (0.133).

4.4.1.3 Number of nodes per vine

Number of nodes per vine had low negative direct effect (-0.01) along with the negative indirect effect through days to first harvest (-0.012), sex ratio (-0.455) and per cent fruit set (-0.731). Positive indirect effect was observed through number of branches per vine(0.241), vine length(0.38), days to anthesis of first female flower (0.117), number of nodes to first female flower to appear(0.135), days to last harvest (0.139), number of fruits per plant(0.33), average fruit weight (0.213) and fruit length (0.128).

4.4.1.4 Days to anthesis of first female flower

Days to anthesis of first female flower had high positive direct effect (0.25) on yield. Negative indirect effect was observed through number of nodes per plant (-0.047), days to first harvest (-0.03), days to last harvest (-0.023), per cent fruit set (-0.34) and fruit length (-0.036). Positive indirect effect was observed through number of branches (0.15), vine length (0.219), number of nodes to first female flower to appear (0.167), number of fruits per plant (0.133) and fruit weight (0.053).

4.4.1.5 Number of nodes to first female flower

Number of nodes to first female flower had high positive direct effect (0.211) on yield. Positive indirect effect was observed through number of primary branches per plant (0.18), vine length (0.302), days to anthesis of first female flower (0.198), days to last harvest (0.065), number of fruits per plant (0.252), average fruit weight (0.242) and fruit length (0.082). While Negative indirect effect was observed through number of nodes per vine (-0.064), days to first harvest (-0.035), sex ratio (-0.263) and per cent fruit set (-0.592).

4.4.1.6 Days to first harvest

Days to first harvest had low negative direct effect (-0.06) on yield along with negative indirect effect through number of nodes per vine (-0.019), days to last harvest (-0.134), per cent fruit set (-0.133) and number of fruits per plant (-0.095) whereas positive indirect effect were seen through number of branches per plant(0.22), vine length(0.121), days to anthesis of first female flower(0.122), number of nodes to first female flower to appear (0.121), sex ratio(0.137), average fruit weight (0.223) and fruit length (0.12).

4.4.1.7 Days to last harvest

Days to last harvest had high positive direct effect (0.328) on yield. Negative indirect effect was observed through number of branches per plant (-0.025), number of nodes per vine (-0.041), days to anthesis of first female flower (-0.018), sex ratio (-0.166) and per cent fruit set (-0.547). Positive indirect effects were seen through vine length (0.178), number of nodes to first female flower (0.042), days to first harvest (0.025), average fruit weight (0.095) and fruit length (0.019).

4.4.1.8 Sex ratio

Sex ratio had high positive direct effect (0.89) on yield along with negative indirect effect through number of branches per plant (-0.203), vine length(-0.175),days to anthesis of first female flower (-0.019), number of nodes to first female flower (-0.063), days to first and last harvest (-0.009 and -0.062, respectively), average fruit weight (-0.131), number of fruits per plant (-0.464) and fruit length (-0.167). Positive indirect effect was observed through number of nodes per vine (0.051) and per cent fruit set (0.639).

4.4.1.9 Per cent fruit set

Per cent fruit set had low negative direct effect (-1.017) on yield. Positive indirect effect was observed through number of branches per plant (0.29), vine length(0.272), days to anthesis of first female flower (0.083), number of nodes to first female flower (0.123), days to last harvest (0.177), average fruit weight (0.128), number of fruits per plant (0.479) and fruit length (0.084) while, negative indirect effect was seen through number of nodes per vine (-0.071), days to first harvest (-0.008) and sex ratio (-0.556).

4.4.1.10 Number of fruits per plant

Number of fruits per plant had highest positive direct effect (0.581) on yield. Positive indirect effect was observed through number of branches per plant (0.26), vine length (0.235), days to anthesis of first female flower (0.057), number of nodes to first female flower to appear (0.091), days to first and last harvest (0.01 and 0.144, respectively), average fruit weight (0.069) and fruit length (0.092). While negative indirect effect was observed through number of nodes per vine (-0.056), sex ratio (0.706) and per cent fruit set (-0.84).

Table 8. Genotypic path coefficient analysis among yield component in ridge gourd [*Luffa acutangula* (L.) Roxb] genotypes

	1	2	3	4	5	6	7	8	9	10	11	12	rG
1	0.528	0.194	-0.045	0.071	0.071	-0.025	-0.016	-0.341	-0.558	0.286	0.158	0.195	0.629**
2	0.251	0.409	-0.092	0.134	0.156	-0.018	0.143	-0.379	-0.677	0.335	0.262	0.133	0.641**
3	0.241	0.38	-0.01	0.117	0.135	-0.012	0.139	-0.455	-0.731	0.33	0.213	0.128	0.591**
4	0.15	0.219	-0.047	0.25	0.167	-0.03	-0.023	-0.067	-0.34	0.133	0.053	-0.036	0.219 ^{NS}
5	0.18	0.302	-0.064	0.198	0.211	-0.035	0.065	-0.263	-0.592	0.252	0.242	0.082	0.505**
6	0.22	0.121	-0.019	0.122	0.121	-0.06	-0.134	0.137	-0.133	-0.095	0.223	0.12	0.025 ^{NS}
7	-0.025	0.178	-0.041	-0.018	0.042	0.025	0.328	-0.166	-0.547	0.255	0.095	0.019	0.422**
8	-0.203	-0.175	0.051	-0.019	-0.063	-0.009	-0.062	0.89	0.639	-0.464	-0.131	-0.167	-0.796**
9	0.29	0.272	-0.071	0.083	0.123	-0.008	0.177	-0.556	-1.017	0.479	0.128	0.084	0.806**
10	0.26	0.235	-0.056	0.057	0.091	0.01	0.144	-0.706	-0.84	0.581	0.069	0.092	0.937*
11	0.146	0.187	-0.037	0.023	0.089	-0.024	0.054	-0.201	-0.228	0.07	0.572	0.26	0.412**
12	0.274	0.144	-0.034	-0.023	0.046	-0.019	0.017	-0.393	-0.228	0.142	0.395	0.376	0.471**

Residual=0.07748

Diagonal values indicates direct effect

rG= Genotypic correlation coefficient of fruit yield per plant

* and ** Indicate significant at 5 and 1 per cent probability level, respectively.

1.Number of branches per plant 90DAT

5. Number of nodes to first female flower

9. Per cent fruit set

2. Vine length 90DAT

6. Days to first harvest

10. Number of fruits per plant

3. Number of nodes per plant 90DAT

7. Days to last harvest

11. Fruit weight

4. Days to anthesis of first female flower

8. Sex ratio

12. Fruit length

4.4.1.11 Average fruit weight

Average fruit weight had high positive direct effect (0.572) on yield. Positive indirect effect was observed through were number of branches per plant(0.146), vine length(0.187), days to anthesis of first female flower (0.023), number of nodes to first female flower (0.089), days to last harvest(0.054), number of fruits per plant(0.07) and fruit length(0.26). Negative indirect effect were seen through number of nodes per plant(-0.037),days to first harvest(-0.024), sex ratio (-0.201) and per cent fruit set(-0.028).

4.4.1.12 Fruit length

Fruit length had high positive direct effect (0.376) on yield. Positive indirect effect were through number of branches per plant(0.274), vine length(0.144), number of nodes to first female flower to appear(0.046), days to last harvest(0.017), number of fruits per plant(0.142) and average fruit weight(0.395). Similarly, negative indirect effect was recorded through number of nodes per plant (-0.034), days to anthesis of first female flower (-0.023), days to first harvest (-0.019), per cent fruit set (-0.228) and sex ratio (-0.395).

4.4.2 Phenotypic path coefficient

4.4.2.1 Number of branches per plant

Phenotypic path coefficient presented in the Table 9 revealed that the number of branches per plant had high positive direct effect (0.046) on yield. Positive indirect effect was observed through were vine length(0.031), number of nodes per plant(0.005), days to anthesis of first female flower (0.0103), per cent fruit set(0.044), number of fruits per plant(0.369), average fruit weight(0.091) and fruit length(0.022) while, negative indirect effect was observed through number of nodes to first female flower (-0.037), days to first and last harvest(-0.016and -0.001, respectively) and sex ratio (-0.021).

4.4.2.2 Vine length

Vine length had high positive direct effect (0.068) on yield. Negative indirect effects were seen through number of nodes to first female flower (-0.083), days to first harvest (-0.013) and sex ratio (-0.028). Positive indirect effect was observed through number of branches per plant(0.021), number of nodes per vine(0.009), days to anthesis of first female flower (0.022), per cent fruit set (0.055), days to last harvest (0.004), number of fruits per plant (0.434), average fruit weight (0.148) and fruit length (0.016).

4.4.2.3 Number of nodes per vine

Number of nodes per vine had low positive direct effect (0.010) on yield. Positive indirect effect was observed through were number of branches per plant (0.02), vine length (0.062), days to anthesis of first female flower (0.018), days to last harvest (0.003), per cent fruit set (0.058), number of fruits per plant (0.404), average fruit weight (0.121) and fruit length(0.015) while, negative indirect effect was seen through number of nodes to first female flower (-0.07), days to first harvest (-0.008) and sex ratio (-0.03).

4.4.2.4 Days to anthesis of first female flower

Days to anthesis of first female flower had high positive direct effect (0.047) on yield. The positive indirect effect was observed through number of branches per vine (0.01), vine length (0.032), number of nodes per vine (0.004), days to last harvest (0.0002), per cent fruit set (0.021), number of fruits per plant (0.142) and average fruit weight (0.019). Negative indirect effect were observed through number of nodes to first female flower (-0.081), days to first harvest (-0.026), sex ratio (-0.002) and fruit length (-0.002).

4.4.2.5 Number of nodes to first female flower

Number of nodes to first female flower had low negative direct effect (-0.119) along with negative indirect effect through days to first harvest (-0.026) and sex ratio (-0.023). While positive indirect effect were observed through number of branches per vine (0.014), vine length (0.048), number of nodes per vine (0.006), days to anthesis of first female flower (0.032), days to last harvest (0.002), per cent fruit set (0.045), number of fruits per plant (0.319), average fruit weight (0.119) and fruit length (0.009).

4.4.2.6 Days to first harvest

Days to first harvest had direct negative low (-0.058) effect along with negative indirect effect through number of nodes to first female flower to appear (-0.053), days to last harvest (-0.002) and number of fruits per plant (-0.106). While positive indirect effect was observed through number of branches per vine (0.013), vine length (0.015), number of nodes per vine (0.001), days to anthesis of first female flower (0.021), sex ratio (0.017), per cent fruit set (0.009), average fruit weight (0.076) and fruit length (0.01).

4.4.2.7 Days to last harvest

Days to last harvest had low positive direct effect (0.01) on yield. Negative indirect effect were seen through number of branches per vine (-0.005), number of nodes to first female flower to appear (-0.023) and sex ratio (-0.018). Similarly, positive indirect effect was observed through vine length (0.025), number of nodes per vine (0.003), days to anthesis of first female flower (0.00012), days to first harvest (0.01), per cent fruit set (0.033), number of fruits per plant (0.273), average fruit weight (0.038) and fruit length (0.004).

4.4.2.8 Sex ratio

Sex ratio had high positive direct effect (-0.094) along with negative indirect effect were seen through number of branches per vine (-0.01), vine length (-0.021), number of nodes per vine (-0.003), days to anthesis of first female flower (-0.001), days to first and last harvest (-0.01 and -0.002 respectively), per cent fruit set (-0.045), number of fruits per plant (-0.551), average fruit weight (-0.053) and fruit length (-0.01), whereas positive indirect effect was observed through number of nodes to first female flower (0.03).

4.4.2.9 Per cent fruit set

Per cent fruit set had high positive direct effect (0.087) on yield. Negative indirect effect was observed through number of nodes to first female flower (-0.061), days to first harvest (-0.006) and sex ratio (-0.048) whereas positive indirect effect was observed through number of branches per plant (0.023), vine length (0.043), number of nodes per vine (0.007), days to anthesis of first female

flower (0.011), days to last harvest (0.004), number of fruits per plant (0.642), fruit weight (0.066) and fruit length (0.008).

4.4.2.10 Number of fruits per plant

Number of fruits per plant had high positive direct effect (0.794) on yield. Positive indirect effect was observed through number of branches per plant (0.021), vine length (0.037), number of nodes per vine (0.005), days to anthesis of first female flower (0.008), days to first and last harvest (0.008 and 0.003, respectively), per cent fruit set (0.071), fruit weight (0.037) and fruit length (0.009). Negative indirect effect were seen through number of nodes to first female flower to appear (-0.048) and sex ratio (-0.065).

4.4.2.11 Average fruit weight

Average fruit weight had high positive direct effect (0.33) on yield. Positive indirect effect was observed through number of braches per plant (0.015), vine length (0.031), number of nodes per vine(0.004), days to anthesis of first female flower (0.003), days to last harvest (0.001), per cent fruit set (0.018), number of fruits per plant (0.089) and fruit length (0.031). Negative indirect effects were seen through number of nodes to first female flower (-0.043), sex ratio (-0.015) and days to first harvest (-0.013).

4.4.2.12. Fruit length

Fruit length had high positive direct effect (0.047) on yield. Negative indirect effect was observed through days to anthesis of first female flower (-0.002), number of nodes to first female flower to appear (-0.022), days to first harvest (-0.012) and sex ratio (-0.021). Positive indirect effect were seen through number of branches per plant(0.021), vine length (0.023), number of nodes per vine (0.003), days to last harvest (0.001), per cent fruit set (0.015), number of fruits per plant (0.148) and average fruit weight (0.218).

Table 9. Phenotypic path coefficient analysis yield component in ridge gourd [*Luffa acutangula* (L.) Roxb] genotypes.

	1	2	3	4	5	6	7	8	9	10	11	12	rP
1	0.046	0.031	0.005	0.0103	-0.037	-0.016	-0.001	-0.021	0.044	0.369	0.091	0.022	0.610**
2	0.021	0.068	0.009	0.022	-0.083	-0.013	0.004	-0.028	0.055	0.434	0.148	0.016	0.632**
3	0.02	0.062	0.01	0.018	-0.07	-0.008	0.003	-0.03	0.058	0.404	0.121	0.015	0.573**
4	0.01	0.032	0.004	0.047	-0.081	-0.026	0.0002	-0.002	0.021	0.142	0.019	-0.002	0.160 ^{NS}
5	0.014	0.048	0.006	0.032	-0.119	-0.026	0.002	-0.023	0.045	0.319	0.119	0.009	0.463**
6	0.013	0.015	0.001	0.021	-0.053	-0.058	-0.002	0.017	0.009	-0.106	0.076	0.01	-0.036 ^{NS}
7	-0.005	0.025	0.003	0.00012	-0.023	0.01	0.01	-0.018	0.033	0.273	0.038	0.004	0.334*
8	-0.01	-0.021	-0.003	-0.001	0.03	-0.01	-0.002	0.094	-0.045	-0.551	-0.053	-0.01	-0.588**
9	0.023	0.043	0.007	0.011	-0.061	-0.006	0.004	-0.048	0.087	0.642	0.066	0.008	0.774**
10	0.021	0.037	0.005	0.008	-0.048	0.008	0.003	-0.065	0.071	0.794	0.037	0.009	0.903**
11	0.015	0.031	0.004	0.003	-0.043	-0.013	0.001	-0.015	0.018	0.089	0.33	0.031	0.406**
12	0.021	0.023	0.003	-0.002	-0.022	-0.012	0.001	-0.021	0.015	0.148	0.218	0.047	0.434**

Residual=0.01495

Diagonal values indicates direct effect

rP= Phenotypic correlation coefficient of fruit yield per plant

* and ** Indicate significant at 5 and 1 per cent probability level, respectively.

1. Number of branches per plant 90DAT

2. Vine length 90DAT

3. Number of nodes per plant 90DAT

4. Days to anthesis of first female flower

5. Number of nodes to first female flower

6. Days to first harvest

7. Days to last harvest

8. Sex ratio

9. Per cent fruit set

10. Number of fruits per plant

11. Fruit weight

12. Fruit length

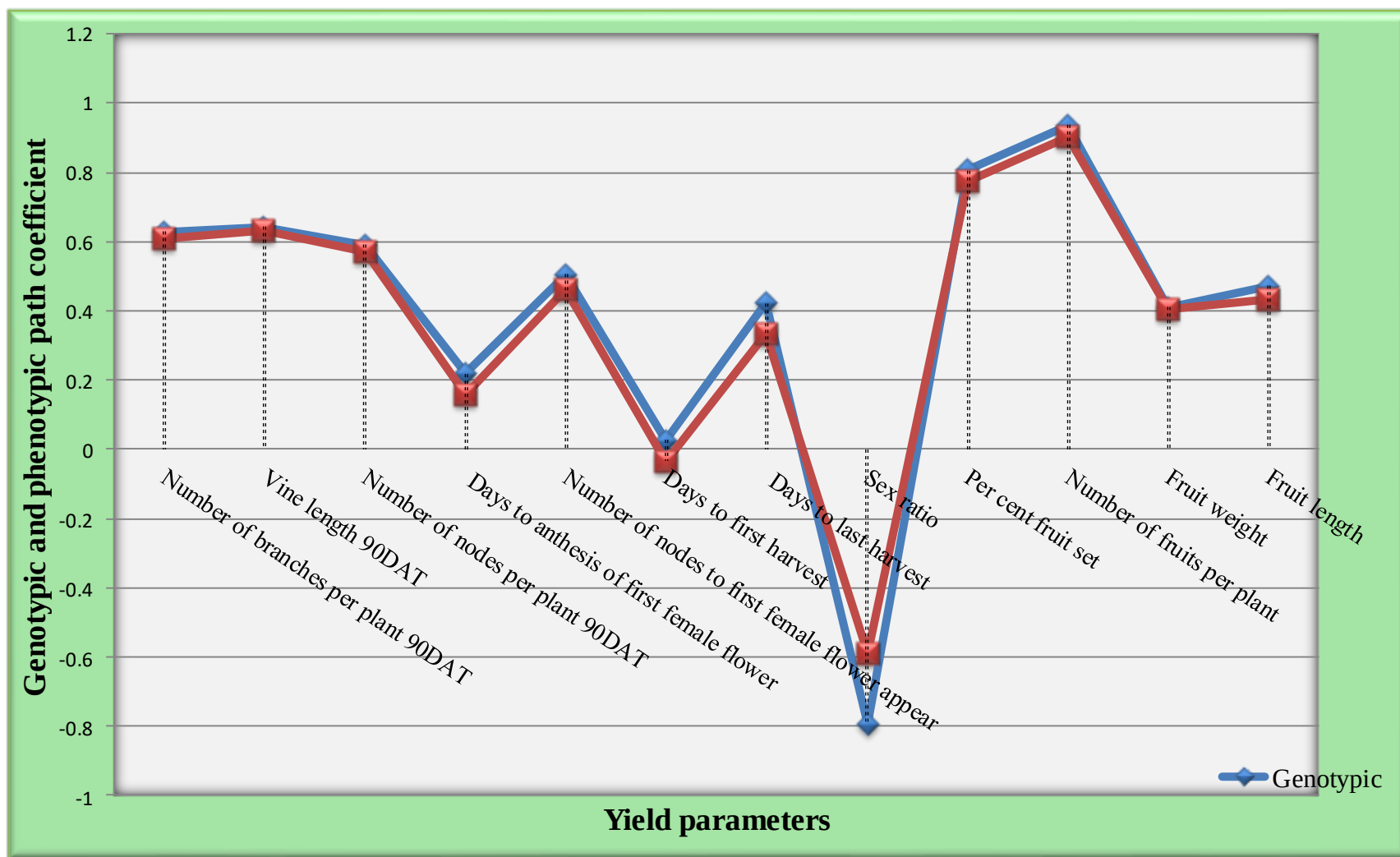


Fig. 4: Genotypic and phenotypic path coefficient of different characters with yield per vine in ridge gourd.

4.5 Screening of ridge gourd genotypes for downy mildew resistance under artificial condition

Downy mildew caused by *Pseudoperonospora cubensis* is an important disease causing severe losses in ridge gourd. However, works on screening the ridge gourd genotypes against this disease are limited as there is no such information on highly resistant line. Thus, it is necessary to evaluate the ridge gourd genotypes against the disease under different agro-climatic conditions.

Screening of ridge gourd genotypes through artificial inoculation of the pathogen revealed that the disease initiated on twenty one days after inoculation. Symptoms observed in leaves and plants due to downy mildew incidence are presented in Plate 7 and 7a, respectively. The genotypes were grouped into following categories based on the per cent disease index as given by Jamadar and Desai (1999) (Immune: 0, Resistant:1-10%, Moderately resistant:11-25%, Moderately susceptible: 26-50%, Susceptible:51-75%, Highly susceptible: >75%).

Results pertaining to screening of twenty seven genotypes against *P. cubensis* under artificial conditions in the polyhouse to identify the resistance sources are presented in Table 10. The genotypes Deepthi and IC-92638 were found to show resistant reaction with a PDI% of 9.9% and 8.66%, respectively, while IC-126249 (19.72% PDI), Thovinkere Local (19.04%), IC-335912 (12.79%), Sirsi Local (12.2%), Arka Sujat (23.10%), IC-92675 (20.3%) and IC-3444652 (1.59%) were found to be moderately resistant. Moderately susceptible reaction was observed in the genotypes viz., Kolar Local (27.06%), IC-344605 (34.67%), IC-124268 (26.17%), IC-201145 (25.4%), Gokak Local (41.75%), Green long (26.66%), Mysuru Local (24.28%), IC-385912 (31.64%), Arka Sumeet (39.02%), Ghataprabha Local (24.87%), Jaipur Long (29.71%) and Yaderanghalli Local (26.2) whereas Pusa Nasdar (52.88%), Pusa Nutan (64.2%) and IC-144613 (54.12%) were susceptible and high susceptibility was recorded in IC-92816 and IC-144606 with PDI of 75.25% and 78.14%, respectively.

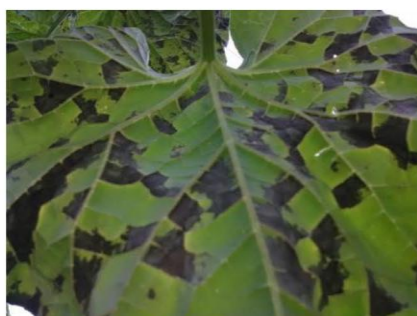
The genotypes with low incidence of downy mildew will be useful in resistance breeding programmes in order to develop the resistant varieties.



Healthy leaf



Loss of chlorophyll content



Chlorotic lesions



Necrosis



Completely died and curled up

Plate 7: Symptoms observed in leaves of ridge gourd due to downy mildew



Symptoms observed at early stage of crop



Symptoms observed at later stage of crop

Plate 7a: Symptoms observed in ridge gourd plants due to downy mildew

Table 10. Screening resistance of different ridge gourd genotypes to downy mildew incidence

Sl. No.	Genotypes	PDI (%)	Reaction
1.	IC-92638	8.66	Resistant
2.	Deepthi	9.9	Resistant
3.	Sirsi Local	12.2	Moderately resistant
4.	IC-335912	12.79	Moderately resistant
5.	IC-344652	18.59	Moderately resistant
6.	Thovinkere Local	19.04	Moderately resistant
7.	IC-126249	19.72	Moderately resistant
8.	IC-92675	20.03	Moderately resistant
9.	IC-244512	21.08	Moderately resistant
10.	Arka Sujat	23.10	Moderately resistant
11.	Ghataprabha Local	24.87	Moderately susceptible
12.	IC-201145	25.4	Moderately susceptible
13.	Yaderanghalli Local	26.2	Moderately susceptible
14.	IC-124268	26.17	Moderately susceptible
15.	Green Long	26.66	Moderately susceptible
16.	Kolar Local	27.06	Moderately susceptible
17.	Jaipur Long	29.71	Moderately susceptible
18.	IC-385912	31.64	Moderately susceptible
19.	Mysuru Local	34.38	Moderately susceptible
20.	IC-344605	34.67	Moderately susceptible
21.	Arka Sumeet	39.02	Moderately susceptible
22.	Gokak Local	41.75	Moderately susceptible
23.	Pusa Nasdar	52.88	Susceptible
24.	IC-144613	54.12	Susceptible
25.	Pusa Nutan	64.2	Susceptible
26.	IC-92618	75.25	Highly Susceptible
27.	IC-144606	78.14	Highly Susceptible

V. DISCUSSION

The magnitude of heritable variability is the most important component in any breeding material as it has a close bearing on response to selection. However occurrence of adequate genetic variability is an essential pre requisite for all crop improvement programmes. Knowledge of the amount of variability and heritability aids, the crop breeder for effecting improvement in any crop by choosing suitable breeding technique. The source material for genetical improvement would be identified by studying the amount of variability available in the genotypes. This necessitates the evaluation of the assemblage for various requirements in the single environment. Accordingly ridge gourd genotypes were evaluated for their genetic potential in respect of growth, morphological, yield and yield attributes and also for downy mildew disease resistance so as to identify source material to enhance productivity.

The objective of any breeding programme will mostly be oriented towards the improvement of the yield. Since the yield is dependent upon different growth and yield contributing characters. Hence, to understand growth and yield contributing characters and genetic potential of yield must be probed through the study of its component characters by employing useful biometrical tools. Some of these parameters include genotypic and phenotypic co-efficient of variation, heritability, genetic advance, genotypic and phenotypic correlations, path co-efficient analysis help to base selection procedure to a required balance when two opposite desirable characters affecting the principle characters are also being selected. It also helps to improve different characters simultaneously (Falconer, 1981).

In ridge gourd, the crop productivity is limited by pests and diseases. The full potential of available sources of resistance can only be realized if the genotypes are screened against downy mildew which will help for identification of resistant sources and in successful introgression into commercial variety.

5.1 Variability, heritability and genetic advance over mean

Existence of genetic variability among the genotypes for the characters to be improved is the most basic requirement for successful selection. In the present investigation, variance due to treatments (genotypes) was significant for all the characters except for 100 seed weight. It indicated that sufficient variability existed for all the characters and considerable improvement could be achieved in most of these characters by selection. However, the analysis of variance by itself is not enough and conclusive to explain all the inherent genotypic variance in the collections. One of the way in which the variability of these characters assessed is through a simple approach of examining the range of variation. Range of variation observed for all the traits in the present study indicated the presence of sufficient amount of variation among the genotypes for all the characters studied.

The range in the values reflects the amount of phenotypic variability which is not very reliable since it includes genotypic, environmental and genotype X environmental interaction components and does not reveal as to which character is showing higher degree of variability. Further, the phenotype of crop is influenced by additive gene effect (heritable), dominance (non-heritable) and epistasis (non-allelic interaction). Hence, it becomes necessary to split the observed variability into phenotypic variation (PV) and genotypic variation (GV) which indicates the extent of variability existing for various traits. However, these GV and PV estimates are influenced by the units of measurements of the various traits and even these estimates don't give a true picture. But, the estimates of phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) will indicate the extent of variability existing for various traits irrespective of their units of measurements. However, even those characters fail to give a correct picture about the extent of inheritance of the characters. Therefore, heritability of characters should also be taken into consideration, as it enables the plant breeder to decide the extent of selection pressure to be applied under a particular environment, which separates out the environmental influence from the total variability. Nevertheless, its use would be limited as that is prone to change with environments, material etc.

The estimation of heritability has a greater role to play in determining the effectiveness of selection for a character provided it is considered in conjunction with the predicted genetic advance as suggested by Panse and Sukhatme (1967) and Johnson *et al.* (1955) since the heritability is influenced by bio-metrical method, generation of hybrid, sample size of experimental material and environment. The principle concern of the present investigation was to study the genetic variability, characters association and direct and indirect effect on yield of ridge gourd genotypes.

With these points in view, the results of the variability observed in the ridge gourd genotypes evaluated in the present investigation are discussed here under.

5.1.1 Morphological and growth parameters

In the present study low genotypic and phenotypic co-efficient of variation were recorded for days to first harvest. This low GCV and PCV estimates indicated the variability of lower magnitude and suggests the need for generation of variability either by introduction, exploration or by hybridization to get substantial gain in their improvement. Similar findings were reported by Dubey *et al.* (2013), Choudhary and Suresh Kumar (2011) in ridge gourd, Hossian *et al.* (2010) in cucumber, Rahman *et al.* (1986) in bottle gourd, Kumar *et al.* (2007) in sponge gourd, Koppad *et al.* (2015) in ridge gourd, Samadia (2011) in ridge gourd, Malashetty (2010), Murulidara *et al.* (2009) in pumpkin, Ram *et al.* (2006), Samadia (2007) in round melon for days to first harvest.

Low GCV and moderate PCV was observed for days to last harvest and sex ratio. These results are confirmed by Koppad *et al.* (2015), Hanumegowda (2011) for days to last harvest, Koppad *et al.* (2015), Basavarajeshwari *et al.* (2014) in cucumber, Rabbani *et al.* (2012) in ridge gourd, Ananthan *et al.* (2005) in ridge gourd for sex ratio

Moderate GCV and high PCV was recorded for days to anthesis of first male flower. PCV is invariably higher for all the parameters mentioned above as compared to GCV due to environmental influence and genetic variability did not show any consistent pattern of change suggesting that non heritable factors contributed to the increased phenotypic variability and large genotype X Environment interactions play an important role in the expression of these characters, Khatoon *et al.* (2016) and Samadia (2007) reported similar findings for days to anthesis of first male flower.

Moderate GCV and PCV estimates were observed for internodal length, days to anthesis of first female flower, days to 50% flowering indicating the limited variability for these traits in germplasm used for study. This result is in accordance with Raja *et al.* (2007) in bitter gourd, Samadia (2007) for days to anthesis of first female flower and Hossian *et al.* (2010) in cucumber for internodal length. Afangideh and Uyoh. (2007) in cucumber, Islam *et al.* (1993) for days to 50% flowering.

The phenotypic co-efficient of variation was high in number of primary branches per vine, vine length, number of nodes per vine, number of nodes to first male and female flower indicating that maximum amount of variability had present in genotypes for these characters. Hence, there is less possibility for improvement of such trait. The genotypic co-efficient of variation provides measure of genetic variability present in the character. The high estimates of GCV was recorded the number of primary branches per vine followed by vine length, number of nodes per vine, number of nodes to first male flower and female flower. GCV indicates the presence of exploitable genetic variability for these traits. Hence, selecting of yield attributing characters would be effective. These similar results were obtained by Islam *et al.* (2009) in bitter gourd, Singh *et al.* (2014) in bitter gourd, Raja *et al.* in (2007) bottle gourd, Kumar *et al.* (2007) in bottle gourd, Choudhary and Suresh Kumar (2011) in ridge gourd, Dubey *et al.* (2013a) in *Luffa*, Koppad *et al.* (2015), Singh *et al.* (2002) in ridge gourd, Kumar *et al.* (2013) in sponge gourd. Basumatary *et al.* (2014) in spine gourd for number of primary branches per vine whereas Khatoon *et al.* (2016), Dubey *et al.* (2013), Dubey *et al.* (2013a), Choudhary and Suresh Kumar (2011) in ridge gourd, Hossain *et al.* (2010) in cucumber, Kumar *et al.* 2007 in bottle gourd, Fayeun *et al.* (2012) in pumkin for vine length, Choudhary *et al.* (2011) in melon, Islam *et al.* (2009) in bitter gourd for number of nodes per vine, Kumar *et al.* (2007) in bottle gourd, Hossian *et al.* (2010) in cucumber, Singh *et al.* (2002) in ridge gourd for number of nodes of first male appear, Kumar *et al.* (2007) in bottle gourd, Hossian *et al.* (2010) in cucumber. Singh *et al.* (2002) is ridge

gourd, Choudhary *et al.* (2014), Choudhary *et al.* (2008), Samadia (2011) in ridge gourd, Basumatary *et al.* (2014) in spine gourd for number of nodes to first female flower. The effectiveness of selection for any characters depends not only on the amount of phenotypic and genotypic variability but also on estimates of heritability. Co-efficient of variation measures the magnitude of variability present in a population whereas heritability indicates the reliability with which a genotypic will be evaluated by phenotypic expression.

High estimates of heritability were noticed for number of primary branches per vine, vine length, number of nodes per vine, internodal length, days to anthesis of first male flower, number of nodes to first male and female flower indicating that characters are less influenced by environmental factors and are under the control of additive gene effect. Therefore selection for improvement of such characters would be rewarding. Similar results were reported by Islam *et al.* (2009) in bitter gourd, Dubey *et al.* (2013a), Koppad *et al.* (2015), Radha Rani (2012), Singh *et al.* (2002), Basamatary *et al.* (2014) in spine gourd, Kumar *et al.* (2013) in sponge gourd for number of primary branches per vine, Koppad *et al.* (2015a), Khatoon *et al.* (2016), Dubey *et al.* (2013), Dubey *et al.* (2013a), Choudhary *et al.* (2008), Choudhary and Suresh Kumar (2011) for vine length, Radha Rani (2012), Khatoon *et al.* (2016) for number of nodes per vine, Sultana (2015) in pumkin, Choudhary *et al.* (2008), Rabbani *et al.* (2012) for internodal length, Islam *et al.* (2009) in bitter gourd, Dubey *et al.* (2013), Khatoon *et al.* (2016), Samadia (2007), Singh *et al.* (2002) in ridge gourd, Narayanakutty *et al.* (2006) in snake gourd for days to anthesis of first male flower, Islam *et al.* (2009) in bitter gourd, Kumar *et al.* (2007) for number of nodes to first male flower, Basumatary *et al.* (2014) in spine gourd, Choudhary *et al.* (2014), Choudhary *et al.* (2008), Samadia (2011), Singh *et al.* (2002) in ridge gourd for number of nodes of to first female flower.

Moderate heritability was recorded for days to anthesis of first female flower, days to 50% flowering, days to first harvest, days to last harvest and sex ratio indicating the involvement of both additive and non-additive effects in the genetic control of these characters. Although heritability estimates of these characters did not show consistent pattern of change. These results are in conformity with the findings of the earlier workers viz., Sultana *et al.* (2015) in pumkin, Chudhary and Suresh Kumar (2011), Dubey *et al.* (2013), Dubey *et al.* (2013a), Koppad *et al.* (2015) for days to anthesis of first female flower, Islam *et al.* (1993) for days to 50% flowering, Choudhary and Suresh Kumar (2011), Varalakshmi *et al.* (1995), Singh *et al.* (2002), Karuppaiah *et al.* (2002) for days to first harvest, Koppad *et al.* (2015) for days to last harvest, Basavarajeshwari *et al.* (2014) for sex ratio.

Heritability estimates along with genetic gain (GAM) is more useful than heritability alone in predicting the resultant effect for selecting the best individuals (Johnson *et al.*, 1955). GA is the measure of improvement that can be achieved by practising selection in a population. High GAM was observed for number of primary branches per vine, vine length, number of nodes per vine, days to anthesis of first male flower, number of nodes to first male and female flower indicating that the characters were governed by additive genes and selection will be rewarding for improvement of such traits. These results are in conformity with Raja *et al.* (2007) in bitter gourd, Radha Rani (2012), Singh *et al.* (2002) for number of primary branches per vein, Singh *et al.* (2002), Samadia (2007) in round melon, Khatoon *et al.* (2016), Choudhary and Suresh Kumar (2011), Fayeun *et al.* (2012), Kumar *et al.* (2007) for vine length, Islam *et al.* (2009) bitter ground, Husna *et al.* (2011) in bottle gourd, Kumar *et al.* (2007) for days to anthesis of first male flower, Kumar *et al.* (2007), Choudhary *et al.* (2014), Choudhary *et al.* (2008), Samadia (2007), Singh *et al.* (2002) for number of nodes to first female flower.

The characters days to anthesis of first female flower and days to 50% flowering exhibited moderate GAM which indicated that these characters were governed by non-additive genes have heterosis breeding may be useful. These results are supported by Choudhary and Suresh Kumar (2011), Sultana *et al.* (2015), Choudhary *et al.* (2008) for days to anthesis of first female flower, Islam *et al.* (1993) for days to 50% flowering.

Low GAM was observed for internodal length, days to first harvest, sex ratio and days to last harvest indicates that the characters were governed by non-additive gene action and hence selection for this character is not useful. Similar findings are reported by Fayeun *et al.* (2012), Choudhary *et al.* (2008) for internodal length, Choudhary and Suresh Kumar (2011), Kumar *et al.* (2007), Koppad *et al.* (2015a), Samadia (2011), Johnson *et al.* (1955), Malashetty (2010) for days to first harvest.

Hanumegowda (2011) for days to last harvest, Basavarajeshwari *et al.* (2014), Ananthan *et al.* (2005), Mohanty (2000), Mohanty and Mishra (1999) for sex ratio.

5.1.2 Yield and yield parameters

High values of PCV as well as GCV was recorded for number of fruits per plant and fruit yield per plant. The high magnitude of GCV further revealed the greater extent of variability present in the characters, suggesting good scope for improvement through selection of this crop. Similar finding here also been reported by Islam *et al.* (2009) in bitter gourd, Husna *et al.* (2011) and Kumar *et al.* (2007) in bottle gourd, Basavarajeshwari *et al.* (2014) in cucumber, Choudhary *et al.* (2008), Dubey *et al.* (2013a), Khatoon *et al.* (2016), Rabbani *et al.* (2012) in ridge gourd for number of fruits per plants, Choudhary *et al.* (2008), Dubey *et al.* (2013), Dubey *et al.* (2013a), Khatoon *et al.* (2016), Koppad *et al.* (2015a), Radha Rani (2012), Samadia (2011), Singh *et al.* (2002) for fruit yield.

Moderate estimates of GCV and PCV observed for average fruit weight and fruit length indicating the limited variability for these traits in germplasm used for study. This result is accordance with Khan *et al.* (2009), Koppad *et al.* (2015) for average fruit weight, Raja *et al.* (2007), Choudhary *et al.* (2008), Koppad *et al.* (2015), Koppad *et al.* (2015a), Ram *et al.* (2006), Choudhary *et al.* (2014) for fruit length. Thus in the present germplasm, it appears that the phenotypic variability for all the parameters is true measure of genotypic variability as there is narrow difference between the estimates of GCV and PCV. Therefore selection based on phenotype would be fruitful in the improvement of these traits.

Low estimates of GCV and moderate estimates of PCV were observed for per cent fruit set and fruit diameter which indicates that these characters were more sensitivity to environmental factors. Thus, there is least scope for improvement through selection. These results are conformity with the earlier workers Hanumegowda (2011) in ridge gourd and Islam *et al.* (2009) in bitter gourd. Low GCV is conformity with Koppad *et al.* (2015a), Kumar *et al.* (2013), Singh *et al.* (2002), Basavarajeshwari *et al.* (2014), whereas moderate PCV was conformity with Koppad *et al.* (2015), Ram *et al.* (2006), Rabbani *et al.* (2012), Samadia (2007), Kumar *et al.* (2013) in ridge gourd.

Heritability estimates along with the genetic gain (GAM) is more useful than heritability alone in predicting the resultant effect for selecting the best individuals (Johnson *et al.*, 1995). The high heritability with high GAM for number of fruits per plant, fruit yield per plant and average fruit weight indicated the predominant role of additive genetic. Therefore, there is scope for improvement of these fruits through phenotypic selection as its estimates of GCV and PCV are closer as well as parallel and phenotypic variability is a good measure of genotypic variability. Similar results are reported by Husna *et al.* (2011). Radha Rani (2012), Samadia (2007), Kumar *et al.* (2007), Basavarajeshwari *et al.* (2014), Husna *et al.* (2011), Choudhary and Suresh Kumar (2011), Khatoon *et al.* (2016) in ridge gourd for number of fruits per plant, Islam *et al.* (2009), Singh *et al.* (2014), Husna *et al.* (2011), Kumar *et al.* (2007), Basavarajeshwari *et al.* (2014), Choudhary *et al.* (2014), Khatoon *et al.* (2016), Koppad *et al.* (2015a), Samadia *et al.* (2007), Singh *et al.* (2002), Narayanankutty *et al.* (2006), for fruit yield per plant. Singh *et al.* (2014), Raja *et al.* (2007), Husna *et al.* (2011), Choudhary *et al.* (2008), Sultana *et al.* (2015), Choudhary and Suresh Kumar (2011), Choudhary *et al.* (2011), Samadia *et al.* (2002), Singh *et al.* (2002) for average fruit weight.

Moderate variability and moderate GA was recorded for per cent fruit set indicating the involvement of both additive and non-additive gene effects in the genetic control of the characters. Moderate heritability and low GA were observed for fruit diameter also indicated the involvement of both additive and non-additive gene effects in the genetic control of the character. An estimate of moderate heritability with low genetic advance was observed with fruit diameter indicating that the characters were under the control of non-additive gene action. This result was confirmed by Raja *et al.* (2007).

Fruit length had moderate heritability indicating the involvement of both additive and non-additive effects in the inheritance of this character. These results are confirmed by Afangideh and Uyoh (2007), Sultana *et al.* (2015), Koppad *et al.* (2015a), Koppad *et al.* (2015) and fruit length also exhibits high GAM indicating that this character was controlled by additive gene actions, selection for

this character will improve the yield and similar finding were reported by Khatoon *et al.* (2014), Choudhary and Suresh Kumar (2011), Radha Rani (2012), Samadia (2007), Singh *et al.* (2002), Kumar *et al.* (2007), Raja *et al.* (2007), Islam *et al.* (2009).

5.1.3 Quality parameters

High heritability along with high genetic advance over per cent of mean was observed for vitamin C, total chlorophyll, crude protein content, indicated that the genotypes could be evaluated in multi-location traits and selected as straight introduction for these characters and can be used as a parents in the hybridization programme for further improvement.

5.1.4. Seed parameters

The PCV and GCV are moderate for 100 seed weight and recorded low heritability with high genetic advance over per cent mean was observed. The results are similar with Samadia (2007), Narayanankutty *et al.* (2006), Basumatary *et al.* (2014), Raja *et al.* (2007) with respect to GCV and PCV. Ram *et al.* (2006), Mladenovic *et al.* (2012) with respect to heritability and Singh *et al.* (2002), Raja *et al.* (2007), Kumar *et al.* (2007) with respect to GAM. These results are indicating that these characters are controlled by both additive and non-additive gene actions. Hence, the recurrent selection can be practised. Higher estimates of GCV and PCV and broad sense heritability associated with high genetic advance over per cent mean was recorded for seed yield per fruit and number of seeds per fruit. These results are accordance with Ram *et al.* (2006), Samadia *et al.* (2007), for seed yield per fruit, Samadia *et al.* (2007), Singh *et al.* (2012), Narayanankutty *et al.* (2006), Kumar *et al.* (2013) and Raja *et al.* (2007). High values of GCV are an indication of high genetic variability among the genotypes. Thus the scope for improvement of these characters through simple selection would be better. High heritability showing that the characters are under control of additive gene action indicates ample scope of improvement of these characters through simple selection.

5.2 Character association

In any crop improvement programme, it becomes necessary to have simultaneous progress of more than one character, especially in the case of complex character like yield, which is influenced by many other traits. This is due to the physiological and linkage relationship of genes governing various characters. Hence, knowledge of correlations between different economical characters are of importance in selection programmes. Positive correlation makes simultaneous improvement in two or more attributes possible, whereas, negative association indicates the need to compromise between desirable characters.

The simple correlation study is inadequate to measure the association as different genotypes are susceptible to environment in varying degrees. An estimate of phenotypic and genotypic correlations provides way for understanding environmental influence on heritable traits expression.

In the present investigation, genotypic correlation is higher than phenotypic correlations for all the characters, indicating little influence of environment and the presence of inherent association between various characters.

In the present study, correlation co-efficient analysis between the components of ridge gourd was worked out for 12 parameters as only these characters influences the yield. However, more reliance was placed on the genotypic correlations.

Fruit yield per plant showed positive and significant correlation with number of primary branches per plant 90 DAT, vine length 90DAT, number of nodes per vine 90DAT, number of nodes to first female flower, days to first and last harvest, per cent fruit set, number of fruits per plant, fruit weight and fruit length both at genotypic and phenotypic level. Since, these association characters

are in the desirable direction, selection for these traits may improve the yield per plant. Whereas fruit yield per plant had negative significant association with sex ratio implies that as sex ratio increases fruit yield per plant decreases. Similar findings were reported by Choudhary and Suresh Kumar (2011), Choudhary *et al.* (2008), Choudhary *et al.* (2014a), Choudhary *et al.* (2014), Dubey *et al.* (2013), Varalakshmi *et al.* (1995), Dubey *et al.* (2013), Dubey *et al.* (2013a), Hanumegowda (2011), Khatoon *et al.* (2016), Narasannavar *et al.* (2014), Radha Rani (2012), Narayanankutty *et al.* (2006), Basumatary *et al.* (2014), Dey *et al.* (2005)

Number of primary branches had highly significant and positive association with vine length, number of nodes per vine, days to first harvest, per cent fruit set, number of fruits per plant, fruit length and fruit yield per plant and these can be simultaneously improved by applying selection pressure on number of primary branches, in view of its positive association with these traits. Negative and significant correlation with sex ratio and days to last harvest was observed which suggest that simultaneous improvement for these traits and some compromise has to be made while selection for these traits. This result is in accordance with Radha Rani (2012), Ram *et al.* (2006), Narasannavar *et al.* (2014), Basumatary *et al.* (2014).

Vine length was highly significant and positively associated with number of nodes per vine, days to anthesis of first female flower, number of nodes to first female flower, days to last harvest, per cent fruit set, number of fruits per plant, average fruit weight and fruit yield. Days to first harvest and fruit length had also positive and significant association with the trait both at genotypic and phenotypic level which shows that vine length has direct influence on increasing these characters. But it also had highly significant and negative correlation with sex ratio, suggesting that simultaneous improvement for these traits and some compromise has to be made while selection for these traits.

Number of nodes per vine exhibited highly significant and positive correlation with days to anthesis of first female flower, number of nodes to first female flower, days to last harvest, per cent fruit set, number of fruits per plant, fruit weight and fruit yield. Fruit length had positive and significant correlation with this trait. It shows that number of nodes had direct influence on increasing these characters.

Days to anthesis of first female flower had highly significant and positive association with number of nodes to first female flower, days to first harvest and significantly positive association with per cent fruit set. Indicating that as the days to first female flower increases there is correspond decrease in the fruit yield per plant. So, selection for this trait will be useful in increasing the yield Choudhary *et al.* (2008), Narasannavar *et al.* (2014).

Number of nodes to first female flower had strong positive significant association with days to first harvest, per cent fruit set, number of fruits per plant, average fruit weight and fruit yield/plant both at genotypic and phenotypic levels suggesting that the selection for lower node of female flower would result in early yield. Hence, selection pressure on any of these traits would bring about improvement in these entire traits. Similar findings have been reported by Narasannavar *et al.* (2014). However, negative and significant association of the trait with sex ratio suggest that selection for early lower nodes to first female flower production would bring about improvement in these traits.

Days to first harvest, days to last harvest, average fruit weight and fruit length was positive and significantly correlated within traits both at genotypic and phenotypic levels, suggesting the possibility of simultaneous improvement of the traits will be effective. Days to first harvest had no significant association with the remaining traits. However, days to last harvest exhibited highly significant and positive association with per cent fruit set and fruit yield/plant. Number of fruits per plant had also significant and positive correlation with the trait both at genotypic and phenotypic level. This suggests that there is a possibility of simultaneous improvement of these traits will be rewarding. Similar findings are reported by Narasannavar *et al.* (2014).

Sex ratio had highly significant and negative association with per cent fruit set, number of fruits per plant, fruit length and fruit yield per plant, suggesting that simultaneous improvement for these traits is impracticable and some compromise has to be made while selecting for these traits.

Per cent fruit set had significant and positive association with number of fruits per plant and fruit yield/plant which suggests that the possibility of simultaneous improvement by applying selection pressure on per cent fruit set, in view of its positive association with these traits. Average fruit weight and fruit length had no significant association with the trait. These results are in conformity with the findings of the earlier workers viz., Hanumegowda *et al.* (2011) and Narasannavar *et al.* (2014).

Number of fruits per plant had highly significant and positive association with fruit yield per plant. Hence, selection pressure on this character would bring improvement in yield. These results are supported by Hanumegowda *et al.* (2011), Khatoon *et al.* (2016),

Average fruit weight was highly and positively association with fruit length and fruit yield per plant both at genotypic and phenotypic level. Similar results were confirmed by Choudhary *et al.* (2008), Choudhary *et al.* (2014), Narasannavar *et al.* (2014) and Ram *et al.* (2006). Fruit length was highly significant and positively associated with fruit yield per plant indicated the possibility of simultaneous selection for these traits. These results are in conformity with Choudhary *et al.* (2008), Hanumegowda *et al.* (2011), Narasannavar *et al.* (2014).

5.3 Path co-efficient analysis

Though correlation analysis indicated the association pattern of component traits with yield, it simply represents the overall association of a particular trait with yield rather than providing cause and effect relationship. The technique of path co-efficient analysis developed by Wright (1921) and demonstrated by Dewey and Lu (1957) facilitates in partitioning the correlation co-efficient into direct and indirect contribution of various characters on yield. It is a standardized partial regression co-efficient analysis. As such, it measures the direct influence of one variable upon other. Such information would be of great value in enabling the breeder to specifically identify important component traits of yield and utilize the genetic stock for improvement in a planned way. In the present study, path co-efficient analysis between the components of ridge gourd was worked out. As the genotypic associations are inherent, the path analysis is discussed only at genotypic level.

In the present study path analysis was performed for total yield per plant with yield contributing components. Both genotypic and phenotypic path were worked out, but genotypic path should be considered with more weightage as phenotypic path will have greater influence of environmental factors.

Among the 12 traits chosen for path analysis, number of primary branches per plant (0.629), vine length (0.641), number of nodes per plant (0.591), number nodes to first female flower (0.505), days to last harvest (0.422), per cent fruit set (0.806), number of fruits per plant (0.937), fruit weight (0.412) and fruit length (0.471) had significant correlation with fruit yield at both phenotypic and genotypic level.

Among these some viz., number of primary branches per plant, vine length, days to anthesis of first female flower, days to last harvest, sex ratio, number of fruits per plant, fruit weight and fruit length, had positive direct effect indicating their true positive and significant positive association with yield. Therefore, direct selection for these traits would be rewarding for improvement of yield. These results are supported by Choudhary *et al.* (2008), Choudhary *et al.* (2014), Dubey *et al.* (2013), Dubey *et al.* (2013a), Narasannavar *et al.* (2014), Radha Rani (2012), Narayanankutty *et al.* (2006) and Islam *et al.* (2009).

Number of primary branches per vine had high positive direct effect on yield at both phenotypic and genotypic level. Positive indirect effect was observed through vine length, days to anthesis of first female flower, number of nodes to first female flower, number of fruits per plant, average fruit weight and fruit length, resulting in significant positive genotypic and phenotypic correlation with yield. These results are in accordance with Malashetty (2010), Prasanna *et al.* (2002) in ridge gourd, Kumar *et al.* (2007).

Vine length had high positive direct effect at both phenotypic and genotypic level along with positive indirect effect through number of primary branches, days to anthesis first female flower, number of nodes to first female flower, days to last harvest, number of fruits per plant, average fruit weight and fruit length resulting in significant positive genotypic and phenotypic correlation with yield. Similar findings are reported by Malashetty (2010), Prasanna *et al.* (2002) in ridge gourd, Kumar *et al.* (2007), Bharathi *et al.* (2006), in spine gourd, Ahmed *et al.* (2005).

Number of nodes per vine had low negative direct effect on yield along with positive indirect effect through number of primary branches per vine, vine length, days to anthesis of first female flower, number of nodes to first female flower appear, days to last harvest, number of fruits per plant, average fruit weight and fruit length resulted in significant positive genotypic and phenotypic correlation with yield. Negative indirect effect was observed through days to first harvest, sex ratio and per cent fruit set.

Days to anthesis of first female flower had high positive direct effect on yield at both phenotypic and genotypic level. Negative indirect effect was observed through number of nodes per plant, days to first harvest, days to last harvest, sex ratio, per cent fruit set and fruit length. Positive indirect effect was seen through number of primary branches per plant, vine length, number of nodes to first female flower, number of fruits per plant and average fruit weight.

Number of nodes to first female flower had highest positive direct effect on yield only at genotypic level. Negative indirect effect was observed through number of nodes per vine, days to first harvest, sex ratio and per cent fruit set resulted in significant negative correlation with yield both at genotypic and phenotypic level. Positive indirect effect was observed through number of primary branches per plant, vine length, days to anthesis of first female flower, days to last harvest, number of fruits per plant, average fruit weight and fruit length resulted in significant positive genotypic and phenotypic correlation with yield. Similar results were obtained by Islam *et al.* (2009), Bharathi *et al.* (2006).

Days to first harvest had low negative direct effect on yield at both phenotypic and genotypic level along with negative indirect effect through number of nodes per vine, days to last harvest, per cent fruit set and number of fruits per plant. Positive indirect effect was seen through number of primary branches per plant, vine length, days to anthesis of first female, number of nodes to first female flower, sex ratio, average fruit weight and fruit length. Similar results were reported by Rajput *et al.* (1996) in ridge gourd.

Days to last harvest had high positive direct effect on yield at both phenotypic and genotypic level. Positive indirect effect were seen through vine length, number of nodes to first female flower, days to first harvest, number of fruits per plant, average fruit weight and fruit length resulted in significant positive genotypic and phenotypic correlation with yield.

Sex ratio had high positive direct effect on yield at both phenotypic and genotypic level along with negative indirect effect through number of primary branches per plant, days to anthesis of first female flower vine length, number of nodes to first female flower, days to first and last harvest, average fruit weight, number of fruits per plant and fruit length resulted in significant negative genotypic and phenotypic correlation with yield. Similar results were obtained by Dey *et al.* (2005).

Per cent fruit set had low negative direct effect on yield at both genotypic levels. Positive indirect effect was observed in number of primary branches per plant, vine length, days to anthesis of first female flower, number of nodes to first female flower, days to last harvest, average fruit weight, number of fruits per plant and fruit length, while negative indirect effect was seen through number of nodes per vine, days to first harvest and sex ratio resulted in significant positive genotypic and phenotypic correlation with yield.

Number of fruits per plant had high positive direct effect on yield at both phenotypic and genotypic level. Positive indirect effect was observed through number of primary branches per plant, vine length, days to anthesis of first female flower, number of nodes to first female flower, days to first and last harvest, average fruit weight and fruit length resulted in significant positive genotypic and

phenotypic correlation with yield. These results are supported by Dubey *et al.* (2013), Islam *et al.* (2009), Malashetty (2010).

Average fruit weight had high positive direct effect on yield at both phenotypic and genotypic level. Positive indirect effect was observed through the number of primary branches per plant, vine length, days to anthesis of first female flower, number of nodes to first female flower, days to last harvest, number of fruits per plant and fruit length resulting in significant positive genotypic and phenotypic correlation with yield. Similar findings are reported by Dubey *et al.* (2013), Dubey *et al.* (2013a), Narasannavar *et al.* (2014), Dey *et al.* (2005).

Fruit length had high positive direct effect on yield. Positive indirect effects were seen through number of primary branches per plant, vine length, number of nodes to first female flower, days to last harvest, number of fruits per plant and average fruit weight resulting in significant positive genotypic and phenotypic correlation with yield.

Number of fruit per plant, average fruit weight and sex ratio was the most important contributing characters to fruit yield per plant as they showed very high direct effect at both phenotypic and genotypic level. Days to first harvest and per cent fruit set showed high negative direct effect on fruit yield per plant.

From the breeder's point of view, the character with high positive correlation and high direct effects at genotypic level are useful for selection. Thus, it can be concluded that number of fruits per plant and average fruit weight are most important traits influencing yield through direct effect coupled with high positive correlation.

In phenotypic path analysis also similar trends were observed in case of direct and indirect effects as well as correlations with yield. Number of fruits per plant and average fruit weight were the most important attribute contributing to yield. Therefore, direct selection for these traits would be rewarding for improvement of yield.

5.4 Screening of ridge gourd genotypes for downy mildew resistance

The genotypes Deepthi and IC-92638 were found to show resistant reaction, while IC-126249, Thovinkere Local, IC-335912, Sirsi Local, Arka Sujat, IC-92675, IC-335912 and IC-344652 were found to be moderately resistant.

None of the cultivars showed immune or highly resistant reaction to downy mildew disease. The resistance may be due to morphological and biochemical properties of the genotype. This result revealed that resistance will not fully ensures total crop protection, but choosing resistant varieties should rather be considered as a part of overall integrated disease management strategy, in particular they can be especially useful where the threat from downy mildew disease are very high. Hence the most resistant lines identified can be used as useful sources of resistance in breeding downy mildew disease resistant for ridge gourd cultivars.

VI. SUMMARY AND CONCLUSION

Findings of the research work on “Studies on genetic variability in ridge gourd [*Luffa acutangula* (L.) Roxb.]” genotypes are summarized below. The work was carried out at PG research block, College of Horticulture, Mysuru during the period of June, 2015 to April, 2016. In this study twenty genotypes were used by using randomized block design. The present study was undertaken to elicit information on the nature of variability in ridge gourd genotypes, correlation and path analysis studies on yield contributing component and to screen the genotypes against downy mildew disease.

The analysis of variance revealed that significant difference was observed for all the genotypes for all the characters studied except for 100 seed weight. The phenotypic co-efficient of variation was higher than the genotypic co-efficient of variation for all the characters studied indicating that non heritable factors contributed to the increased phenotypic variability & large genotype and environment interactions play an important role in the expression of these characters.

Low PCV and GCV were recorded for days to first harvest indicating the existence of limited variability in the germplasm evaluated for the trait. This necessitates the need for generation of new variability for this character where this variability has to be generated through introduction and hybridization of diversified genotypes to generate transgressive segregants.

Low GCV and moderate PCV were observed for number of primary branches per plant at 45 DAT, days to last harvest, sex ratio, percent fruit set and fruit diameter. Moderate GCV and high PCV were recorded for vine length, days to anthesis of first male flower and fruit length indicating that moderate amount of variability present in the germplasm for these characters.

Moderate GCV and PCV were observed for internodal length at 90 DAT, days to anthesis of first female flower, days to 50% flowering, average fruit weight and 100 seed weight indicating the limited variability for these traits in germplasm used for study. This suggests the need for generation of variable either by introduction, exploration or by hybridization to get the substantial gain in their improvement.

High PCV and GCV were recorded for parameters like number of primary branches per plant at 90 DAT, vine length at 90 DAT, number of nodes per plant at 45 and 90 DAT, internodal length at 45 DAT, number of nodes to first male and female flower to appear, number of fruits per plant, fruit yield per plant, vitamin C, crude protein, total chlorophyll content, seed yield per plant and number of seeds per fruit indicating that high magnitude of variability present in the germplasm for these characters. A high value of GCV indicates that there is a lot of scope for improvement of these characters through simple selection.

Heritability estimates were high for number of primary branches per plant at 90 DAT, vine length at 45 and 90 DAT, number of nodes per vine at 45 and 90 DAT, internodal length at 45 and 90 DAT, days to anthesis of first male flower, number of nodes to first male and female flower, number of fruits per plant, fruit yield per plant, average fruit weight, vitamin C, crude protein content, total chlorophyll content, seed yield per fruit and number of seeds per fruit indicating that these characters were less influenced by the environmental effect and were effectively transmitted to progeny.

High genetic advance over per cent of mean was observed for number of primary branches per plant at 90 DAT, vine length at 45 and 90 DAT, number of nodes per vine at 45 and 90 DAT, internodal length at 45 DAT, days to anthesis of first male flower, number of nodes to first male and female flower to appear, number of fruits per plant, fruit yield per plant, average fruit weight, fruit length, vitamin C, crude protein content, total chlorophyll content, seed yield per fruit and number of seeds per fruit indicating that these characters were controlled by additive gene action, selection for these characters will improve the yield. Simple selection schemes would suffice for improvement of these traits.

The genetic advance over per cent of mean was low for characters internodal length at 90 DAT, days to first and last harvest, sex ratio and fruit diameter. This situation arises when the variability for the character is low and the characters are controlled by non-additive gene action as they are highly influenced by environmental effects. Hence the simple selection would be ineffective for trait improvement.

High heritability coupled with high genetic advance as per cent of mean was observed for characters like number of primary branches per plant at 90 DAT, vine length at 45 and 90 DAT, number of nodes per vine at 45 and 90 DAT, internodal length at 45 DAT, days to anthesis of first male flower, number of nodes to first male and female flower, number of fruits per plant, fruit yield per plant, average fruit weight, vitamin C, crude protein content, total chlorophyll content and number of seeds per fruit indicates the predominant role of additive gene action in governing of these traits and improvement of these trait through simple selection would be rewarding.

High heritability coupled with moderate to low GAM was observed for internodal length 90 DAT indicating the role of non-additive gene effects. Hence, improvement in these traits would be more effective by selecting specific combinations followed by inter mating of lines.

For character association, genotypic and phenotypic correlations were considered. In the present study, genotypic correlations was higher than phenotypic correlations indicating high heritable nature of the character like fruit yield per plant which showed positive and significant correlation with number of primary branches per plant at 90 DAT, vine length at 90 DAT, number of nodes per vine at 90 DAT, number of nodes to first male and female flower appear, days to last harvest, percent fruit set, number of fruits per plant, fruit weight, fruit length, seed yield per fruit and 100 seed weight both at genotypic and phenotypic level. Since, these association characters are in the desirable direction, selection for these traits may improve the yield per plant. Whereas fruit yield per plant had negative significant association with sex ratio implies that as sex ratio decreases, fruit yield per plant increases. This suggested that simultaneous improvement of these traits is effective.

The path co-efficient analysis for fruit yield per plant was carried out considering 12 independent component characters, at both phenotypic and genotypic level. Path coefficient analysis revealed that the number of primary branches per plant, vine length, days to anthesis of first female flower, number of nodes to first female flower, days to last harvest, sex ratio, number of fruits per plant, fruit weight and fruit length were the most influencing factors with direct positive effect on fruit yield. Thus, these characters deserve greater weightage during selection for yield. The direct selection for these traits would be rewarding for improvement in the fruit yield per plant.

The genotypes Deepthi and IC-92638 were found to show resistant reaction, while IC-126249, Thovinkere Local, IC-335912, Sirsi Local, Arka Sujat, IC-92675, IC-335912 and IC-3444652 were found to be moderately resistant. The most resistant lines identified can be used as sources of resistance in breeding downy mildew disease resistant ridge gourd cultivars.

FUTURE LINE OF WORK

1. The promising and elite genotypes should be used as parents in hybridization to develop a variety with good quality and high productivity.
2. Hybridization should be resorted to create recombinants and transgressive segregants.
3. There is a need to identify specific combinations which exhibit heterosis for economic characteristics.
4. The identified resistant lines should be used as sources of resistance in breeding downy mildew disease resistant for ridge gourd cultivars.

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* Originals not seen

APPENDIX- I

Meteorological data recorded during the period of experimentation (June-2015 to April - 2016) in Mysuru.

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
	Minimum	Maximum	Minimum	Maximum	
June 2015	29.97	20.64	70.13	84.67	164.10
July 2015	20.33	29.70	65.81	82.00	14.40
August 2015	20.23	30.64	65.55	81.32	55.20
September 2015	20.12	30.99	61.63	80.20	130.00
October 2015	19.57	30.44	61.61	81.19	99.20
November 2015	19.69	28.08	70.73	83.53	122.60
December 2015	17.89	29.21	54.26	80.39	1.60
January 2016	16.98	29.96	41.35	17.90	0.40
February 2016	17.64	32.96	32.34	71.17	0.00
March 2016	20.62	35.56	29.00	70.52	3.00
April 2016	22.79	37.22	28.27	70.63	19.00

APPENDIX II

Per se performance for morphological and growth parameters in ridge gourd [*Luffa acutangula* (L.) Roxb].

	Number of branches per plant		Vine length(cm)		Number of nodes per vine		Internodal length (cm)	
	45 DAT	90 DAT	45 DAT	90 DAT	45 DAT	90 DAT	45 DAT	90 DAT
Deepti	2.71	4.1	235.65	341.5	17.4	29.35	13.6	11.63
Kolar Local	2.7	3.95	219.2	371	14.15	28.4	15.56	13.07
IC-344512	2.05	4.0	207.9	513.1	14.3	32.55	14.68	15.87
IC-344605	2.6	3.1	242.88	551.15	17.1	40.15	14.2	13.75
IC-126249	2.6	4.65	249.94	618.5	16.4	38.1	15.29	16.36
Thovinkere local	2.5	3.9	226.48	529.725	13.9	34.56	16.47	15.47
IC-92675	2.6	3.8	178.55	412.6	16.95	27.46	10.51	15.03
Arka Sujat	2.5	6.8	234.05	516.65	17.93	37.96	13.08	14.79
IC-144613	2.9	3.7	259.28	393/0	14.4	25.7	18.02	15.36
IC-92638	2.33	3.7	234.7	514.5	7.7	30.73	30.63	16.9
IC-124268	3.3	3.8	158.93	465.7	12.9	27.93	12.3	16.87
IC-335912	2.7	4.0	162.2	219.955	15.55	18.3	10.76	12.03
IC-344652	2.5	4.8	173.8	297.05	18.3	17.4	9.49	17.31
IC-201145	2.4	3.0	118	241	12.05	20.825	9.78	11.71
Gokak local	2.4	3.2	219.25	406.56	17.0	24.5	12.9	17.47
IC-92618	2.8	3.6	274.4	428.62	13.75	27.9	20.13	15.79
Green long	3.3	4.1	167.45	228.5	11.76	17.6	14.31	13.11
Mysuru local	2.5	3.4	184.5	271.63	17.25	30.5	10.72	8.92
IC-385912	2.9	4.0	257.33	667.565	16.98	43.425	15.63	15.39
IC-146606	2.75	3.8	206.6	361	20.34	26.82	10.2	13.49
Jaipur long	2.9	3.2	248.45	464.09	14.7	30.075	16.89	15.42
Arka Sumeet	2.9	7.4	213.75	818.94	24.6	49.57	8.69	16.53
Yaderanghalli Local	2.6	4.3	291.0	798.19	14.61	41.08	19.95	19.45
Pusa Nasdar	2.25	4.3	181.6	268.135	11.45	23.52	15.92	11.42
Ghataprabha local	2.5	3.6	160.4	223.27	10.75	20.34	14.9	10.97
S.Em+-	0.17	0.25	1.04	13.98	1.04	1.47	1.65	1.14
<u>CD.@5%</u>	0.5	0.74	3.02	40.8	3.02	4.3	4.83	3.32
CV	9.18	8.75	9.58	4.51	9.58	6.99	16.03	11.06

APPENDIX II continued.

	Days to anthesis for first male flower	Days to anthesis for first female flower	Number of nodes to first male flower	Number of nodes to first female flower	Days to 50 % flowering	Days to first harvest	Days to last harvest	Sex ratio
Deepti	24.58	34.675	4.3	8.7	46.95	42.87	109.5	24.86
Kolar Local	23.91	38.2	3.3	7.4	51.225	48.6	90	24.11
IC-344512	25	32.17	3.7	7	40.3	50.9	103.5	25.58
IC-344605	23.5	35.335	3.6	8.7	46.3	43.7	99.5	24.25
IC-126249	31.5	38.625	5.6	10.8	50.9	47.45	88.5	20.07
Thovinkere local	24.63	34.325	2.05	10.2	47.375	45	109.5	22.38
IC-92675	24.5	30.035	4.2	10.25	38.97	45.38	103.5	25.62
Arka Sujat	30.67	35.6	3.83	9.5	49.74	52.5	91.5	20.57
IC-144613	24.6	23.8	4.4	6.8	37.1	48.53	90	26.05
IC-92638	37.6	30.665	6.4	7.98	39.925	39.55	114	18.28
IC-124268	24.6	34.325	3.2	9.3	42.91	46.1	87.5	26.63
IC-335912	21	34.375	3.1	4.4	36.66	50.34	89	26.76
IC-344652	24.38	36.875	4.4	8	49.565	46.88	94	23.06
IC-201145	23.8	31.28	3.7	6	39.57	44.88	93	24.74
Gokak local	24.5	36.835	3.8	11	41.99	54.89	102.5	23.72
IC-92618	24.28	34.375	3.3	6	36.95	45.7	92	26.7
Green long	21.77	27.975	3.33	5.5	40.35	49.17	103.5	27.4
Mysuru local	21.74	31.83	3.2	8.25	36.12	49.38	91	22.2
IC-385912	24.3	38.75	4.6	11.1	46.26	47.5	113	24.84
IC-146606	22.55	32.17	5.2	7.74	41.765	47	103.5	25.8
Jaipur long	22.4	33.25	3.9	9.08	50.05	45.5	103.5	21.89
Arka Sumeet	29.9	38.35	6.1	14.5	50.125	51.05	100	23.48
Yaderanghalli Local	42.78	47.34	4.7	21.54	56.42	58.58	106.5	24.59
Pusa Nasdar	23.7	35	3	12.24	44.215	49	92	22.75
Ghataprabha local	24.04	38.65	3.3	7.63	50.83	49	84.5	28.36
S.Em+-	1.69	2.69	0.49	1.13	3.31	2.28	5.57	1.63
CD.@5%	4.94	7.84	1.43	3.29	9.66	6.66	16.26	4.74
CV	9.26	10.98	17.31	17.37	10.52	6.73	8.03	9.5

APPENDIX III

Per se performance for yield and yield parameters in ridge gourd [*Luffa acutangula* (L.) Roxb]

	Per cent fruit set (%)	Number of fruits per plant	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (mm)	Fruit yield (g)
Deepti	70.72	5.01	201.4	25.05	41.06	1014.6
Kolar Local	67.41	5.32	193.9	27.15	51.01	1031.604
IC-344512	66.69	3.89	242.8	29.8	52.09	945.891
IC-344605	66.83	4	176.3	18.1	52.63	731.564
IC-126249	76.98	6.6	201	21.3	43.95	1330.52
Thovinkere local	69.58	6.695	175.4	24	53.57	1173.67
IC-92675	67.42	4.045	221.5	21.4	44.48	883.288
Arka Sujat	75.73	6.3	252.2	39.8	50.32	1593.54
IC-144613	63.42	3.855	235.4	29.35	45.98	903.746
IC-92638	74.1	8	226	29.6	43.34	1825.2
IC-124268	53.97	2.94	267.9	29.45	47.21	792.022
IC-335912	54.61	2.045	141.4	18.1	37.72	297.036
IC-344652	72.05	5.82	176.7	21.95	56.1	1028.88
IC-201145	53.98	4.005	143.9	23.9	41.11	578.336
Gokak local	62.2	3.045	264.7	29.125	47.2	430.701
IC-92618	57.27	2.72	173.7	24.8	40.66	471.384
Green long	57.4	2.695	180.5	25.95	50.25	617.185
Mysuru local	65.01	3.995	163.1	26.6	45.25	652.447
IC-385912	66.31	4.11	228	30.2	44.64	928.764
IC-146606	72.72	4.885	232.9	31.15	45.29	1132.524
Jaipur long	56.84	2.945	233.8	34	44.21	684.936
Arka Sumeet	77.46	6.75	266.8	37.85	44.04	1802.37
Yaderanghalli Local	78.16	6.1	210.3	25.27	44.97	1282.05
Pusa Nasdar	70.38	4.23	219.6	27.6	43.49	932.652
Ghataprabha local	51.41	1.595	189.5	25.2	46.06	302.423
S.Em+-	4.8	0.5	15.12	2.71	2.88	125.78
<u>CD.@5%</u>	14	1.47	44.12	7.92	8.42	367.4
CV	10.29	15.98	10.24	14.18	8.81	18.75

APPENDIX IV

Per se performance for quality and seed parameters in ridge gourd [*Luffa acutangula* (L.) Roxb].

	Vitamin C (mg)	Crude Protein (%)	Chlorophyll (mg)	Seed yield per fruit (g)	Number of seeds/ fruit	100 seed weight (g)
Deepti	17.44	16	2.07	15.17	95.34	15.21
Kolar Local	4.95	16.83	1.91	14.92	113.42	13.16
IC-344512	12.4	8.82	2.17	12.84	90.08	14.12
IC-344605	14.96	15.7	1.54	25.09	173.51	13.81
IC-126249	17.95	10.26	2.98	32.67	198.32	12.53
Thovinkere local	14.08	12.77	1.52	27.84	183.84	15.2
IC-92675	21.28	17.01	1.62	18.1	140.5	12.87
Arka Sujat	17.89	4.83	0.91	21.25	144.59	14.71
IC-144613	21.65	7.39	2.09	25.51	146.31	17.41
IC-92638	17.2	9.24	2.3	23.75	138.5	17
IC-124268	16.63	5.53	1.57	12.34	81.18	14.58
IC-335912	10.72	14.95	1.59	22.51	168.18	13.56
IC-344652	10.33	9.98	2.21	22.17	131.01	17.04
IC-201145	39.15	22.09	2.52	11.17	76.42	14.45
Gokak local	14.56	14.77	2.39	8.42	68.5	11.34
IC-92618	20.08	14.77	1.67	12.94	171.83	10.48
Green long	15.31	16.45	1.56	10.75	55.09	24.21
Mysuru local	17.7	15.68	2.09	17	127.5	13.07
IC-385912	10.24	17.99	1.74	15.59	109.09	15.77
IC-146606	16.03	13.58	1.97	27.01	142.68	18.17
Jaipur long	12.12	9.91	1.55	11.5	81	14.62
Arka Sumeet	16.9	4.06	1.73	16.42	93.35	17.96
Yaderanghalli Local	16.83	11.69	1.23	25.92	143.5	17.29
Pusa Nasdar	16.57	10.96	2.17	8.59	64.17	15.08
Ghataprabha local	17.66	13.51	3.03	13.83	96.17	14.34
S.Em+-	1.75	0.6	0.12	2.59	18.38	2.11
CD.@5%	5.1	1.75	0.36	7.56	53.66	6.16
CV	15.06	6.74	9.11	20.21	21.42	19.74