# GENETIC VARIABILITY STUDIES IN CHILLI (*Capsicum annuum* L.) FOR YIELD AND YIELD ATTRIBUTING CHARACTERS


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**SHIVAMOGGA**

## CERTIFICATE

This is to certify that the thesis entitled **'GENETIC VARIABILITY STUDIES IN CHILLI (*Capsicum annuum* L.) FOR YIELD AND YIELD ATTRIBUTING CHARACTERS'** submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE) in GENETICS AND PLANT BREEDING** to the College of Horticulture, Mudigere. University of Agricultural and Horticultural Sciences, Shivamogga is a bonafide record of research work carried out by **JAYANTHI B. V.,** I.D. No. **MH2TAH0200** (jayanthibv16@gmail.com) during the period of study in this university under my guidance and supervision and no part of this thesis has previously formed the basis for the award of any other degree, diploma, associateship, fellowship or any other similar titles.

**Mudigere**
**January, 2021**

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**GENETIC VARIABILITY STUDIES IN CHILLI (*Capsicum annuum* L.) FOR YIELD AND YIELD ATTRIBUTING CHARACTERS**

**(JAYANTHI, B. V.)**

**ABSTRACT**

The present investigation in chilli (*Capsicum annuum* L.) was carried out during rabi season 2019 with 63 genotypes in Augmented block design. Analysis of variance revealed that highly significant difference for all the characters indicating existence of genetic variability among genotypes. Estimates of PCV were higher than GCV with narrow differences for most of the traits. The high estimates of heritability coupled with genetic advance as per cent mean was observed for plant height, number of primary branches, secondary branches, fruit length, fruit diameter, fruits per plant, fruit weight, fruit yield per plant, fruit yield per plot, test weight, germination percentage, root length, shoot length, root to shoot ratio and seedling vigour index-1. Fruit yield per plant was positively and significantly correlated with number of secondary branches, fruit diameter, number of fruits per plant and fruit weight in both green and red ripe chilli. Path analysis revealed that fruit yield per plant had a direct positive effect on days to first flowering, days to 50 per cent flowering, days to first picking, plant height, number of secondary branches, fruit length, fruit diameter, number fruits per plant, and fruit weight which are important characters to be accounted for gaining improvement in yield. Chilli genotypes were grouped into seven clusters based on Mahalanobis $D^2$ statistic. Cluster I was largest having 38 genotypes followed by cluster II with 19 genotypes. The maximum inter cluster distance was observed between clusters IV and V. Highest intra cluster distance was observed in cluster II. Red ripe fruit yield per plant contributed maximum to the total genetic divergence (36.61 %) followed by green fruit yield per plant (32.97 %). IC-545662, IC-119556, IC-545660 and G-3 recorded higher yield and can be utilized for further breeding programme.

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**ಮೆಣಸಿನಕಾಯಿಯಲ್ಲಿನ (ಕ್ಯಾಪ್ಸಿಕಮ್ ಆ್ಯನಮ್ ಎಲ್.) ಇಳುವರಿ ಮತ್ತು ಇಳುವರಿಯ ಗುಣಲಕ್ಷಣಗಳ ಅನುವಂಶಿಕ ವ್ಯತ್ಯಾಸದ ಅಧ್ಯಯನ**

**(ಜಯಂತಿ, ಬಿ. ವಿ.)**

**ಸಾರಾಂಶ**


ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವನ್ನು ೨೦೧೯ರ ಹಿಂಗಾರಿನಲ್ಲಿ ೬೩ ಮೆಣಸಿನಕಾಯಿ ತಳಿಗಳೊಂದಿಗೆ ವರ್ಧಿತ ಬ್ಲಾಕ್ ವಿನ್ಯಾಸದಲ್ಲಿ ನಡೆಸಲಾಯಿತು. ಇಳುವರಿ ಮತ್ತು ಗುಣಲಕ್ಷಣಗಳ ವ್ಯತ್ಯಾಸದ ವಿಶ್ಲೇಷಣೆ ನಡೆಸಿದಾಗ ತಳಿಗಳ ನಡುವೆ ಅನುವಂಶಿಕ ವ್ಯತ್ಯಾಸಗಳು ಗಮನಾರ್ಹ ಪ್ರಮಾಣದಲ್ಲಿ ಇರುವುದು ಕಂಡುಬಂದಿದೆ. ಬಾಹ್ಯ ಗುಣಲಕ್ಷಣಗಳ ವ್ಯತ್ಯಾಸದ ಗುಣಾಂಕವು ಅನುವಂಶಿಕ ವ್ಯತ್ಯಾಸದ ಗುಣಾಂಕಕ್ಕಿಂತ ಹೆಚ್ಚಿನ ಪ್ರಮಾಣದಲ್ಲಿದ್ದು ಜೊತೆಗೆ ಕಡಿಮೆ ಪ್ರಮಾಣದ ವ್ಯತ್ಯಾಸಗಳನ್ನು ಹೊಂದಿದೆ. ಅಧಿಕ ಅನುವಂಶಿಕತೆ ಜೊತೆಗೆ ಹೆಚ್ಚು ಅನುವಂಶಿಕದ ಮುಂಗಡದ ಸರಾಸರಿಯು ಗಿಡದ ಎತ್ತರ, ಪ್ರಾಥಮಿಕ ರೆಂಬೆಗಳ ಸಂಖ್ಯೆ, ದ್ವಿತೀಯ ರೆಂಬೆಗಳ ಸಂಖ್ಯೆ, ಕಾಯಿಯ ಉದ್ದ, ಕಾಯಿಯ ವ್ಯಾಸ, ಒಂದು ಸಸ್ಯಕ್ಕೆ ಕಾಯಿಗಳ ಸಂಖ್ಯೆ, ಕಾಯಿಯ ತೂಕ, ಒಂದು ಸಸ್ಯಕ್ಕೆ ಕಾಯಿಯ ಇಳುವರಿ, ಪರೀಕ್ಷಾ ತೂಕ, ಶೇಕಡಾವರು ಮೊಳಕೆಯ ಪ್ರಮಾಣ, ಬೇರಿನ ಉದ್ದ, ಚಿಗುರಿನ ಉದ್ದ, ಬೇರು ಮತ್ತು ಚಿಗುರಿನ ಅನುಪಾತ ಮತ್ತು ಸಸಿಯ ಸಧೃಡತೆ ಸೂಚ್ಯಂಕ–೧ ರಲ್ಲಿ ಕಂಡುಬಂದಿದೆ. ಪ್ರತಿ ಸಸ್ಯದ ಕಾಯಿಯ ಇಳುವರಿ, ದ್ವಿತೀಯ ರೆಂಬೆಗಳ ಸಂಖ್ಯೆ, ಕಾಯಿಯ ವ್ಯಾಸ, ಒಂದು ಸಸ್ಯದ ಕಾಯಿಗಳ ಸಂಖ್ಯೆ, ಮತ್ತು ಕಾಯಿಯ ತೂಕವು ಹಸಿರು ಮತ್ತು ಕೆಂಪು ಮಾಗಿದ ಕಾಯಿಯ ಇಳುವರಿಯೊಂದಿಗೆ ಸಕಾರಾತ್ಮಕವಾಗಿ ಹಾಗು ಗಮನಾರ್ಹವಾಗಿ ಸಂಬಂಧ ಹೊಂದಿದೆ. ಮೊದಲು ಹೂ ಬಿಡುವ ದಿನಗಳು, ಶೇಕಡಾ ೫೦ ರಷ್ಟು ಹೂ ಬಿಡಲು ತೆಗೆದುಕೊಳ್ಳುವ ದಿನಗಳು, ಮೊದಲು ಕೊಯ್ಯುವ ದಿನಗಳು, ಸಸ್ಯದ ಎತ್ತರ, ದ್ವಿತೀಯ ರೆಂಬೆಗಳ ಸಂಖ್ಯೆ, ಕಾಯಿಯ ಉದ್ದ, ಕಾಯಿಯ ವ್ಯಾಸ, ಒಂದು ಸಸ್ಯಕ್ಕೆ ಕಾಯಿಗಳ ಸಂಖ್ಯೆ, ಒಂದು ಸಸ್ಯಕ್ಕೆ ಕಾಯಿಯ ಇಳುವರಿ ಮತು ಕಾಯಿಯ ತೂಕವು ಪ್ರತಿ ಸಸ್ಯಕ್ಕೆ ಕಾಯಿಯ ಇಳುವರಿಯ ಮೇಲೆ ಸಕಾರಾತ್ಮಕ ನೇರ ಪರಿಣಾಮವನ್ನು ಬೀರಿರುವುದು ಕಂಡುಬಂದಿದೆ ಹಾಗೂ ಇವು ಇಳುವರಿಯಲ್ಲಿ ಸುಧಾರಣೆಯನ್ನು ಪಡೆಯಲು ಪ್ರಮುಖ ಪಾತ್ರ ವಹಿಸುತ್ತವೆ. ಮಹಾಲನೋಬಿಸ್ ಡಿ² ಸ್ಟ್ಯಾಟಿಸ್ಟಿಕ್ ಪದ್ಧತಿಯ ಅಂಕಿ ಆಧಾರದ ಮೇಲೆ ಮೆಣಸಿನಕಾಯಿ ತಳಿಗಳನ್ನು ೭ ಗುಂಪುಗಳಾಗಿ ವಿಂಗಡಿಸಲಾಗಿದೆ. ಮೊದಲನೆ ಗುಂಪು ದೊಡ್ಡದಾಗಿದ್ದು ೩೮ ತಳಿಗಳನ್ನೊಳಗೊಂಡಿದೆ ನತಂರ ಗುಂಪು ೨ ರಲ್ಲಿ ೧೯ ತಳಿಗಳು ಕಂಡುಬಂದಿವೆ. ಗುಂಪು ೪ ಮತ್ತು ೫ ರ ನಡುವೆ ಗರಿಷ್ಠ ಅಂತರವಿದ್ದು ನಂತರ ಗುಂಪು ೪ ಮತ್ತು ೭. ಗುಂಪು ೨ ರಲ್ಲಿ ಗರಿಷ್ಠ ಗುಂಪಿನೊಳಗಿನ ಅಂತರವನ್ನು ಗಮನಿಸಲಾಗಿದೆ. ಪ್ರತಿ ಸಸ್ಯದ ಕೆಂಪು ಮಾಗಿದ ಕಾಯಿಯ ಇಳುವರಿ (೩೬.೬೧ %) ನಂತರ ಪ್ರತಿ ಸಸ್ಯದ ಹಸಿರು ಕಾಯಿಯ ಇಳುವರಿ (೩೨.೯೭ %) ಅನುವಂಶಿಕ ವೈವಿಧ್ಯತೆಗೆ ಗರಿಷ್ಠ ಕೊಡುಗೆ ನೀಡಿತು ಎಂಬುವುದು ತಿಳಿದು ಬರುತ್ತದೆ. IC- ೫೪೫೬೬೨, IC- ೧೧೯೫೫೬, IC- ೫೪೫೬೬೦ ಮತ್ತು G-೩ ತಳಿಗಳು ಹೆಚ್ಚಿನ ಇಳುವರಿಯನ್ನು ನೀಡುವ ಕ್ಷಮತೆಯನ್ನು ಹೊಂದಿದ್ದು ಇವುಗಳನ್ನು ಭವಿಷ್ಯದಲ್ಲಿ ಸಸ್ಯಗಳ ತಳಿ ಅಭಿವೃದ್ಧಿ ಕ್ರಮಗಳನ್ನು ಕೈಗೊಳ್ಳುವ ಮೂಲಕ ಮತ್ತಷ್ಟು ಸುಧಾರಿಸಬಹುದಾಗಿದೆ.



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ಅನುವಂಶೀಯತೆ ಮತ್ತು ಸಸ್ಯ ತಳಿ ಅಭಿವೃದ್ಧಿ ವಿಭಾಗ
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# INTRODUCTION

# I INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important vegetable, spice and cash crop grown throughout India. It belongs to the genus capsicum under the family Solanaceae having chromosome number of 2n = 24. The primary center of origin of chilli is Mexico with secondary center in Guatemala and Bulgaria (Salvador, 2002). Chilli is grown for its pungent fruits, used in both green and ripe or dry form. It was introduced by Portuguese into southern parts of India and its cultivation further spread throughout India by the end of the $19^{th}$ century (Bahurupe *et al*., 2013).

There are estimated 1,600 different varieties of chilli with five domesticated species including *Capsicum annuum* L, *Capsicum frutescens* L, *Capsicum chinensis* L, *Capsicum baccatum* L and *capsicum pubescens* L (Bosland and Votava, 2000). In India, only two types *viz*., *Capsicum annuum* L and *Capsicum frutescens* L are documented and most of the cultivated varieties of chilli belongs to the *Capsicum annuum*. The cultivated species has its unique place in the diet as vegetable cum spice (Gadaginmath, 1992). It is classified under self-pollinated crops but the extent of natural out-crossing has also reported up to 66.40 per cent (Singh *et al*., 1994). Due to the long history of cultivation and out-crossing nature of the crop, large genetic diversity is available in most of its cultivated areas (Patel and Patel, 2014).

Chilli is occupying an area of about 25 per cent of the cultivated area in India (State of Indian Agriculture 2012-13, Ministry of Agriculture). India is the largest producer and exporter of chilli with a share of 56.4 per cent in the world export market. In India, chilli is grown in an area of 7.75 lakh hectares with the annual production of 14.92 lakh metric tons with productivity of 1.9 tons per hectare. Andhra Pradesh is the largest producer of chilli in India and contributes about 26 per cent of the total area under chilli followed by Maharashtra (15 %) and Karnataka (11 %) (NHB, 2018-19).

Chilli is the most economic additive to improve food acceptability. It is referred to as universal spice having diverse utilities as a vegetable, spice, condiment, culinary purpose, medicinal properties due to rich source of various phytochemicals and other compounds. Immature green chilli fruit contains phytonutrients like ascorbic acid, carotenoids, rutin *etc*. It has also acquired an excellent importance due to the presence of oleoresin which allows better colour distribution and flavour (Maurya *et al.,* 2017).

Chilli contains a wide range of essential nutrients and bioactive compounds which are known to exhibit antioxidant, antiviral, antimicrobial, anticancer and anti-inflammatory properties. It is a rich source of vitamin A, B, C, E and P (Quresh *et al.,* 2015). The pungency of chilli is due to the presence of alkaloid capsaicin which can directly scavenge various free radicals and thus acts as an anticancerous compound.

A wide range of variability exists in this crop (Nandi, 1992). Cultivation in small holdings by individual farmers under diverse environmental conditions particularly in South Penisular region, Northeastern foothills of Himalaya and Gangetic plains (Pradheep and Veeraragavathatham, 2006). Knowledge on the nature of variability and association of yield with its components is of great importance for the identification of superior parents in any breeding programme. The right evaluation and selection provide scope for identifying desirable genes for exploitation, either in itself or through hybridization. The effectiveness of selection successively depends upon the genetic variability present within the population.

To initiate any breeding programme work, it is necessary to assess the genetic variability present in the indigenous genotypes for yield and its components. Genetic parameters like genotypic and phenotypic coefficient of variations are useful in detecting the quantity of variability present in the germplasm. Heritability and genetic advance helps in determining the influence of environment in expression of the characters and the extent to which improvement is possible after selection. Hence, the genotypes were characterized to assess the variability and identification of promising genotypes which can be used in breeding programmes (Datta and Das, 2013).

Burton and De Vane (1953) suggested that genetic variability along with heritability should be considered for assessing the utmost and accurate effect of selection. The knowledge of nature and magnitude of genetic variability in the population is of immense value for the planning of efficient breeding programme to enhance the yield potential of the genotype (Singh *et al.*, 2017).

Yield is a complex character controlled by a massive number of contributing characters and their interaction. It is not only influenced by polygenes but also influenced to a greater extent by the environment. The study of the correlation coefficient helps in the simultaneous selection of more than one character, since the yield is dependent on many component characters. Knowledge of correlation alone is insufficient to elucidate the true association between the characters. To possess a clear picture of yield components for effective selection programme, it might be desirable to think about the relative magnitude of varied characters. Path coefficient analysis will help for checking out the entire correlation into indirect and direct effects which is beneficial in selecting high yielding genotypes (Vidya *et al*., 2018).

The productivity of chilli in India is low due to the dominance of open-pollinated varieties (Pandit and Adhikary, 2014). The other limiting factors attributed for low productivity are lack of superior genotypes or improved cultivars for use in the breeding programme to develop potential hybrids, the severe incidence of insect pests (thrips, mites, and borers) and diseases (anthracnose, leaf spots and viral diseases) leading to a tremendous reduction in yield and quality. So, the breeder needs to review the nature and degree of genetic divergence which is important to settle on the proper sort of parents for purposeful heterosis breeding. So, to the benefit of transgressive segregants, the knowledge of the genetic distance between parents is necessary (Srinivas *et al*., 2013). This facilitates the identification of promising genotypes which may further be used directly or indirectly in breeding programmes.

Hence, keeping the overview of the above perspectives, the present investigation entitled “Genetic variability studies in chilli (*Capsicum annuum L.*) for yield and yield attributing characters” is formulated with the following objectives:

1. To assess the extent of genetic variability for yield and its component traits in chilli genotypes.
2. To study the character association and path analysis among yield and its contributing characters.
3. To assess the genetic diversity among the genotypes for yield and its component traits.

# REVIEW OF LITERATURE

# II REVIEW OF LITERATURE

A vegetable breeder is primarily concerned with the improvement of both quantitative and qualitative characters. Several studies have been carried out for improvement of various traits in chilli. The magnitude of such success lies with the selection of the base material and its creative manipulation. The research that has been done on genetic variability, heritability, genetic advance, character association, path coefficient analysis and genetic divergence has been very useful in support of plant improvement activities in chilli. In this chapter, an attempt has been made to review the available relevant literature on chilli and presented under following headings.

2.1 Genetic variability studies

2.2 Correlation and path coefficient analysis

2.3 Genetic divergence

## 2.1 GENETIC VARIABILITY STUDIES

A good range of variability in any crop provides a far better chance of selecting desirable types. The extent of improvement expected by selection in any population depends on the genetic variability available within the population. The importance of genetic variability was perceived for the primary time by a Russian scientist, Vavilov (1951) who advocated that wider the range of variability in the available germplasm, better probabilities for choosing superior genotypes (Simmonds, 1962). The relevant literature on variability studies in chilli (*Capsicum annuum* L.) is reviewed below:

Kumari *et al.* (2010) studied the genetic variability in 94 genotypes of paprika (*Capsicum annuum* L.) for seventeen characters and observed high PCV, GCV and high heritability coupled with high genetic advance for number of fruits per plant, fresh fruit yield per plant, capsanthin, capsaicin and oleoresin content indicating a better magnitude of variability for these traits and consequently more scope for their improvement through selection. Plant height and fruit diameter exhibited moderate PCV and GCV estimates suggesting the possible role of environment in the expression of these characters.

Padhar and Zaveri (2010) studied genetic variability in fifty chilli genotypes for twelve quantitative traits. Significant differences were observed for all the traits studied. The estimates of GCV and PCV were high for number of fruits per plant, fresh fruit yield per plant, dry fruit yield per plant, pulp to seed ratio, girth of fruit and length of fruit. Similarly, high amount of heritability and genetic advance was also observed for all the characters.

Sharma *et al*. (2010) evaluated 23 genetically diverse genotypes of bell pepper. Significant differences were observed among the genotypes for all the traits. Genotypes PRC-1, SSP, Kandaghat Sel. and Ranichauri Sel-1 were outperformed for fruit yield per plant, average fruit weight, number of fruits per plant and took minimum number of days to 50 per cent flowering. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was high for fruit yield per plant indicating that the trait had wide genetic variability and would respond better to selection. High heritability and high genetic advance were recorded for average fruit weight, fruit yield per plant, fruit diameter and days to the first harvest indicating the role of additive gene action for the inheritance of those traits.

Suryakumari *et al*. (2010) evaluated ninety-four genotypes for 17 characters. Results revealed that higher phenotypic and genotypic coefficient of variation and heritability coupled with high genetic advance was observed for number of fruits per plant, fresh fruit yield per plant, dry fruit yield per plant, 100 seed weight, number of seeds per fruit. Plant height, plant spread and fruit diameter exhibited moderate PCV and GCV estimates suggesting the possible role of environment in expression of these characters.

Chattopadhyay *et al.* (2011) studied the genetic variability for different yield attributing traits with the green and dry yield of chilli. Thirty-four genotypes were characterized for two years. Two genotypes, 'Chaitail Pointed' and 'BCCH Selection 4' were found most promising to green fruit yield (272.79 g, 221.10 g / plant) and dry fruit yield (54.56 g, 44.44 g / plant). Phenotypic and genotypic coefficient of variation values for green fruit weight (119.95 %, 111.26 %), green fruit girth (89.76 %, 48.93 %), the weight of red ripe fruit (112.02 %, 111.93 %) and number of fruits per plant (86.05 %, 85.02 %) were recorded to be high.

Jyothi *et al*. (2011) evaluated 10 genotypes of chilli for 8 characters and found significant differences among genotypes in respect of all the characters studied. High GCV and PCV were observed for ripe chilli yield, dry chilli yield, number of fruits per plant, number of seeds per fruit and fruit length indicating a better magnitude of variability in these traits and consequently, greater scope for improvement through simple selection. Low GCV and PCV were recorded for plant height and fruit girth suggesting a limited variability for these traits.

Kumar *et al.* (2012) carried out genetic variability studies in chilli and found that the phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits like number of branches at 150 days after transplanting, days to flower anthesis, number of fruits per plant and average fruit weight. Genetic advance at 5 per cent was found high for 150 days after transplanting, number of fruits per plant, ascorbic acid and fruit yield per plant (g). Whereas, genetic advance as per cent mean at 5 per cent was noticed high for all the traits except days to flower initiation and days to first harvest.

Jogi *et al*. (2013) observed genetic variability in 50 chilli genotypes for thirty-two characters. A high degree of variation was observed for all the characters. The difference between the phenotypic coefficient of variation and genotypic coefficient of variation was found to be narrow for most of the traits.

Amit *et al*. (2014) studied 23 chilli genotypes and recorded high coefficient of variation both at the phenotypic and genotypic level for number of fruits per plant, fruit weight and dry (red) yield. Number of the fruits per plant, green fruit yield per plant, dry (red) yield per plant, number of seeds per plant and plant height exhibited high genetic advance as percentage of mean along with high heritability. These results indicated the influence of additive gene action. High genetic advance for number of fruits per plant and fruit yield per plant were also recorded.

Magaji *et al*. (2014) carried out an experiment to study genetic variability among chilli for heat tolerance and morphophysiological traits. Highly significant variation was observed among the genotypes in response to high temperature (CMT), photosynthesis rate, plant height, disease incidence, fruit length, fruit weight, number of fruits and yield per plant. High genetic advance as per cent of the mean (>20 %) was observed for CMT, photosynthesis rate, fruit length, fruit weight, number of fruits and yield per plant. Similarly, high heritability (>60 %) was also observed indicating the substantial effect of additive gene.

Pandit and Adhikary (2014) estimated variability and heritability for important reproductive and yield characters in 41 chilli genotypes. The close estimates of phenotypic and genotypic coefficient of variation were noted in all the characters except fruit width, which imply that contribution towards final phenotypic expression of these characters are mostly genetic rather than environmental. Very high genetic advance as per cent of mean was recorded in fruit yield per plant and moderately high genetic advance as per cent of mean was recorded in days to 50 per cent flowering, placenta length, fruit length, number of fruits per plant and number of seeds per plant, indicating that these characters are most likely governed by additive gene action and hence will be rewarding.

Yatung *et al*. (2014a) concluded that in chilli analysis of variance revealed significant differences among genotypes for all the traits. High PCV and GCV were observed for days to first flowering, plant height, number of seeds per fruit, number of fruits per plant and fruit yield per plant.

Bijalwan and Madhvi (2015) evaluated 16 genotypes of chilli for 15 characters and recorded higher phenotypic coefficient of variation than genotypic coefficient of variation for all the characters indicating the influence of environment on these characters. High GCV, PCV, heritability and genetic advance as percentage of mean were noted for fruit weight at edible maturity (61.04 %, 61.37 %, 99.02 % and

125.09 %, respectively), fruit yield per plant (47.67 %, 48.24 %, 97.63 % and 97.03 %, respectively) and number of fruits per plant (39.77 %, 40.11 %, 98.31 % and 81.24 %, respectively). Therefore, selection should be imposed considering these traits for improvement of population in chilli.

Janaki *et al.* (2015) evaluated 63 genotypes of chilli to study genetic variability, heritability and genetic advance for ten quantitative traits. The results revealed that significant differences among the genotypes for all the traits studied, indicating the presence of sufficient variability within the studied material. The PCV was above the GCV and the difference between PCV and GCV was narrow for most of the characters revealing little influence of the environment in the expression of these traits. High magnitude of PCV and GCV were observed for per cent fruit set, number of fruits per plant, fruit diameter, average dry fruit weight, number of seeds per fruit and yield per plant suggesting the existence of a wide range of genetic variability in the germplasm for these traits. High heritability coupled with high genetic advance as per cent of mean was observed for all the characters except days to 50 per cent flowering indicating the predominance of additive gene action making selection simpler.

Jogi *et al*. (2015) studied genetic variability, heritability and genetic advance as a per cent of mean for 11 characters in 50 chilli genotypes. The difference between the phenotypic and genotypic coefficient of variation was found to be narrow for most of the traits. The high estimates of heritability were found for number of fruits per plant at first picking (98.20 %), total number of fruits per plant (94.67 %), total yield (91.37 %), fruit length (96.22 %), fruit width (96.22 %) and fruit weight (96.44 %).

Mahantesh *et al*. (2015**)** recorded genetic variability in chilli for yield and quality attributes. Among fifty chilli genotypes, a high degree of variation was observed for all the traits. The difference between the phenotypic coefficient of variation and genotypic coefficient of variation was found to be narrow for most of the traits. High estimates of heritability were found for number of fruits per plant at first picking (98.20 %), total number of fruits per plant (94.67 %), total yield (91.37 %), fruit length (96.22 %), fruit width (96.22 %), stalk length (81.04 %) and fruit weight (96.44 %).

Maurya *et al*. (2015) evaluated 30 genotypes of chilli to assess genetic variability, heritability and genetic advance and observed high heritability coupled with high genetic advance for seed to husk ratio, average dry fruit weight and dry fruit yield per plant.

Quresh *et al*. (2015) evaluated 10 accessions of chilli for 35 qualitative and 11 quantitative parameters and recorded wide variation among the genotypes for important characters on fruit and seed yield. Such genetic variability is often a valuable resource for genetic improvement including developing resistance against insect pests and diseases and noted wide variation is important for fruit and seed yield.

Abhinaya *et al*. (2016) evaluated 32 genotypes of chilli for genetic variability and results revealed that presence of significant variability among the genotypes for all the characters. Higher estimates of GCV and PCV values indicated presence of substantial genetic variability and less environmental influence for plant height, secondary branches per plant, fruit weight, stalk length, fruits per plant, seeds per fruit, fresh fruit yield per plant and dry fruit yield per plant. High heritability coupled with high genetic advance as per cent mean was noticed for most of the traits except days to 50 per cent flowering and 1000 seed weight suggesting presence of additive gene action for inheritance of these yield attributes. Hence, simple selection would be effective for improvement of these traits.

Gorka *et al*. (2016) evaluated 18 diverse genotypes of chilli and observed highest phenotypic coefficient of variation (PCV) of 90.04 per cent and genotypic coefficient of variation (GCV) of 83.97 per cent for a total number of fruits per plant. The traits *viz.,* a complete number of fruits per plant, average fruit weight, capsaicin percentage and fruit yield per plant gave high heritability and genetic advance indicating that these are controlled by additive gene action and could be improved by direct selection.

Kadwey *et al.* (2016) evaluated 25 diverse hot chilli genotypes and recorded the highest phenotypic coefficient of variation for number of fruits per plant (42.0), dry fruit yield per plant (30.34), seed yield per plant (28.94), fruit weight of dry chilli (23.38), number of primary branches per plant at thirty days after transplanting (21.88) and fruit width (21.0). While, highest genotypic coefficient of variation was observed for number of fruits per plant (41.77), dry fruit yield per plant (29.61), seed yield per plant (27.67) and fruit weight of dry chilli (21.67).

Kannan *et al*. (2016) evaluated eight diverse genotypes of chilli for genetic variability, heritability and genetic advance. Analysis of variance revealed that significance differences among the genotypes for all the characters studied. The higher estimates of genotypic coefficient of variation (GCV) were observed for flower per branch (21.59 %), cluster per plant (19.26 %), flower per branch (16.93 %) and stem diameter (15.49 %). The higher estimates of heritability along with genetic advance recorded for flowers per branch, fruits per plant, cluster per plant, stem diameter, plant weight and days to 50 per cent flowering indicated the scope for improvement of these characters through selection.

Meena *et al*. (2016) evaluated genetic variability, heritability and genetic advance in chilli (*Capsicum annuum* L.) and observed that the genotypes Azad mich-1, Sel-16 and 7919 performed better in terms of leaf area and had maximum value (116.38 $cm^2$), succeeded by red ripe fruit yield per plant (85.40), fruit width (38.23 cm), number of branches per plant (34.43), days to 50 per cent flowering (32.46), days to first harvest (27.83), pedicel length (27.78 cm), fruit yield per plant (17.73 g), fruit length (16.64 cm) and plant height (12.76 cm).

Rekha *et al*. (2016) assessed 43 genotypes of chilli and recorded high coefficient of variation both at phenotypic and genotypic level for the traits like fruit set per cent, number of fruits per plant, dry fruit yield per plant, number of seeds per fruit and average dry fruit weight.

Sahu *et al*. (2016) evaluated 19 genotypes of chilli. The analyses of variance revealed that the mean sum of squares due to genotypes were highly significant for all the characters, indicating the presence of variability in the genotypes. The genotype 2012/CHIVAR-5 was recorded highest yield and earliest flowering was noted in 2012/CHIVAR – 8.

Gobu *et al.* (2017) conducted experiment using seventy-three eggplant genotypes to assess the nature and extent of genetic variability, heritability and genetic advance under normal (0 % PEG-6000 as control) in germination phases in three replications in a completely randomized design. The observations on germination per cent, root, shoot and seedling length, fresh weight of seedlings and total dry matter were recorded on tenth day after incubation. Further, seed vigour and root to shoot ratio were computed to understand the drought tolerance ability of the genotypes. The results of the analysis of variance for all the characters studied were found to be highly significant in both the conditions indicating the availability of huge variability. A high range of variation and high heritability coupled with high genetic advance was recorded for most of the traits.

Jogi *et al*. (2017) studied genetic variability, heritability, genetic advance and genetic advance as a per cent over mean for 15 characters in 50 genotypes of chilli. The high estimates of heritability were found for number of fruits per plant at first picking (98.20 %) and yield (94.67 %).

Kumar *et al.* (2017) conducted investigation on thirty genotypes of mungbean to evaluate genetic variability, character association and genetic divergence for eleven seed quality traits for the identification of most diverse and promising genotypes. The genotypes differed significantly for all characters under study. Higher genotypic and phenotypic coefficient of variation was observed for germination after accelerating ageing (96 hr), seedling vigour index II and seedling dry weight. High heritability coupled with high genetic advance was recorded for seedling dry weight, seedling vigour index I and seedling vigour index II.

Kumari *et al*. (2017) evaluated 16 genotypes of chilli to examine their performance for fruit yield and its component traits. Analysis of variance revealed that the genotypes differed significantly for all the characters namely, days to 50 per cent flowering, plant height (cm), days to first picking, fruit length (cm), fruit girth (cm), number of fruits per plant and fruit yield per plant indicating the existence of enough amount of variability. Genotype namely 2014/CHIVAR-9 recorded highest total fruit yield per plot which ranged from 8.00 kg to 19.52 kg with an overall mean of 14.03 kg. The highest total fruit yield was recorded in genotype 2014/CHIVAR-9, which was significantly at par with the performance of kasha Anmol-2 (18.50 kg), 2014/CHVAR-7 (17.83 kg), 2014/CHIVAR-10 (16.99 kg) and 2016/CHIVAR-6 (15.90 kg).

Maurya *et al*. (2017) carried out an experiment to estimate the performance of chilli genotypes for yield and qualitative traits and found significant variation among all the genotypes for various characters under study. Maximum dry matter content was found in genotype PC 20131 and fruit yield per plant in PC 20132 (89.79 g).

Murmu *et al*. (2017) conducted an experiment to study the genetic variability in 24 genotypes of chilli and revealed the significant differences among the genotypes for nearly all the characters studied, indicating the presence of an excellent deal of genetic variability for different traits. Genotype hyb-3(2)-2, one of the most promising one, showed maximum fruit yield per plant, fruit length, fruit girth and pericarp thickness.

Singh *et al.* (2017) evaluated 18 genotypes of chilli to estimate genetic variability, heritability and genetic advance. Analysis of variance revealed highly significant difference among the genotypes for all the characters studied. The PCV was higher than the GCV for all the traits. High magnitude of PCV and GCV were observed for number of fruits per plant followed by average fruit weight, fruit yield per plant, while it had been low for number of branches per plant. High heritability coupled with high genetic advance as percentage of mean was observed for average fruit weight, number of fruits per plant which suggested that the predominance of additive gene action indicating better scope for improvement of these traits by an efficient selection programme.

Debbarma *et al.* (2018) tested chilli variety Pusa Jwala to study the priming effects on germination and seedling growth traits. The variety was primed with water (hydro priming), GA3 (50, 100 and 150 ppm), PEG 6000 (-1.1 and -1.5 MPa) for 12, 24 and 36 hours at 25°C and keeping unprimed seeds as control. Significant variation for germination per cent, fresh ungerminated seeds, mean germination time, germination index, seed vigour index, root and shoot length, seedling fresh and dry weight, and seedling emergence was observed among the treatments. For both the crops, GA3 and PEG priming were found the most effective. Twelve hours of hydro-priming and 24 hours of GA3 and PEG priming were found to be the best duration. GA3 @ 50 ppm and PEG 6000 @ -1.1 MPa were the best for enhancement of germination and seedling growth traits in both the crops.

Kerketta *et al*. (2018) evaluated seventeen genotypes in chilli on eighteen different traits *viz*., plant height (cm), number of branches per plant, plant spread (E-W, N-S), days to flower anthesis, days to 50 per cent flowering, days to first harvest, fruit length (cm), fruit diameter (mm), fruit weight (g), number of fruits plant$^{-1}$, number of seeds fruit$^{-1}$, seeds weight fruit$^{-1}$, green fruit yield plant$^{-1}$ and fruit yield hectare$^{-1}$(q) were taken into consideration. The results revealed that the genotype Pant chilli-4 showed the highest yield per plant (1432.83 g) and fruit yield per hectare (36.42 q / ha).

Kumar *et al*. (2018a) studied 37 advanced lines of green chilli to determine yield and yield-related traits. The results related to yield characters revealed that genotype ST-16 recorded higher yield per plant (939.30 g). The genotype ST-28 recoded the higher plant height (84.46 cm) and plant spread (58.51 cm) while genotype ST-37 (4.40) for primary branches and higher number of secondary branches per plant recorded in ST-36 (9.60). The genotype ST-07 has taken a minimum number of days (22.50) for first flowering and days to 50 per cent flowering. Number of fruits per plant recorded maximum in genotypes ST-33 (198), fruit length in ST-25 (12.62 cm) and fruit diameter in ST-20 (1.59 cm). Whereas, maximum fruit weight was recorded in ST-14 (7.85 g), lowest stalk length in ST-22 (1.80 cm) of the stalk to fruit ratio in ST-01 (0.021).

Kumar *et al*. (2018b) evaluated 14 genotypes of chilli for seed quality parameters and observations were recorded on different seed quality traits like 1000 seed weight, standard germination (%), radical length (cm), plumule length (cm), seedling length (cm), 10 seedlings fresh weight (g), 10 seedlings dry weight (g), seedling vigour index-I and seedling vigour Index-II. A great extent of variability was observed among the various genotypes for the characters studied. The genotype UHFC 12-5 was promising for radical length (5.11 cm), plumule length (5.27 cm), seedling length (10.38 cm) and seedling vigour index-I (671.07). Maximum value for 10 seedlings fresh weight (0.29 g) and seedling vigour index-II (18.69) was noted in UHFC 12-1.

Nagaraju *et al*. (2018) evaluated 53 genotypes of chilli to spot potential genotypes for 12 quantitative traits. The analysis of variance revealed significant differences among the genotypes for all the twelve characters indicating the presence of genetic variability among the genotypes. Among 53 genotypes, Meghalaya Local recorded maximum plant height, plant spread and number of primary branches per plant. Whereas, the genotype IHR 2900 recorded the earliest for days to 50 per cent flowering and days to 50 per cent ripening. However, the maximum red ripe fruit yield was recorded in genotype IHR 4611. The characters showing a good range of variation provide ample scope for selecting superior types and the selected genotypes are often used in further breeding programme.

Yogeshkumar *et al*. (2018) evaluated fifty-five genotypes of byadagi chilli for 16 parameters. The phenotypic coefficient of variation is observed for all the characters studied, indicating the predominance of environment over the genetic parameters.

Higher GCV and PCV were observed for number of fruits per plant, stalk to fruit ratio and plant yield. So, these traits imply the potential for crop improvement through selection.

Kumar *et al*. (2019) studied genetic variability in chilli among 34 genotypes. The analysis of variance revealed a significant difference among 34 genotypes for all the character studied indicating the presence of variability. The GCV and PCV were more in fruit yield per plant (37.02 % and 40.75 %), average dry fruit weight (19.25 and 20.42 %) and average fresh fruit weight (33.10 % and 34.38 %). High heritability was recorded with average dry fruit weight (92.69 %) and average fresh fruit weight (91.33 %) genetic advance as a percentage of mean was higher in case of dry fruit yield per plant (69.28 %) and average dry fruit weight (65.64 %).

Sreenivas *et al*. (2019) evaluated different components of genetic variability for 15 growth and yield component traits employing 45 genotypes. High GCV and PCV values were recorded for all the characters except for days to 50 per cent flowering, days to ripe fruit, maturity from anthesis and 1000 seed weight. The proportion of genetic contribution to the overall phenotypic expression of most of the traits was very high. Both heritability and genetic advance was high for all the characters under study except days to ripe fruit maturity from anthesis, revealing additive genetic control of characters. Selection would be most useful for the improvement of these traits.

## 2.2 CORRELATION AND PATH COEFFICIENT ANALYSIS

A simple or phenotypic correlation coefficient is a measure of the degree of association between two characters. The correlation is an important consideration in the quantitative inheritance of characters and is of practical value in the selection of two or more traits, simultaneously. It is a statistical measure which is used to find out the degree (strength) and direction of the relationship between two or more variables. The concept of correlation was elaborated by Fisher (1918) and Wright (1921).

Sharma *et al*. (2010) evaluated 23 genotypes of chilli. At genotypic levels, the traits fruit length, fruit diameter and number of fruits per plant revealed a significant positive correlation with fruit yield per plant. Number of fruits per plant exhibited the highest positive direct effect followed by average fruit weight, number of branches per plant, pedicel length and harvest duration at the genotypic level.

Chattopadhyay *et al*. (2011) studied the correlation and path coefficient analysis, the results revealed that number of fruits per plant, green fruit length for green chilli, the weight of dry fruit and the number of fruits per plant for dry chilli were found to be the most important selection indices.

Hasanuzzaman and Golam (2011) revealed that yield per plant was significantly and positively correlated with fruit length, fruit weight and number of fruits per plant and days to fruit maturity (green) at phenotypic level, whereas, at genotypic level, yield per plant significantly and positively correlated with all the characters mentioned above including fruit width, positive correlation existed between plant height and plant canopy width at genotypic level. Fruit length had significant and positive genotypic and phenotypic correlation with fruit width and fruit weight. The path analysis showed that selection should be done through number of fruits per plant. The residual effect of path analysis was 0.21 at genotypic level which indicated all the important traits had been considered.

Singh and Singh (2011) reported positive correlation of number of fruits per plant with weight of fruit per plant and red ripened fruit yield. Path analysis revealed that the characters *viz*., number of fruits per plant, weight of fruits per plant and red ripened fruit yield were the most important traits for improving the genotypes.

Ullah *et al.* (2011) evaluated 12 chilli (*Capsicum frutescence* L.) genotypes for morphological traits. The higher genotypic coefficient of variations was found in case of fruit yield per plant followed by fruits per plant, average fruit weight and fruit length. Fruits per plant, fruit length and fruit diameter were the major characters contributing to yield as these traits were significantly and positively associated with yield per plant. Maximum contribution of fruits per plant to yield was observed in path analysis, which was followed by average fruit weight, days to first flowering and fruit length through higher direct effect. So, for increasing fruit yield per plant, a chilli genotype should have higher number of fruits per plant, coupled with large fruit length, high fruit diameter and high average fruit weight.

Yadeta *et al*. (2011) evaluated 21 genotypes of chilli and reported the positive significant phenotypic as well as genotypic correlation of fruit yield per plant with fruit length, fruit weight and canopy diameter. At genotypic level, the path analysis revealed that the fruit weight had maximum positive effect followed by number of days to flowering, canopy diameter, plant height, days to maturity, pericarp thickness, fruits per plant and primary branches per plant.

Kumar *et al*. (2012) observed in chilli that the traits like number of branches at 150 days after transplanting, days to flower anthesis, number of fruits per plant, average fruit weight and fruit length showed positive correlation with fruit yield per plant (g).

Singh and Singh (2012) evaluated 50 germplasm of chilli to assess the genetic variability and association of their different traits. The study revealed that early fresh fruit yield per plant was positively and significantly correlated with number of fruits per plant, fruit length, fresh fruit yield per plant, number of seeds per fruit, seed weight per fruit and dry fruit yield per plant at both genotypic and phenotypic levels and suggested that traits like fruit length, early fresh fruit yield per plant, number of fruits per plant, seed weight per fruit, dry fruit yield per plant and fresh fruit yield per plant were the most important traits for improving the chilli genotypes.

Jogi *et al*. (2013) studied correlation and path coefficient analysis in 50 genetically diverse indigenous and exotic genotypes of chilli and reported that significant positive phenotypic and genotypic association of fruit yield with all the characters except days to first flowering and fruit weight, found positive correlation of early fruit yield and late fruit yield with total fruit yield. The genotypic path coefficient analysis showed that ascorbic acid and chlorophyll content had high direct positive effect on total fruit yield.

Amit *et al.* (2014) assessed 23 genotypes and recorded positively and significant correlation of fruit yield (green and red) per plant with number of fruits per plant and fruit length. It revealed that the characters *viz*., plant height, fruit length, number of fruits per plant, fruit weight and fruit yield (green and red) are the most important traits for genetic improvement of chilli.

Patel and Patel (2014) revealed that green fruit yield per plant was positively correlated with number of fruits per plant, average fruit weight and moisture content at both genotypic and phenotypic levels. Path analysis revealed that characters like number of secondary branches per plant, number of fruits per plant and average fruit weight had high and positive direct effects on green fruit yield.

Vikram *et al*. (2014) studied the genetic correlation and path coefficients among 20 traits of chilli. Green fruit yield per plant showed positive and significant correlation with average green fruit weight, fruit length and fruit breadth at middle while dry fruit yield exhibited the same with fruit length, green fruit yield per plant and alpha carotene content indicating the effective improvement in yield (green and dry) through above characters. Path analysis towards dry yield per plant revealed the importance of average dry fruit weight, number of fruits per plant, fruit length, green fruit yield per plant and alpha carotene content in the improvement of dry fruit yield per plant.

Yatung *et al*. (2014a) conducted correlation studies in chilli and found fruit yield per plant was positively and significantly correlated with number of branches per plant and number of fruits per plant.

Abhinaya *et al*. (2016) studied the genetic correlation and path coefficients among 20 traits of chilli. Dry fruit yield per plant depicted significant and positive correlation with fruits per plant and fresh fruit yield per plant suggesting possibility of simultaneous improvement. Positive direct effects of fruit length, fruit girth and fresh fruit yield per plant on dry fruit yield per plant were revealed by path co-efficient analysis suggesting that more importance should be given to these characters for improving dry fruit yield per plant.

Bijalwan and Mishra (2016) studied the correlation and path coefficient analysis among 16 genotypes in chilli for 15 different qualitative and quantitative characters and observed that fruit yield per plant was positively and significantly correlated with fruit weight at edible maturity, number of fruits per plant, fruit length and number of branches per plant but negative and significant association was found with days to 50 per cent flowering indicating that early flowering and early picking might be associated with increasing the fruit yield per plant. Path coefficient analysis revealed that the highest positive direct effect on fruit yield per plant was exerted by fruit weight at edible maturity followed by number of fruits per plant and fruit length, while highest negative effect on fruit yield per plant was exerted by number of branches per plant and pedicel length.

Dolkar *et al*. (2016) studied the character association and path analysis in 12 advanced breeding lines of chilli for 16 important characters. The studies indicated that the fruit yield was significantly positive with per cent fruit set, number of fruits per plant, number of secondary branches per plant, plant height, fruit weight, pericarp weight and number of primary branches at both genotypic and phenotypic level. However, days to flowering and days to 50 per cent flowering showed negative and significant correlation with total yield. The genotypic and path coefficient analysis revealed that total green chilli yield had high direct positive effect on number of fruits per plant and pericarp weight.

Hasan *et al*. (2016) conducted an experiment to assess the genetic association and selection indices in thirty chilli genotypes and reported that fruit length, fruit weight and fruits per plant showed significant and positive correlation with yield per plant both at genotypic and phenotypic level. Selection indices were constructed through discriminate functions and using five characters. Highest relative efficiency was found for fruit weight + fruits per plant + yield per plant comparable to other combination of characters.

Mamatha *et al*. (2016) conducted a field experiment on 40 chilli genotypes to study the genetic correlation and path coefficients for 10 different quantitative characters. The correlation study revealed that significant and positive correlation was observed for number of branches at 60 DAT (0.796), number of branches at 90 DAT (0.645) and number of fruits per plant (0.767) at genotypic level and plant height at 90 DAT (0.452) and number of fruits per plant (0.708) at phenotypic level indicating that association between the pair of characters are less influenced by the environmental factors. Path analysis revealed that highest positive direct effect was reported in number of branches at 60 DAT (0.2819), days to first harvest (0.7624), number of fruits per plant (0.2331) and fruit yield (0.6745 t / ha) at genotypic level and plant height at 90 DAT (0.0119), days to first harvest (0.0353) and fruit yield (0.9719 t / ha) at phenotypic level suggested that selection of these traits will improve the yield.

Rohini and Lakshmanan (2016) observed significant positive correlation among the genotypes for all the characters studied *viz*., number of fruits per plant, fruit length, individual fruit weight, fruit girth, plant height, seeds per fruit and dry pod yield per plant. The path analysis showed that the maximum contribution of fresh fruits yield per plant to dry pod yield which was followed by individual dry pod weight, number of fruits per plant, number of harvests, days to 50 per cent flowering, pedicle length and number of branches per plant having direct effect. Hence, for increasing fruit yield per plant a chilli hybrid should have higher number of fruits per plant, coupled with large fruit length, high fruit girth and high average fruit weight.

Pandiyaraj *et al.* (2017) evaluated 33 chilli genotypes to study twelve quantitative and four qualitative traits. The results showed that genotypic correlation coefficients were higher than phenotypic correlation coefficients for all the characters studied. The genotypic correlation coefficient revealed that yield per plant displayed significant and positive association with ascorbic acid content (0.438), plant height (0.404), capsanthin content (0.398), mean pod weight (0.348) and pod length (0.346). It had negative association with number of pods per plant (-0.096), number of seeds per pod (-0.085), pod girth (-0.066), carotene content (-0.001). The path coefficient analysis revealed that mean pod weight, number of secondary branches per plant and plant height, red pod yield per plant could be considered major yield components and give importance while exercising selection.

Pujar *et al.* (2017) conducted a field experiment to study correlation and path analysis of 63 chilli genotypes and results revealed that fruit yield had positive and highly significant association with number of fruits per plant and fruit set percentage. At genotypic and phenotypic level, path coefficient analysis revealed that fruit set percentage and fruit weight had the highest positive direct effect on fruit yield and most of the fruit related traits contributed to fruit yield mainly through fruit girth and fruit weight.

Bundela *et al*. (2018) conducted a study on correlation and path coefficient analysis in chilli for yield and yield attributing traits. Among the 25 genotypes path coefficient analysis revealed that the highest positive direct effect on fruit yield per plant was exerted by average fruit weight followed by plant height, number of primary branches, days taken for first flowering, number of fruits per plant, fruit length, fruit pericarp thickness, fruit breadth, number of seeds per fruit and days to first fruit harvesting, while highest negative direct effect on fruit yield per plant was exerted by ascorbic acid content, number of branches per plant, plant stem girth and days for 50 per cent flowering. Therefore, selection should be practiced for average fruit weight, number of fruits per plant, fruit pericarp thickness and fruit length for direct improvement of fruit yield per plant.

Shwetha *et al.* (2018) evaluated forty-two genotypes of chilli for correlation and path analysis for growth and yield contributing characters. The results revealed that plant height had positive and significant correlation with number of secondary branches, fruit length, green fruit weight and green fruit yield per plant. The path coefficient analysis brought out the number of fruits per plant, fruit width and average fruit weight as major yield components, which could be considered as selection indices for improvement. The results suggested that due emphasis should be given to the genotypes that are having maximum number of fruits per plant, fruit length, fruit girth and fruit weight in the selection process due to their high positive direct effect on green fruit yield.

Vidya *et al.* (2018) conducted correlation and path analysis studies in 20 genotypes in chilli for 14 different qualitative and quantitative characters. Correlation coefficients at genotypic and phenotypic level indicated that fruit length, fruit diameter showed highly significant and positive genotypic and phenotypic correlation coefficient with fruit yield per plant. Path coefficient analysis revealed that fruit diameter, days to first flowering had negative direct effect on fruit yield per plant. Days to first harvesting had low positive direct effect on fruit yield per plant. Plant height and days to first harvesting had a negligible effect on fruit yield per plant.

Kumari *et al.* (2019) carried out an experiment on sixteen chilli genotypes to understand the direction and magnitude of correlation between fruit yield and its attributing traits. Results revealed that significant and positive correlation of total fruit yield, both at genotypic and phenotypic levels was recorded with fruit yield per plant, fruit length, number of seeds per fruit, number of fruits per plant and number of primary branches. Thus, direct selection for the above traits will be helpful in improving total fruit yield of chilli affects the growth, development and ultimately fruit yield.

Negi and Sharma (2019) evaluated 33 genotypes of chilli the results showed that the estimates of PCV and GCV were high for dry fruit yield per plant. Correlation studies revealed that marketable red ripe fruit yield per plant showed positive association with fruit length, fruit girth, fruit width, plant height, average red ripe fruit weight, marketable red ripe fruits per plant, total red ripe fruits per plant, per cent marketable red ripe fruits per plant, average dry fruit weight and dry fruit yield per plant at both the levels. Total red ripe fruits per plant directly contributed maximum toward the marketable red ripe fruit yield per plant followed by per cent marketable red ripe fruits per plant contributed directly to a limited extent at both phenotypic and genotypic levels.

Sran and Jindal (2019) evaluated 42 chilli genotypes under three different dates of transplanting, for the evaluation of correlation and path analysis, genetic variability, phenotypic and genotypic coefficient of variances (PCV and GCV), heritability and genetic advance of 19 different chilli traits. The results indicated that fruit yield had significant and positive correlations with number of fruits plant$^{-1}$, fruit weight, plant spread, days to first picking and plant height at phenotypic and genotypic level. The selection based on these traits would ultimately improve the fruit yield. The narrow gap between GCV and PCV indicated low environmental influence. The path analysis revealed that days to first picking, fruit length, pericarp thickness and powder yield had positive genotypic direct effect on fruit yield. The number of fruits plant$^{-1}$ and fruit weight could be used as good benchmarks for the selection, because these traits had high GCV, heritability and genetic advance. Hence, it would be rewarding to lay stress on these characters in selection programme for the improvement**.**

Sreenivas *et al*. (2019) conducted correlation and path analysis studies in 45 genotypes in chilli for 15 different growth and yield component traits. Dry fruit yield per plant was found positively and significantly correlated with all the traits except days to 50 per cent flowering and days to ripe fruit maturity from anthesis. Path coefficient analysis indicated that the maximum direct effect on dry fruit yield/plant was through ripe fruit yield per plant followed by dry fruit weight. From the combining study of correlation and path coefficient, the characters, namely ripe fruit yield/plant and dry fruit weight were the most important selection criteria, emphasis should be given on such traits while imposing selection for amenability in dry fruit yield of chilli.

## 2.3 GENETIC DIVERGENCE

Genetic divergence is used to differentiate well defined population and to choose suitable parents for obtaining heterotic hybrids and cross combinations that are likely to provide better recombinations with desired agronomic values in later generations. The theoretical background of Mahalanobis $D^2$ statistic or generalized distance among the group constellation has been critically discussed in a series of communications (Rao, 1952 and Anderson, 1958). The $D^2$ statistic was found to be an effective tool among the various techniques available for genetics differentiation among population (Rao, 1960; Cassie, 1963 and Sabal, 1965).

Farhad *et al.* (2010) evaluated 45 chilli genotypes for 14 quantitative characters. Cluster analysis was used for grouping the genotypes and the genotypes were categorized into six clusters. Cluster I and cluster III had maximum (11) and cluster II had the minimum number of genotypes. The highest inter cluster distance was observed between clusters II and IV and lowest between clusters I and IV. Cluster II (4.91) had highest intra cluster distance and lowest in cluster I (3.41). The characters like plant height and number of secondary branches per plant contributed maximum variability towards divergence among the chilli genotypes. Considering diversity pattern and other agronomic performance the genotypes C-40 and C-38 from cluster IV, the genotype C-18 from cluster II, the genotypes C-41 and C-37 from cluster V may be taken into consideration as better parents for an efficient hybridization programme.

Gogate *et al*. (2011) concluded that in chilli (*Capsicum annuum var. Longum*) the grouping of genotypes did not show any relationship between genetic divergence and geographic diversity. Totally 11 clusters were made based on $D^2$ values. Cluster distance ranged from 0.00 to 875.95. Number of fruits per plant, chlorophyll content, green fruit yield and ascorbic acid content largely influenced genetic discrimination of genotypes. Genotype Jala, RHRC 16-5. ACG 349, ACS 98-8, ACS 92-4, S 49 and ACS 2000-02 were identified as promising parents for future breeding programme.

Datta and Jana (2011) studied genetic divergence in 65 chilli genotypes for various traits. Pooled results indicated that 65 genotypes were grouped into 11 clusters. Cluster I and III comprised 45 and 11 genotypes, respectively. Rest of the clusters consisted of one genotype in each. The clustering pattern revealed that there was no association of species and geographical distribution for the formation of cluster in genetic divergence. The characters namely, primary branches per plant, days to flowering, ascorbic acid content in fruit and extractable fruit colour were contributing maximum towards divergence and were supposed to play important role in the improvement of chilli.

Misra *et al.* (2011) studied genetic divergence among 38 accessions collected from diverse locations in India for 15 morphological, qualitative and growth characters that included days to first and second flowering, plant height, fruit length and diameter, fresh and dry fruit weight, capsaicin and capsanthin content. Based on this characterization the genotypes were grouped into seven clusters where in substantial diversity among accessions was indicated by the wide range of $D^2$ values (752.901-1918683.00). Accessions with distinct identity were marked, which are likely to be quite suitable for breeding through hybridization combining desirable traits.

Datta and Das (2013) evaluated 53 genotypes of chilli for 23 characters. Based on the $D^2$ value 53 genotypes were grouped into 17 clusters and results indicated that Cluster I and Cluster VII comprised with 29 and 9 genotypes respectively. Rest of the clusters consisted of one genotype in each.

Lahbib *et al*. (2013) evaluated 11 genotypes of *Capsicum annuum* L. species for 7 morphological traits. Using generalized Mahalanobis distance, all 11 landraces were grouped into three clusters. The genetic stocks within cluster had smaller $D^2$ values among themselves than those belonging to different clusters. Accessions FT-6 and FTC 11 (cluster II and III, respectively) had distinct identity. Multivariate analysis indicated large magnitude of phenotypic divergence in the landraces studied and was successful in differentiating the accessions into similar groups on the basis of measured traits. The characteristics that played the greatest role in differentiation were number of fruits per plant, fruit diameter, placenta weight and fruit length.

Hasan *et al*. (2014) conducted a study on genetic diversity among 54 chilli genotypes and observed that the characters like yield per plant, canopy breadth, secondary branches per plant, plant height and seeds per fruit contributed most for divergence in genotypes.

Magaji *et al*. (2014) carried out a study to determine genetic divergence in chilli genotypes and the genotypes were grouped into 8 clusters. Cluster VIII recorded the highest CMT and yield. Cluster IV recorded 13 genotypes while cluster II, VII, and VIII recorded one each. The results revealed that the availability of genetic variance could be useful for exploitation through selection for further breeding purposes.

Yatung *et al*. (2014b) conducted genetic diversity studies among 30 chilli genotypes and all the genotypes were grouped into six clusters. Cluster III had maximum (14) and cluster IV and V had the minimum number (1) of genotypes. The highest (459.81) inter cluster distance was observed between cluster II and IV and the lowest (36.04) between cluster I and IV. Cluster III ($D^2$ = 67.66) exhibited highest intra cluster distance and the lowest was observed in cluster II ($D^2$ = 11.19). Considering diversity pattern and other horticultural performance the genotypes CHFC-7 from cluster IV, genotype CHFC-27 from cluster II and CHFC- 15 from cluster III may be taken into consideration as better parents for an efficient hybridization programme of chilli.

Hasan *et al*. (2015) studied the extent of genetic diversity in 13 genotypes of chilli through 6 yield attributing characters. They grouped the genotype into five different clusters by non-hierarchical clustering and observed that cluster IV produced highest mean for fruit weight (4.48), fruits per plant (149.90) and yield per plant (676.03). Cluster V produced highest mean for fruit length (10.23), pedicel length (4.94) and fruit diameter (10.36).

Abhinaya *et al*. (2016) carried out a study to determine genetic divergence in chilli for 32 genotypes. Cluster I (26) had maximum genotypes and cluster III (1) was solitory. Maximum contribution of capsanthin content (70.97) was observed to the total diversity followed by ascorbic acid (19.56). The inter-cluster distance was observed to be maximum between cluster II and III (D= 447.86). Hence, genotypes from these two clusters can be used in future hybridization program.

Janaki *et al*. (2016) conducted a study to analyze the genetic diversity among 63 genotypes for 10 quantitative and 6 qualitative characters in chilli. Based on hierarchical cluster analysis, the 63 genotypes were grouped into eight clusters. The highest inter cluster distance was observed between clusters IV and VIII (7941.635), whereas, the lowest was observed between clusters VI and VIII (2836.497). The cluster VII exhibited highest intra cluster distance (614.548) and the lowest was observed in cluster VIII (0.00). Considering diversity pattern and horticultural performance, the genotypes Warangal chapatta, LCA-702, LCA724, LCA-756, LCA-353 and LCA-716 were identified as promising parents and could be utilized for efficient hybridization in chilli.

Srivastava *et al*. (2016) studied genetic divergence in 37 genotypes of chilli for 13 yield traits using Mahalanobis $D^2$ statistic. They clustered the genotypes into seven groups, cluster- I was biggest with 13 genotypes followed by cluster IV with 11 genotypes. Cluster III recorded maximum intra-cluster distance (51.85) and maximum inter-cluster distance (345.23) was recoded between cluster-IV and VII. Among 13 yield traits studied, fresh fruit yield per plant and fruit diameter had the maximum contribution towards genetic diversity.

Yadav *et al*. (2016) conducted a study to analyse genetic diversity among 64 chilli accessions of Indian and exotic origin for fourteen qualitative and quantitative traits. Euclideans's inter-cluster distance varied from 12.68 between clusters V and VI to 90.77 between clusters IV and V. Inter-cluster distance was maximum in cluster I (21018) and minimum in cluster V (6.99). Cluster II was represented by only one genotype 'Faslima'. Based on the diversity analysis, parental lines were identified for their utilization in hybridization programme and genetic improvement of chilli.

Bhutia *et al.* (2017) carried out a study to determine genetic divergence in 22 chilli genotypes. The genotypes were grouped into six clusters. Cluster I had maximum of 14 genotypes, while cluster II and III comprised of two genotypes each, while clusters V and VI had one genotype each. The intra and inter cluster distance among 20 genotypes revealed that cluster I showed maximum intra-cluster value (5.868) indicating that genotypes belonging to this cluster were diverse. The top three traits, which contributed most towards the genetic divergence were number of primary branches per plant (13.44 %), followed by days to 50 per cent fruiting (12.20 %) and fruit length (12.14 %). These traits may be used in selecting the genetically diverse parents for hybridization programme to exploit either maximum heterosis or to execute efficient selection in the segregating generation.

Mamatha *et al*. (2017) evaluated 40 genotypes of chilli for divergence studies and observations were recorded for 13 quantitative character. The 40 genotypes were grouped into eight clusters. The cluster I constituted maximum number of genotypes (15) followed by cluster II with 13 genotypes, cluster III with 6 genotypes and cluster VII with 2 genotypes. The highest inter-cluster distance was observed between cluster VI and VIII, whereas, the distance between cluster II and IV was least. The cluster VI recorded maximum intra-cluster distance followed by cluster II and cluster VII. Inter-crossing among the genotypes belonging to cluster VII, II and III was suggested to develop high yielding varieties with desirable characters.

Pradhan *et al*. (2017) analysed the diversity pattern in 12 chilli genotypes based on $D^2$ values, the genotypes were clustered into 5 constellations. Clusters I, II and III contained three genotypes each followed by cluster IV (2) and cluster V (1). The intra and inter cluster distance between cluster III and IV was the highest and this was followed by the distance between cluster IV and V. Cluster I had the highest mean value for branches per plant. Cluster II had the maximum mean values for plant girth and plant height. Cluster III had the highest mean values for average fruit weight, fruit girth and fruit yield per plant. Cluster IV had the highest mean value for fruit length, fruits per plant, days to 50 per cent flowering and crop duration. Cluster V had the lowest mean values for days to 50 per cent flowering and crop duration. Relative contribution of fruit yield per plant to genetic divergence of genotypes in chilli was the maximum, followed by days to 50 per cent flowering and plant height.

Vanitha and Jansirani (2017) analysed diversity pattern using $D^2$ statistic in 74 genotypes of chilli and found substantial differences for all the characters. The genotypes were grouped into 7 clusters. Maximum intra cluster distance (228.90) was observed in cluster-VII followed by cluster- IV (205.06) and cluster-V (191.05) which suggested appreciable genetic diversity within particular cluster. The maximum inter cluster distance was observed between cluster-II and IV (292.86), followed by cluster IV and V (266.67), cluster IV and VII (266.24). Inter- crossing among the genotypes belonging to cluster-I, II, IV and V was suggested to develop high yielding genotypes with desirable characters *viz*., Plant height, number of branches per plant, days to flowering, fresh fruit weight, fruit length, fruit girth, number of fruits per plant, fresh pod yield per plant and dry pod yield per plant.

Gawande *et al*. (2018) evaluated 29 chilli genotypes on the basis of seven yield and yield contributing characters for genetic diversity studies as per Mahalanobis $D^2$ statistic. The 29 chilli genotypes were grouped into 9 clusters. Maximum genotypes were grouped in cluster I followed by cluster II and IV while six clusters found to be solitary having one genotype in each cluster. The maximum intra cluster distance was in cluster IV followed by cluster II whereas, maximum inter cluster distance was exhibited between cluster IV and VI.

Nahak *et al*. (2018) conducted a study on assessment of genetic diversity in different chilli genotypes. Eleven genotypes were grouped into four different clusters by non-hierarchical clustering. The cluster I had the maximum number of genotypes while cluster III and IV each contained only one genotype. Cluster II and III had highest inter cluster distance (249.759) followed by cluster III and IV (239.433). It was also observed that the contribution of fruit yield per plant to genetic divergence of genotypes in chilli was the maximum followed by fruit weight. So, selection of parents differing in these quantitative traits may be proved useful for heterosis breeding programme in chilli.

Sreenivas *et al*. (2019) conducted genetic diversity studies in 45 genotypes of chilli. Based on the determination of divergence all the genotypes were grouped into 7 clusters. The intra- and inter-cluster distance among the genotypes depicted that crossing between the genotypes belonging in Cluster I and VII or Cluster III and VII will be expected to give high heterotic response in F1 generation. The character fruit length contributed the maximum towards genetic divergence followed by fruit diameter, fruits per plant and plant spread (N-S).

# MATERIAL AND METHODS

# III MATERIAL AND METHODS

The present investigation entitled "Genetic variability studies in chilli (*Capsicum annuum* L.) for yield and yield attributing characters" was carried out at experimental block of the Department of Genetics and Plant Breeding, College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga, during rabi season of 2019-20. The experiment was conducted to study the variability, association character and genetic divergence of sixty-three chilli genotypes. The details of the material used and the methods adopted during the course of investigation are presented in this chapter.

## 3.1 Geographical location of the experimental site

The experiment was conducted at experimental block of the Department of Genetics and Plant Breeding, College of Horticulture, Mudigere which is situated in the Western Ghats at 13°7′ North latitude and 74°37′ East longitude with an altitude of 980 m above mean sea level. Mudigere lies in zone-9 of agro-climatic zones of Karnataka.

## 3.2 Climate

College of Horticulture, Mudigere, is geographically situated in the Western Ghats and represents the typical hilly zone (Zone-9 and Region V) of Karnataka. It is located at an altitude of 982 meters above sea level at $13^{0}25'$ North latitude and $75^{0}25'$ East longitude. Mudigere is one of the areas which receive heavy rainfall in Karnataka. The climate of this region is cool and pleasant throughout the year. The data on weather parameters such as rainfall, minimum and maximum temperature and relative humidity recorded at the Agro-meteorological Observatory, Zonal Agricultural and Horticultural Research Station (ZAHRS), Mudigere during crop growth period (2019-2020) are furnished in Appendix-I.

## 3.3 Experimental details

### *3.3.1 Design and layout of the experiment*

The present investigation was carried out on sixty-one diverse genotypes of chilli along with G-4 (Bhagya Lakshmi) and Pusa Jwala as checks. The details of chilli genotypes selected for the study are given in Table 1. Sixty three genotypes of chilli were grown in an Augmented design with 61 test entries and two check entries. Each genotype was represented by a plot size of 3.2 meter x 1.5 meter dimensions with 3 rows.

Data was collected from five randomly selected competitive plants on various morphological, maturity, yield and yield contributing traits. In each block, the checks were allotted randomly.

**Table 1. Details of the chilli genotypes used in the study.**

| SL. No. | Genotypes | Source |
|---|---|---|
| 1 | IC-545734 | NBPGR, New Delhi |
| 2 | Gottikunte -1 | Kolar, Karnataka |
| 3 | Green long chilli | Mysore, Karnataka |
| 4 | IC-545649 | NBPGR, New Delhi |
| 5 | LCA-353 | Lam research station, Guntur, A.P. |
| 6 | IC-119556 | NBPGR, New Delhi |
| 7 | IC-545668 | NBPGR, New Delhi |
| 8 | Badami local | Bagalkot, Karnataka |
| 9 | LCA-334 | Lam research station, Guntur, A.P. |
| 10 | LCA -620 | Lam research station, Guntur, A.P. |
| 11 | IC-545664 | NBPGR, New Delhi |
| 12 | IC-545727 | NBPGR, New Delhi |
| 13 | Piryapattana | Mysore, Karnataka |
| 14 | Kolar local | Kolar, Karnataka |
| 15 | IC-119576 | NBPGR, New Delhi |
| 16 | IC-111593 | NBPGR, New Delhi |
| 17 | IC-545658 | NBPGR, New Delhi |
| 18 | IC-119590 | NBPGR, New Delhi |
| 19 | IC-545665 | NBPGR, New Delhi |
| 20 | Srinivaspura | Kolar, Karnataka |
| 21 | Hindupur | Hindupur, A.P. |
| 22 | IC-545729 | NBPGR, New Delhi |
| 23 | IC-119587 | NBPGR, New Delhi |
| 24 | IC-545725 | NBPGR, New Delhi |
| 25 | G-3 | Lam research station, Guntur, A.P. |
| 26 | Chowdampalli-2 | Hindupur, A.P. |
| 27 | IC-545723 | NBPGR, New Delhi |
| 28 | IC-545730 | NBPGR, New Delhi |
| 29 | Byadagi | Byadagi, Karnataka |
| 30 | Gottikunte -2 | Kolar, Karnataka |
| 31 | IC-545732 | NBPGR, New Delhi |
| 32 | IC-545652 | NBPGR, New Delhi |
| 33 | IC-545655 | NBPGR, New Delhi |
| 34 | IC-545720 | NBPGR, New Delhi |
| 35 | IC-545733 | NBPGR, New Delhi |
| 36 | IC-545667 | NBPGR, New Delhi |


**Plate 1. General view of experimental plot**

| | | |
|---|---|---|
| 37 | Bagepalli | Chikkaballapur, Karnataka |
| 38 | IC-545721 | NBPGR, New Delhi |
| 39 | IC-545651 | NBPGR, New Delhi |
| 40 | IC-545661 | NBPGR, New Delhi |
| 41 | IC-119563 | NBPGR, New Delhi |
| 42 | Balapuram local | Hindupur, A.P. |
| 43 | IC-545728 | NBPGR, New Delhi |
| 44 | LCA-235 | Lam research station, Guntur, A.P. |
| 45 | IC-545663 | NBPGR, New Delhi |
| 46 | IC-545669 | NBPGR, New Delhi |
| 47 | Hosahudya local | Chikkaballapur, Karnataka |
| 48 | IC-119547 | NBPGR, New Delhi |
| 49 | IC-119585 | NBPGR, New Delhi |
| 50 | IC-545735 | NBPGR, New Delhi |
| 51 | IC-545660 | NBPGR, New Delhi |
| 52 | IC-545731 | NBPGR, New Delhi |
| 53 | IC-545724 | NBPGR, New Delhi |
| 54 | IC-119552 | NBPGR, New Delhi |
| 55 | Chowdampalli -1 | Hindupur, A.P. |
| 56 | IC-545653 | NBPGR, New Delhi |
| 57 | LCA-625 | Lam research station, Guntur, A.P. |
| 58 | IC-276117 | NBPGR, New Delhi |
| 59 | IC-545662 | NBPGR, New Delhi |
| 60 | IC-545648 | NBPGR, New Delhi |
| 61 | IC-119560 | NBPGR, New Delhi |
| 62 | Bhagyalakshmi (G-4) | Lam research station, Guntur, A.P. |
| 63 | Pusa Jwala | NBPGR, New Delhi |

### 3.4 Cultural operations

The details regarding various cultural operations carried out during the course of an investigation are furnished below.

*3.4.1 Raising of crop nursery*

The seeds were sown in each cells of pro tray after treating with 50 ppm $GA_3$ for 24 hours and light irrigation was given with the aid of sprayer and covered with polythene sheet. After germination, care was taken to ensure proper growth and development of seedlings in the nursery.

*3.4.2 Field preparation*

The field was ploughed thrice with the incorporation of FYM @ 10t/ha during final land preparation and levelled properly. Then individual plots of the proper size of 3.2 m x 1.5 m were laid out as per the plan of the layout.

*3.4.3 Planting*

The 45 days old seedlings were transplanted to the main field and crop was irrigated through drip. The crop was raised as per the package of practices of horticultural crops of University of Horticultural Sciences, Bagalkot.

*3.4.4 Fertilizer application*

The recommended dose of 150 kg N, 75 kg $P_2O_5$ and 75 kg of $K_2O$ per ha was applied. The total amount of phosphorous, potash and 50 per cent nitrogen was applied to the soil before planting. The remaining amount of nitrogen applied in two splits. The top dressing was done at 30 and 60 days after transplanting.

*3.4.5 Weeding and irrigation*

The plots were kept weed-free by regular hand weeding at an interval of 15 days. Depending on the soil moisture status and climatic conditions, irrigation was given at an interval of 5-6 days during the experimentation.

*3.4.6 Harvesting*

Green fruits were harvested at maturity and attained marketable size *i.e*. edible maturity stage. Picking of fruits was done till the last marketable produce was obtained.

### 3.5 Observations recorded on growth, yield and quality attributes

*3.5.1 Sampling procedure*

Five plants were tagged per treatment were selected randomly and observations were recorded on selected plants for different characters. The mean value of the data obtained from five plants in each treatment was worked out to represent a particular collection with respect to a particular character. The data recorded on five plants per treatment was averaged and subjected to statistical analysis.

*3.5.2 Seed quality parameters*

Germination test for seed quality parameters was conducted by germination paper method. Seeds of each variety were kept in duplicate at room temperature for two weeks. The seed samples of each lot were subjected to different seed quality tests *viz*., test weight, initiation of germination, germination percentage, shoot length, root length, total seedling length and seedling vigour index-I. Observations were recorded as below.

*3.5.2.1 Test weight (g)*

1000 dried seeds were counted using seed counter and counted seeds were weighed and expressed in grams.

*3.5.2.2 Speed of germination*

The speed of germination was calculated by dividing the number of seeds germinated on a particular day by the total number of days.

$$\text{Speed of germination} = \frac{\text{number of seeds germinated on particular day}}{n}$$

*3.5.2.3 Germination percentage (%)*

The germination percentage was calculated on the fifteenth day of germination of seeds.

*3.5.2.4 Shoot length (cm)*

The length of the shoot from the base of the shoot to the tip was expressed in centimetres.

*3.5.2.5 Root length (cm)*

The length of the root from the base of the root to the tip was expressed in centimetres using a scale.

*3.5.2.6 Total seedling length (cm)*

The length of the seedling from the base of the root to the tip of the shoot was expressed in centimetres.

3.5.2.7 Seedling vigour index-I

It was calculated by multiplying germination percentage and total seedling length. Seedling vigour index-I= germination % × total seedling length.

*3.5.3 Growth parameters*

*3.5.3.1 Plant height (cm)*

The height of five tagged plants was recorded from ground level to the tip of the fully opened leaves of main stem at first picking and an average of the plant height was recorded.

*3.5.3.2 Number of branches/plants*

The number of branches per plant was recorded from five randomly selected plants of each plot at the time of the first picking and an average was recorded as a number of branches per plant.

*3.5.3.3 Days to first flowering*

Days to first flowering was recorded (plot basis) as a number of days from transplanting to when the first flower appeared on the plant of the genotype.

*3.5.3.4 Days to 50 per cent flowering*

Days to 50 per cent flowering was recorded (plot basis) as a number of days from transplanting to the date when 50 per cent of plants bloomed and the average number of days was calculated.

*3.5.3.5 Days taken for first picking*

Days to first picking was recorded as a number of days taken from the date of transplanting to the date of first picking of marketable fruits randomly selected plants of each plot and the average value was calculated.

*3.5.3.6 Number of fruits per plant*

This character was recorded by counting the total number of fruits harvested at different pickings in the sample plants till the final marketable harvest. The mean was calculated over data of five selected plants per plot.

*3.5.3.7 Green fruit yield per plant (g)*

Fruit yield per plant was computed by adding the fruit weight of all the pickings and divided by a number of plants and expressed in grams per plant.

*3.5.3.8 Green fruit weight (g)*

Weight of five fruits was recorded in gram from five randomly selected plants of each genotype

*3.5.3.9 Green fruit length (cm)*

Length of the fruits was measured from the stem end to the blossom end of the fruit and expressed in centimetres.

*3.5.3.10 Green fruit yield per plot (kg)*

The weight of the fruits harvested from each picking was recorded from each plot (including tagged plants) and total yield per plot was estimated by adding the yields of all the harvest expressed in kilograms per plot.

*3.5.3.11 Red ripe fruit yield per plant (g)*

Red ripe fruit yield per plant was computed by adding the fruit weight of all the pickings and divided by a number of plants and expressed in grams per plant.

*3.5.3.12 Red ripe fruit weight (g)*

Weight of five red ripe fruits was recorded in gram from five randomly selected plants of each genotype.

*3.5.3.13 Red ripe fruit length (cm)*

Length of the red ripe fruits was measured from the stem end to the blossom end of the fruit and expressed in centimetres.

*3.5.3.14 Red ripe fruit yield per plot (kg)*

The weight of the fruits harvested from each picking was recorded from each plot (including tagged plants) and total yield per plot was estimated by adding the yields of all the harvest expressed in kilograms per plot.

*3.5.3.15 Fruit diameter (cm)*

Fruit diameter was measured in the middle of the fruit after harvesting with the help of digital Vernier calliper.

*3.5.3.16 Yield per hectare (t/ha)*

Fruits harvested in each plot from all pickings were weighed in kilograms. Yield per hectare was calculated by using the following formula and expressed in tonnes per hectare.

$$\text{Yield per hectare (t)} = \frac{\text{Yield per plot (kg)}}{\text{Plot area}} \times \frac{10000}{1000}$$

**3.6 Statistical analysis**

The data collected from the experiment were subjected to various statistical analyses to draw a suitable inference. The details of the statistical procedures followed are given below.

*3.6.1. Analysis of variance (ANOVA)*

Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1957). Using the mean values of randomly selected plants were used to find out the significance of treatment effects. The details of the analysis of variance are as follows.

| **Source of variation** | **df** | **Variation sum of squares** | **Mean squares** | **F ratio** |
|---|---|---|---|---|
| Block | b-1 | bSS | bMS | bMS/EMS |
| Treatment | e-1 | eSS | eMS | eMS/EMS |
| Checks | c-1 | cSS | cMS | cMS/EMS |
| Varieties | v-1 | vSS | vMS | vMS/EMS |
| Check vs. Varieties | 1 | csSS | cMS | cMS/EMS |
| Error | (c-1) (b-1) | ESS | EMS | |
| Total | N-1 | TSS | | |

Where,

b = Number of blocks

v = Number of genotypes

e = Number of entries

c = Number of checks

SS = Sum of squares

MSS= Mean sum of squares

df = Degrees of freedom

For seed quality studies the experiment was laid out in Completely Randomized Design (CRD) by following the procedure outlined by Panse and Sukhatme (1957). The analyzed data were subjected to ANOVA with critical difference values tabulated at one per cent level of significance of the corresponding degrees of freedom.

| Source of variation | df | MSS | F (Cal.) |
|---|---|---|---|
| Treatments | t-1 | Treatment sum of squares / (t-1) | Treatment sum of squares / Error sum of squares |
| Error | n-t | Error sum of squares / (n-t) | |
| Total | n-1 | | |

Where, t= treatments, n=number of observations

The standard error was calculated as,

$$S.Em\pm = \sqrt{EMSS/r}$$

The significance of treatment mean squares and replication mean squares were tested by comparing with error mean squares referring to 'F' table values at 5 per cent level of probabilities.

*3.6.2 Estimation of genetic variability parameters*

*3.6.2.1 Genotypic, phenotypic and environmental variances*

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

$$\text{Genotypic variance } (\sigma_g^2) = \frac{\text{Treatment MSS} - \text{Error MSS}}{r}$$

Environmental variance ($\sigma_e^2$) = Error mean sum of squares

Phenotypic variance ($\sigma_p^2$) = $\sigma_g^2 + \sigma_e^2$

Where, 'r' is number of replications.

*3.6.2.1.2 Genotypic and phenotypic coefficient of variation*

Genotypic and phenotypic coefficients of variances were estimated according to Burton and De Vane (1953) based on an estimate of genotypic and phenotypic variance.

a. Phenotypic coefficient of variation (PCV)

$$PCV(\%) = \frac{\sigma^2 p}{\overline{X}} \times 100$$

b. Genotypic coefficient of variation (GCV)

$$GCV(\%) = \frac{\sigma^2 g}{\overline{X}} \times 100$$

Where,

$\sigma^2_p$= Phenotypic variance

$\sigma^2_g$ = Genotypic variance

$\overline{X}$= General mean

PCV and GCV values were classified as shown below following the method suggested by Robinson *et al*. (1949).

0-10% = Low

>10 - 20% = Moderate

Above 20% = High

*3.6.2.1.3 Heritability (broad sense)*

Heritability (broad sense) was estimated for all the characters using the following formula of Johnson *et al*. (1955).

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

Where,

$h^2_{BS}$ = Heritability (broad sense) expressed in per cent $\sigma^2_g$ = Genotypic variance

$\sigma^2_p$ = Phenotypic variance

0-30% = Low

>30-60% = Moderate

Above 60% = High

*3.6.2.4 Genetic advance (GA)*

The extent of genetic advance expected through selection for each character was estimated by using the following formula of Johnson *et al*. (1955).

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

Where,

$h^2$ = Heritability estimate

k = Selection differential which is equal to 2.06 at 5 per cent intensity of selection.

$\sigma_p$ = Phenotypic standard deviation

Further, the genetic advance as per cent of mean was computed by using the following formula.

$$\text{GA as per cent of mean} = \frac{GA}{Grand\ mean} \times 100$$

Genetic advance as per cent of mean was categorized into low, moderate and high as given below following the method of Johnson *et al*. (1955).

0 -10% = Low

>10-20% = Moderate

Above 20% = High

*3.6.3 Correlation*

To determine the degree of association of yield with its attributing characters, the correlation coefficients were calculated using the following formulae.

$$r_p(XY) = \frac{CoV_p(XY)}{\sqrt{\sigma^2 p(X) + \sigma^2 p(Y)}}$$

Where,

$r_p(XY)$ = phenotypic correlation coefficient between characters 'x' and 'y'

$CoV_p(XY)$ = phenotypic covariance of character 'x' and 'y'

$\sigma^2 p(X)$ = phenotypic variance of character 'x'

$\sigma^2 p(Y)$= phenotypic variance of character 'y'

The calculated 'r' value was compared with table 'r' value at (n-2) degrees of freedom for significance at 0.05 and 0.01 probability levels, where 'n' refers to the number of pairs of observations.

*3.6.4 Path analysis*

Path coefficient analysis as suggested by Wright (1921) and Dewey and Lu (1959) was carried out to know the direct and indirect effect of the morphological traits on foliage yield.

Standard path coefficients or standardized partial regression coefficients were obtained by solving the following set of 'p' simultaneous equations through the use of 'Doolittle technique' in *INDOSTAT* software.

*3.6.5. Genetic divergence*

*3.6.5.1 Mahalanobis $D^2$ analysis*

Mahalanobis (1936) $D^2$ statistics was used for assessing the genetic divergence between populations comprising 61chilli genotypes. The original correlated unstandardized character mean values were transformed into standardized uncorrelated values to simplify the computational procedure. The $D^2$ values were obtained as the sum of squares of the differences between the pairs of corresponding uncorrelated (Ys) values of any two genotypes (Rao, 1952). A total of $D^2$ values were calculated.

$D^2 = \Sigma\, \lambda^{ij}\, \sigma^i \sigma^j$

Where,

$D^2$ = Square of generalized distance

$\lambda ij$ = Reciprocal of the common dispersal index $\sigma i = \mu i1 - \mu i2$

$\sigma j = \mu j1 - \mu j2$

$\mu$ = General mean

Since the formula for computation requires an inversion of higher- order determinants, a transformation of the original correlated unstandardized character mean (Xs) to standardize uncorrelated variable (Ys) was done to simplify the computational procedure. The $D^2$ values were obtained as the corresponding uncorrelated (Ys) values of any two uncorrelated germplasm (Rao, 1952).

*3.6.5.2 Clustering of genotypes*

Using all $D^2$ values, the genotypes were grouped into clusters using Tocher's method as described by Rao (1952).

*3.6.5.3. Intra and Inter-cluster distance*

The intra and inter-cluster distances were calculated by the formula given by Singh and Chaudhary (1977).

$$\text{Square of the intra } - \text{cluster distance} = \frac{\sum \text{DiN}}{N} \times 100$$

$\sum$Di= Sum of the distance between all possible combinations n = Number of all possible combinations

$$\text{Inter } - \text{cluster distance} = \frac{\Sigma \text{Di}j^2}{\text{ninj}} \times 100$$

Where,

Where $\Sigma Dij^2$ is the sum of the distance between all possible combinations ($n_i n_j$) of the germplasm included in the clusters 'i' and 'j'.

ni = number of germplasms in cluster 'i'

nj = number of germplasms in cluster 'j'

# EXPERMENTAL RESULTS

# IV EXPERIMENTAL RESULTS

The present investigation entitled "Genetic variability studies in chilli (*Capsicum annuum* L.) for yield and yield attributing characters" was carried out at College of Horticulture, Mudigere during 2019-20 using chilli genotypes collected from different places. The results obtained from the study are presented under the following headings.

4.1 Analysis of variance

4.2 Genetic variability, heritability and genetic advance

4.3 Correlation coefficient analysis

4.4 Path coefficient analysis

4.5 Genetic divergence

## 4.1 Analysis of variance

The analysis of variance indicated significantly higher amount of variability among the genotypes for growth and yield parameters *viz*., days to first flowering, days to 50 per cent flowering, days taken for first picking, plant height, number of primary branches, number of secondary branches, number of green fruits per plant, green fruit length, green fruit stalk length, green fruit diameter, green fruit yield per plant, green fruit weight, green fruit yield per plot, green fruit yield per hectare, red ripe fruit length, red ripe fruit stalk length, red ripe fruit diameter, number of red ripe fruits per plant, red ripe fruit weight, red ripe fruit yield per plant red ripe fruit yield per plot and red ripe fruit yield per hectare and for seed quality parameters *viz*., test weight, germination percentage, shoot length, root length, root to shoot ratio, seedling vigour index-1, (Table 2 and 3).

## 4.2 Genetic variability, heritability and genetic advance

With a view to understand the extent of variability due to genetic factors *viz*., range, mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability ($h^2$), genetic advance (GA) and genetic advance as per cent mean (GAM) were worked and presented in table (4 and 5).

### *4.2.1 Days to first flowering*

For appearance of first flower, IC-119563 took minimum number of days (46.00) and Kolar local took maximum number of days (65.00) with mean value of 54.54 days. Low GCV (5.97 %) and PCV (7.02 %) were observed. High heritability (72.64 %) along with moderate GAM (10.47 %) were observed for this trait.

**Table. 2 Analysis of variance in chilli genotypes for various quantitative traits.**

| Source / Characters | Blocks | Entries | Checks | Varieties | Checks vs. var | Error |
|---|---|---|---|---|---|---|
| Degrees of freedom | 14 | 62 | 1 | 60 | 1 | 14 |
| Days to first flowering | 7.89 | 19.78** | 43.20** | 17.38 ** | 140.32** | 3.98 |
| Days to 50 per cent flowering | 4.84 | 27.53** | 13.33 | 28.16** | 4.32 | 3.76 |
| Days taken for first picking | 2.46 | 26.39** | 1.20 | 26.76** | 29.17** | 0.84 |
| Plant height (cm) | 10.48 | 125.74** | 3.27** | 61.34** | 837.67** | 10.26 |
| Number of primary branches | 3.168 | 2.28* | 1.58 | 1.72 | 36.83 | 1.43 |
| Number of secondary branches | 7.07 | 11.35** | 1.45 | 8.03** | 220.22** | 1.78 |
| Green fruit length (cm) | 1.462 | 10.75** | 0.003 | 11.09 ** | 0.58 | 1.29 |
| Green fruit stalk length (cm) | 0.114 | 0.330* | 0.024 | 0.320 * | 1.08* | 0.14 |
| Green fruit diameter (cm) | 0.097 | 1.25** | 2.20** | 1.24** | 1.04 ** | 0.08 |
| Number of green fruits per plant | 46.77 | 420.69** | 187.41** | 362.91** | 4120.76** | 40.81 |
| Green fruit weight (g) | 5.13 | 29.81** | 3.57 | 27.69** | 185.15** | 3.00 |
| Green fruit yield per plant (g) | 21417.450 | 140350.30** | 41732.08** | 119822.30** | 1470648.00** | 10881.22 |
| Green fruit yield per hectare (t) | 10.021 | 61.802** | 19.49** | 52.45** | 665.32** | 5.09475 |
| Green fruit yield per plot (kg) | 2.31 | 14.29** | 4.53 | 12.12** | 153.93** | 1.17 |
| Red ripe fruit length (cm) | 1.462 | 10.75** | 0.003 | 11.09** | 0.590 | 1.29 |
| Rec ripe fruit stalk length (cm) | 0.114 | 0.33 * | 0.020 | 0.32* | 1.08 * | 0.14 |
| Red ripe fruit diameter (cm) | 0.011 | 0.853** | 0.220** | 0.871** | 0.364** | 0.022 |
| Number of red ripe fruits per plant | 59.13 | 626.86** | 1238.41** | 531.73** | 5723.60** | 109.93 |
| Red ripe fruit weight (g) | 3.083 | 19.534 ** | 25.854 ** | 19.087 *** | 40.04 ** | 2.48 |
| Red ripe fruit yield per plant (g) | 5228.427 | 38639.29** | 6279.03 | 35429.20** | 263604.90** | 3521.82 |
| Red ripe fruit yield per plot (kg) | 0.566 | 4.414** | 0.675** | 4.056** | 29.618** | 0.038 |
| Red ripe fruit yield per hectare (t) | 2.443 | 19.11** | 2.93** | 17.56** | 128.14** | 1.65 |

* and ** indicates significance at 5 % and 1% level respectively

*4.2.2 Days to 50 per cent flowering*

The genotype IC-119563 took minimum number of days (56.00) for 50 per cent flowering, while Kolar local took maximum number of days (75.00), on an average genotype took 66.18 days for appearance of 50 per cent flowering. The estimates of GCV (6.63 %) and PCV (7.24 %) were low with high heritability (83.66 %) and moderate GAM (12.49 %) for this trait.

*4.2.3 Days taken for first picking*

The number of days taken for first picking was minimum in IC-545653 (80.00) while it was maximum in Kolar local (101.00) with a mean value of 90.73 days. The estimates of GCV (4.98 %) and PCV (7.93 %) were low along with high heritability (96.04 %) and low GAM (9.74 %) for days to first picking.

*4.2.4 Plant height (cm)*

Plant height ranged from 28.95 (IC-545724) to 80.35 cm (IC-276117) with mean value of 53.25 cm. The moderate value of GCV (11.93 %) and PCV (13.36 %) were observed. High heritability (79.72 %) along with high genetic advance over mean (21.93 %) were noticed for this trait.

*4.2.5 Number of primary branches*

The range for number of primary branches was from 3.00 (G-3) to 9.21 (IC-119556) with a mean of 4.79. High GCV (26.73 %), PCV (41.99 %) and high heritability (72.51 %) along with high genetic advance over mean (35.05 %) were noticed for this trait.

*4.2.6 Number of secondary branches*

The range for number of secondary branches was 5.12 (IC-119576) to 17.99 (IC-545662) with mean value of 9.50. High GCV (27.02 %) and PCV (30.59 %) coupled with high heritability (73.40 %) and genetic advance over mean (41.88 %) were noticed for this trait.

*4.2.7 Green fruit length (cm)*

Green fruit length ranged from 6.00 (IC-119576) to 19.65 cm (IC-545735) with a mean value of 9.87 cm. High GCV (28.57 %) and PCV (30.87 %) coupled with high heritability (85.66 %) and high GAM (54.47 %) were observed for fruit length.

*4.2.8 Green fruit stalk length (cm)*

Stalk length ranged from 2.25 (IC-119590) to 4.97 cm (IC-545661) with mean value of 3.36 cm. Moderate GCV (11.73 %) and PCV (16.50 %) with moderate heritability (50.53 %) and GAM (17.17 %) were observed for this trait.

**Table. 3 Analysis of variance for seed quality parameters in chilli.**

| Source of variation/ Characters | Treatments | Error | SEM± | CD @ 5 % | CD @ 1% |
|---|---|---|---|---|---|
| **Degrees of freedom** | 61 | 124 | | | |
| Test weight (g) | 0.039** | 0.00 | 0.007 | 0.019 | 0.025 |
| Germination (%) | 768.92** | 2.57 | 0.926 | 2.59 | 3.37 |
| Root length (cm) | 8.39** | 0.033 | 0.105 | 0.29 | 0.38 |
| Shoot length (cm) | 2.24** | 0.006 | 0.046 | 0.13 | 0.17 |
| Root to shoot ratio | 0.5088** | 0.002 | 0.028 | 0.078 | 0.101 |
| Seedling vigour index - 1 | 404313.57** | 464.62 | 12.45 | 34.88 | 45.34 |

* and ** indicates significance at 5 % and 1% level respectively

*4.2.9 Green fruit diameter (cm)*

Fruit diameter ranged from 0.60 (IC-545728) to 6.50 cm (Gottikunte-1) with a mean value of 2.01 cm. High GCV (47.47 %) and PCV (49.53 %) were observed. High heritability (91.86 %) along with GAM (93.72 %) was observed for fruit diameter.

*4.2.10 Number of green fruits per plant*

Number of green fruits per plant was minimum in IC-545725 (52.10) and it was maximum in IC-545667 (126.35) with a mean value of 77.28. The estimates of GCV and PCV were high (42.68 % and 46.21 %, respectively). High heritability (86.17 %) along with very high genetic advance over mean (81.19 %) were observed for number of green fruits per plant.

*4.2.11 Green fruit weight (g)*

Green fruit weight ranged from 2.10 (Bagepalli) to 22.80 g (IC-545660) with mean value of 8.27 g. GCV (53.45 %) and PCV (57.63 %) were observed. High heritability (86.02%) along with very high GAM (102.12%) was observed for fruit weight.

*4.2.12 Green fruit yield per plant (g)*

The highest green fruit yield per plant was observed in the genotype IC-545662 (1810.78 g) and the lowest yield was observed in IC-119576 (157.74 g) with a mean value of 592.22 g. The estimates of GCV and PCV were high (48.82 % and 51.82 %, respectively). High heritability (88.77 %) along with high genetic advance over mean (94.77 %) were observed for green fruit yield per plant.

*4.2.13 Green fruit yield per plot (kg)*

The highest green fruit yield per plot was observed in the genotype IC-545662 (17.66 kg) and the lowest yield was observed in IC-119576 (1.64 kg) with a mean value of 6.20 kg. The estimates of GCV and PCV were high (47.41 % and 50.54 %, respectively). High heritability (88.00 %) along with high genetic advance over mean (91.63 %) were observed for green fruit yield per plot.

*4.2.14 Green fruit yield per hectare (t)*

The highest green fruit yield per hectare was observed in the genotype IC-545662 (36.27 t) and the lowest yield was observed in IC-119576 (3.41 t) with mean value of 12.89 t. The estimates of GCV and PCV were high (47.41 % and 50.54 %, respectively). High heritability (88.00 %) along with high genetic advance over mean (91.63 %) were observed for green fruit yield per plot.

**Table. 4 Estimates of genetic parameters in chilli genotypes for various quantitative traits.**

| Characters | Mean | Range | | GCV (%) | PCV (%) | $h^2$ (%) | GA | GAM (%) |
|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | | | | | |
| Days to first flowering | 54.54 | 46.00 | 65.00 | 5.97 | 7.02 | 72.64 | 5.71 | 10.47 |
| Days to 50 per cent flowering | 66.18 | 56.00 | 75.00 | 6.63 | 7.24 | 83.66 | 8.26 | 12.49 |
| Days taken for first picking | 90.73 | 80.00 | 101.00 | 4.98 | 7.93 | 96.04 | 9.13 | 9.74 |
| Plant height (cm) | 53.25 | 28.95 | 80.35 | 11.93 | 13.36 | 79.72 | 11.68 | 21.93 |
| Number of primary branches | 4.79 | 3.00 | 9.21 | 26.73 | 41.99 | 72.51 | 1.52 | 35.05 |
| Number of secondary branches | 9.50 | 5.12 | 17.99 | 27.02 | 30.59 | 73.40 | 3.91 | 41.88 |
| Green fruit length (cm) | 9.87 | 6.00 | 19.65 | 28.57 | 30.87 | 85.66 | 5.30 | 54.47 |
| Green fruit stalk length (cm) | 3.36 | 2.25 | 4.97 | 11.73 | 16.50 | 50.53 | 0.55 | 17.17 |
| Green fruit diameter (cm) | 2.01 | 0.60 | 6.50 | 47.47 | 49.53 | 91.86 | 1.88 | 93.72 |
| Number of green fruits per plant | 77.28 | 52.10 | 126.35 | 42.68 | 46.21 | 86.17 | 30.49 | 81.19 |
| Green fruit weight (g) | 8.26 | 2.10 | 22.80 | 53.45 | 57.63 | 86.02 | 8.40 | 102.12 |
| Green fruit yield per plant (g) | 599.22 | 157.74 | 1810.78 | 48.82 | 51.82 | 88.77 | 165.99 | 94.77 |
| Green fruit yield per plot (kg) | 6.19 | 1.64 | 17.66 | 47.41 | 50.54 | 88.00 | 5.68 | 91.63 |
| Green fruit yield per hectare (t) | 12.89 | 3.41 | 36.72 | 47.41 | 50.54 | 88.00 | 11.81 | 91.63 |
| Red ripe fruit length (cm) | 9.04 | 5.37 | 19.15 | 28.57 | 30.87 | 85.66 | 5.30 | 54.47 |
| Red ripe fruit stalk length (cm) | 2.94 | 2.10 | 4.19 | 11.15 | 15.40 | 50.54 | 0.55 | 16.21 |
| Red ripe fruit diameter (cm) | 1.96 | 0.83 | 4.17 | 47.47 | 49.53 | 91.86 | 1.88 | 93.72 |
| Number of red ripe fruits per plant | 67.58 | 36.43 | 110.30 | 31.82 | 36.70 | 75.18 | 32.59 | 56.83 |
| Red ripe fruit weight (g) | 7.21 | 1.50 | 20.75 | 53.37 | 57.34 | 86.63 | 8.46 | 102.32 |
| Red ripe fruit yield per plant (g) | 441.77 | 108.82 | 1075.46 | 58.29 | 62.23 | 80.14 | 173.10 | 112.47 |
| Red ripe fruit yield per plot (kg) | 4.62 | 1.13 | 12.05 | 59.66 | 63.46 | 88.39 | 3.29 | 115.55 |
| Red ripe fruit yield per hectare (t) | 9.62 | 2.35 | 25.05 | 59.69 | 63.48 | 88.40 | 6.86 | 115.60 |

*4.2.15 Red ripe fruit length (cm)*

Red ripe fruit length ranged from 5.37 (IC-119576) to 19.15 cm (IC-545735) with a mean value of 9.04 cm. High GCV (28.57 %) and PCV (30.87 %) with high heritability (85.66 %) and high GAM (54.47 %) were observed for red ripe fruit length.

*4.2.16 Red ripe fruit stalk length (cm)*

Red ripe fruit stalk length ranged from 2.10 (IC-119587) to 4.19 cm (Piryapattana) with mean value of 2.94 cm. Moderate GCV (11.15 %) and PCV (15.40 %) with moderate heritability (50.54 %) and GAM (16.21 %) were observed for this trait.

*4.2.17 Red ripe fruit diameter (cm)*

Fruit diameter ranged from 0.83 (IC-545728) to 4.17 cm (IC-545660) with a mean value of 2.01 cm. High GCV (47.47 %) and PCV (49.53 %) were observed. High heritability (91.86 %) along with high GAM (93.72 %) was observed for fruit diameter.

*4.2.18 Number of red ripe fruits per plant*

Number of red ripe fruits per plant was minimum in Chowdampalli-2 (36.43) and it was maximum in IC-545667 (110.30) with a mean value of 67.58. The estimates of GCV and PCV were high (31.82 % and 36.70 %, respectively). High heritability (75.18 %) along with very high genetic advance over mean (56.83 %) were observed for number of red ripe fruits per plant.

*4.2.19 Red ripe fruit weight (g)*

Red ripe fruit weight ranged from 1.50 (Bagepalli) to 20.75 g (IC-119556) with mean value of 7.21 g. GCV (53.37 %) and PCV (57.34 %) were observed. High heritability (86.63 %) along with very high GAM (102.32 %) was observed for fruit weight.

*4.2.20 Red ripe fruit yield per plant (g)*

The highest fruit yield per plant was observed in the genotype IC-545662 (1075.46 g) and the lowest yield was observed in IC-119576 (108.82 g) with a mean value of 441.77 g. The estimates of GCV and PCV were high (58.29 % and 63.23 %, respectively). High heritability (87.73 %) along with high genetic advance over mean (112.47 %) were observed for red ripe fruit yield per plant.

*4.2.21 Red ripe fruit yield per plot (kg)*

The highest fruit yield per plot was observed in the genotype IC-545662 (12.05 kg) and the lowest yield was observed in IC-119576 (1.13 kg) with a mean value of 4.62 kg. The estimates of GCV and PCV were high (59.66 % and 63.46 %, respectively). High heritability (88.39 %) along with high genetic advance over mean (115.55 %) were observed for red ripe fruit yield per plot.

**Table. 5 Estimates of mean, range, components of variance, heritability and genetic advance for seed quality parameters in chilli.**

| Characters | Mean | Range | | GCV (%) | PCV (%) | $h^2$ (%) | GAM (%) |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | | | | |
| Test weight (g) | 0.62 | 0.35 | 0.83 | 18.40 | 18.41 | 99.91 | 37.89 |
| Germination (%) | 78.62 | 40.00 | 99.00 | 20.35 | 20.39 | 99.59 | 41.83 |
| Root length (cm) | 8.90 | 5.39 | 12.60 | 18.78 | 18.79 | 99.96 | 36.68 |
| Shoot length (cm) | 3.87 | 1.87 | 5.75 | 22.33 | 22.34 | 99.94 | 45.99 |
| Root to shoot ratio | 2.35 | 1.35 | 3.18 | 17.33 | 17.34 | 99.95 | 35.69 |
| Seedling vigour index - 1 | 1014.38 | 113.30 | 1710.00 | 36.17 | 36.19 | 99.96 | 74.53 |

*4.2.22 Red ripe fruit yield per hectare (t)*

The highest fruit yield per hectare was observed in the genotype IC-545662 (25.05 t) and the lowest yield was observed in IC-119576 (2.35 t) with a mean value of 9.62 t. The estimates of GCV and PCV were high (59.69 % and 63.48 %, respectively). High heritability (88.40 %) along with high genetic advance over mean (115.60 %) were observed for red ripe fruit yield per hectare.

*4.2.23 Test weight (g)*

The value for test weight ranged from 0.35 (Bagepalli) to 0.83 g (IC-545723) with a mean value of 0.62 g. Moderate estimates of GCV (18.40 %) and PCV (18.41 %) were observed. High heritability (99.91 %) was observed along with high genetic advance as per cent mean (37.89 %) for the trait.

*4.2.24 Germination percentage (%)*

Germination percentage ranged from 40.00 (IC-119576) to 99.00 per cent (G-4) with a mean value of 78.62 per cent. The high estimates of GCV (20.35 %) and PCV (20.39 %) were observed. High heritability (99.59 %) coupled with high genetic advance as per cent mean (41.83 %) was observed for the trait.

*4.2.25 Root length (cm)*

Root length ranged from 5.39 (IC-545651) to 12.60 cm (LCA-620) with a mean value of 8.90 cm. Moderate estimates of GCV (18.78 %) and moderate PCV (18.79 %) were observed. High heritability (99.96 %) along with high genetic advance as per cent mean (36.68 %) was noticed for the trait.

*4.2.26 Shoot length (cm)*

Shoot length ranged from 1.87 (IC-545651) to 5.75 cm (IC-545735) with a mean value of 3.87 cm. Higher estimates of GCV (22.33 %) and PCV (22.34 %) were observed. High heritability (99.94 %) coupled with high genetic advance as per cent mean (45.99 %) was noticed for the trait.

*4.2.27 Root to shoot ratio*

The range of 1.35 (IC-545723) to 3.18 (IC-119547) was recorded for root to shoot ratio with an average of 2.35. The estimates of GCV and PCV were moderate (17.33 % and 17.34 %, respectively). High heritability (99.95 %) along with high genetic advance over mean (35.69 %) were observed for the trait.

*4.2.28 Seedling vigour index-1*

The value for seedling vigour index-1 ranged from 113.30 (IC-545649) to 1710.00 (LCA-625) with a mean value of 1014.38. Higher estimates of GCV (36.17 %) and PCV (36.19 %) were observed. High heritability (99.96 %) coupled with very high genetic advance as per cent mean (74.53 %) were observed for the trait.

## 4.3 Correlation coefficient analysis

The phenotypic correlation coefficients were determined to know the nature of relationship existing between yield and its component characters as well as the association among component characters themselves. The degrees of association of growth and yield characters with yield and also among themselves at phenotypic level are depicted in Table (6 and 7).

*4.3.1 Association among the yield and component characters in green chilli*

Positive and highly significant association was observed between days to first flowering and days to 50 per cent flowering (0.6063) followed by days to first picking (0.4613) while it exhibited negative association with green fruit yield per plant (-0.2620). While non-significant positive association was observed with number of secondary branches (0.0827) and green fruit length (0.0266). However, this trait exhibited negative non-significant association with green fruit stalk length (-0.0061), number of primary branches (-0.0223), plant height (-0.0960), number of green fruits per plant (-0.1368), green fruit diameter (-0.1793) and green fruit weight (-0.2007).

Highly significant positive association was observed between days to 50 per cent flowering and days to first picking (0.7563). However, its association positive and non-significant with green fruit length (0.1315), number of primary branches (0.0739), number of secondary branches (0.0424) and number of green fruits per plant (0.0024). While it showed negative non-significant association with plant height (-0.0499), green fruit stalk length (-0.1467), green fruit diameter (-0.1850), green fruit weight (-0.1652) and green fruit yield per plant (-0.1863).

None of the characters showed significant association with days taken for first picking. This trait exhibited positive non-significant correlation with plant height (0.0605), number of primary branches (0.0300), number of secondary branches (0.0582), green fruit length (0.2082) and number of green fruits per plant (0.1200). However, negative non-significant correlation was observed with green fruit stalk length (-0.0352), green fruit diameter (-0.0788), green fruit weight (-0.0654) and green fruit yield per plant (-0.0208).

Plant height recorded positive non-significant correlation with green fruit length (0.0897), green fruit diameter (0.0931), number of green fruits per plant (0.0104), green fruit weight (0.0862), number of secondary branches (0.0419) and green fruit yield per plant (0.1052).While it showed negative non-significant correlation with number of primary branches (-0.1234) and green fruit stalk length (-0.1069).

Highly significant positive association of primary branches was observed with number of secondary branches (0.5527). While it showed positive non-significant correlation green fruit length (0.0695), green fruit diameter (0.4300), number of green fruits per plant (0.0759), green fruit weight (0.0286) and green fruit yield per plant

**Table 6. Correlation coefficient among growth and yield parameters in green chilli genotypes.**

| | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X1** | 1 | 0.6063 ** | 0.4613 ** | -0.0960 | -0.0223 | 0.0827 | 0.0266 | -0.0061 | -0.1793 | -0.1368 | -0.2007 | -0.2620* |
| **X2** | | 1 | 0.7565 ** | -0.0499 | 0.0739 | 0.0424 | 0.1315 | -0.1467 | -0.1850 | 0.0024 | -0.1652 | -0.1836 |
| **X3** | | | 1 | 0.0605 | 0.0300 | 0.0582 | 0.2082 | -0.0352 | -0.0788 | 0.1200 | -0.0654 | -0.0208 |
| **X4** | | | | 1 | -0.1234 | 0.0419 | 0.0897 | -0.1069 | 0.0931 | 0.0104 | 0.0862 | 0.1052 |
| **X5** | | | | | 1 | 0.5527 ** | 0.0695 | -0.1685 | 0.04300 | 0.0759 | 0.0286 | 0.0039 |
| **X6** | | | | | | 1 | 0.1094 | 0.0546 | 0.2217 | 0.2175 | 0.3618 ** | 0.4560** |
| **X7** | | | | | | | 1 | 0.2789 * | -0.1488 | 0.1806 | 0.0024 | 0.1083 |
| **X8** | | | | | | | | 1 | 0.0758 | 0.1231 | 0.2027 | 0.2520 |
| **X9** | | | | | | | | | 1 | -0.4541 ** | 0.6529 ** | 0.5350** |
| **X10** | | | | | | | | | | 1 | -0.4723 ** | 0.3025* |
| **X11** | | | | | | | | | | | 1 | 0.9160** |
| **X12** | | | | | | | | | | | | 1 |

* Significance at 5 per cent level and ** Significance at 1 per cent level

X1= Days to first flowering
X2= Days to 50 per cent flowering
X3= Days taken for first picking
X4= Plant height (cm)
X5= Number of primary branches
X6 = Number of secondary branches
X7 = Fruit length (cm)
X8 = Stalk length (cm)
X9= Fruit diameter (cm)
X10 = Number of fruits per plant
X11 = Fruit weight (g)
X12 = Yield per plant (g)

(0.0039). This trait exhibited negative but non-significant association with green fruit stalk length (-0.1685).

Highly significant positive association of number of secondary branches was observed with green fruit weight (0.3618) and green fruit yield per plant (0.4560). While it showed positive non-significant association with green fruit length (0.1094), green fruit stalk length (0.0546), green fruit diameter (0.2217) and number of green fruits per plant (0.2175).

Highly significant and positive correlation was recorded between green fruit length and green fruit stalk length (0.2789). Whereas, it showed positive non-significant association with number of green fruits per plant (0.1806), green fruit weight (0.0024) and green fruit yield per plant (0.1083). It also showed negative non-significant association with green fruit diameter (-0.1488).

Highly significant and positive correlation was observed with green fruit length (0.2789). However, it showed positive non-significant correlation with green fruit diameter (0.0758), number of green fruits per plant (0.1231), green fruit weight (0.2072) and green fruit yield per plant (0.2520).

Green fruit diameter recorded highly significant and positive association with number of green fruits per plant (0.6529) followed by green fruit yield per plant (0.5350) while it showed negative association with green fruit diameter (-0.4541).

Highly significant and positive association of number of green fruits per plant was recorded with green fruit yield per plant (0.3025) and showed negative association with green fruit diameter (0.4723).

Highly significant and positive association with green fruit yield per plant (0.9160) was recorded with green fruit weight.

*4.3.2 Association among the yield and component characters in red ripe chilli*

Highly significant and positive association was observed between days to first flowering and days to 50 per cent flowering (0.6063) followed by days to first picking (0.4613) but exhibited negative association with red ripe fruit yield per plant (-0.2810). While non-significant positive association was observed with red ripe fruit length (0.0944) and number of red ripe fruits per plant (0.1421). However, this trait exhibited negative non-significant association with red ripe fruit stalk length (-0.0206), number of primary branches (-0.0223), number of secondary branches (-0.0827), plant height (-0.0960), red ripe fruit diameter (-0.1984) and red ripe fruit weight (-0.2212).

Highly significant positive association was observed between days to 50 per cent flowering days to first picking (0.7565). However, its association positive non-significant with number of primary branches (0.0739), red ripe fruit length (0.0936) and number of red ripe fruits per plant (0.0439). While it showed negative non-significant

**Table 7. Correlation coefficient among growth and yield parameters in red ripe chilli genotypes.**

| | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X1** | 1 | 0.6063 ** | -0.0960 | -0.0223 | -0.0827 | 0.4613 ** | 0.0944 | -0.0206 | -0.1984 | 0.1421 | -0.2212 | -0.2810* |
| **X2** | | 1 | -0.0499 | 0.0739 | -0.0424 | 0.7565 ** | 0.0936 | -0.1868 | -0.2512 | 0.0439 | -0.1746 | -0.1890 |
| **X3** | | | 1 | -0.1234 | 0.0419 | 0.0605 | 0.1684 | -0.1927 | 0.1491 | 0.0084 | 0.0934 | 0.0840 |
| **X4** | | | | 1 | 0.5527 ** | 0.0300 | 0.0142 | -0.1481 | -0.0853 | 0.0214 | 0.0021 | -0.0150 |
| **X5** | | | | | 1 | -0.0582 | 0.0362 | 0.1663 | 0.1379 | 0.3211 * | 0.3596 ** | 0.3910* |
| **X6** | | | | | | 1 | 0.1059 | -0.2034 | -0.1030 | 0.4344 ** | -0.0747 | -0.0190 |
| **X7** | | | | | | | 1 | 0.1800 | -0.0688 | -0.0906 | -0.0136 | 0.0460 |
| **X8** | | | | | | | | 1 | 0.0049 | 0.0151 | 0.0898 | 0.1910 |
| **X9** | | | | | | | | | 1 | -0.5686 ** | 0.7823 ** | 0.698** |
| **X10** | | | | | | | | | | 1 | -0.5389 ** | 0.3510** |
| **X11** | | | | | | | | | | | 1 | 0.9100** |
| **X12** | | | | | | | | | | | | 1 |

* Significance at 5 per cent level and ** Significance at 1 per cent level

X1= Days to first flowering X2= Days to 50 per cent flowering X3= Plant height (cm) X4= Number of primary branches
X5= Number of secondary branches X6= Days taken for first picking X7 = Fruit length (cm) X8 = Stalk length (cm)
X9= Fruit diameter (cm) X10 = Number of fruits per plant X11 = Fruit weight (g) X12 = Yield per plant (g)

association with plant height (-0.0499), number of secondary branches (-0.0424), red ripe fruit stalk length (-0.1868), red ripe fruit diameter (-0.2512), red ripe fruit weight (-0.7460) and red ripe fruit yield per plant (-0.1890).

Days taken for first picking exhibited positive non-significant correlation with plant height (0.0605), number of primary branches (0.0300) and red ripe fruit length (0.1059). However, negative non-significant correlation was observed with red ripe fruit stalk length (-0.2034), number of secondary branches (-0.0582), red ripe fruit diameter (-0.1030), red ripe fruit weight (-0.0747) and red ripe fruit yield per plant (-0.0190).

Plant height trait recorded positive non-significant correlation with red ripe fruit length (0.1684), red ripe fruit diameter (0.1491), number of red ripe fruits per plant (0.0084), red ripe fruit weight (0.0939), number of secondary branches (0.0419) and red ripe yield per plant (0.0840). While it showed negative non-significant correlation number of primary branches (-0.1234) and red ripe fruit stalk length (-0.1827).

Number of primary branches showed highly significant positive association was with number of secondary branches (0.5527). While it showed positive non-significant correlation red ripe fruit length (0.0142), number of red ripe fruits per plant (0.0214) and red ripe fruit weight (0.0021). This trait exhibited negative non-significant association with red ripe fruit stalk length (-0.1481), red ripe fruit diameter (-0.0853) and red ripe yield per plant (-0.0150).

Highly significant positive association of number of secondary branches was observed with number of red ripe fruits per plant (0.3211), red ripe fruit weight (0.3596) and red ripe fruit yield per plant (0.3910). While it showed positive non-significant association with red ripe fruit length (0.0362), red ripe fruit stalk length (0.1663) and red ripe fruit diameter (0.1379). Whereas, negative non-significant correlation was observed with days to first flowering (-0.0827), days to 50 per cent flowering (-0.424) and days to first picking (-0.0582).

Red ripe fruit length exhibited positive and non-significant association with red ripe fruit stalk length (0.1800) followed by red ripe fruit yield per plant (0.0460). Contrary to this the trait showed negative non-significant association with red ripe fruit diameter (-0.0688), number of red ripe fruits per plant (-0.0906) and red ripe fruit weight (-0.0136).

Red ripe fruit stalk length recorded positive non-significant correlation with fruit diameter (0.0049), number of red ripe fruits per plant (0.0151), fruit weight (0.898) and red ripe fruit yield per plant (0.1910).

Highly significant and positive association was observed between red ripe fruit diameter and fruit weight (0.7823) followed by red ripe fruit yield per plant (0.6980) while it showed negative association with number of red ripe fruit yield per plant (-05686).

Number of red ripe fruits recorded highly significant and positive correlation with red ripe fruit yield per plant (0.3510) and showed negative significant association with red ripe fruit weight (-0.5389)

Highly significant and positive association was observed between red ripe fruit weight and red ripe fruit yield per plant (0.9100).

**4.4 Path coefficient analysis**

The correlation coefficient would only indicate the relationship of independent variable with the dependent variable without specifying cause and effect relationship. The result of path coefficient analysis gives relative contribution of different characters towards the total yield per plant, by partitioning the correlation coefficient into direct and indirect effect of a selected trait and its indirect effect through other characters were computed and presented in Table (8 and 9).

Days to first flowering had direct positive effect on green fruit yield (0.0009). Its indirect positive effect through days to first picking (0.0056), plant height (0.0023), number of primary branches (0.0022), green fruit length (0.0014) and green fruit stalk length (0.0001). Indirect negative effect was exhibited via green fruit diameter (-0.0021), days to 50 per cent flowering (-0.0062), number of secondary branches (-0.0114), number of green fruits per plant (-0.0544) and green fruit weight (-0.2000).

Days to 50 per cent flowering on green fruit yield had a direct negative effect (-0.0102) and also an indirect positive effect through days to first picking (0.0092), green fruit length (0.0068), green fruit stalk length (0.0023), plant height (0.0012) and days to first flowering (0.0005). However, it exhibited negative indirect effect through green fruit diameter (-0.0021), number of secondary branches (-0.0059), number of primary branches (-0.0074), number of green fruits per plant (-0.0134) and green fruit weight (-0.1646).

Days to first picking had direct positive effect on green fruit yield (0.0121) whereas, its indirect positive contribution via number of green fruits per plant (0.0416), green fruit length (0.0108), green fruit stalk length (0.0006) and days to first flowering (0.0004). On the other hand, its indirect negative effect via green fruit diameter (-0.0009), plant height (-0.0014), number of primary branches (-0.0030), days to 50 per cent flowering (-0.0077), number of secondary branches (-0.0081) and green fruit weight (-0.0651) was observed.

The direct effect of plant height on fruit yield was negative (-0.0238). However, its indirect positive effect through green fruit weight (0.0859), number of green fruits per plant (0.0164), number of primary branches (0.0124), number of secondary

**Table 8. Path coefficient analysis among growth and yield parameters in green chilli genotypes.**

| | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **X1** | **0.0009** | 0.0005 | 0.0004 | -0.0001 | 0.0002 | -0.0001 | 0.0001 | 0.0003 | -0.0002 | 0.0179 | -0.0002 |
| **X2** | -0.0062 | **-0.0102** | -0.0077 | 0.0005 | -0.0008 | 0.0004 | -0.0013 | 0.0015 | 0.0019 | 0.0001 | 0.0017 |
| **X3** | 0.0056 | 0.0092 | **0.0121** | 0.0007 | 0.0004 | -0.0007 | 0.0025 | -0.0004 | -0.0010 | 0.0129 | -0.0008 |
| **X4** | 0.0023 | 0.0012 | -0.0014 | **-0.0238** | 0.0029 | -0.0010 | -0.0021 | 0.0025 | -0.0022 | -0.0012 | -0.0021 |
| **X5** | 0.0022 | -0.0074 | -0.0030 | 0.0124 | **-0.1006** | -0.0556 | -0.0070 | 0.0169 | -0.0043 | -0.0077 | -0.0029 |
| **X6** | -0.0114 | -0.0059 | -0.0081 | 0.0058 | 0.0765 | **0.1384** | 0.0151 | 0.0076 | 0.0307 | 0.0155 | 0.0501 |
| **X7** | 0.0014 | 0.0068 | 0.0108 | 0.0046 | 0.0036 | 0.0057 | **0.0518** | 0.0144 | -0.0077 | 0.0134 | 0.0001 |
| **X8** | 0.0001 | 0.0023 | 0.0006 | 0.0017 | 0.0027 | -0.0009 | -0.0044 | **-0.0159** | -0.0012 | 0.0024 | -0.0032 |
| **X9** | -0.0021 | -0.0021 | -0.0009 | 0.0011 | 0.0005 | 0.0026 | -0.0017 | 0.0009 | **0.0116** | -0.0209 | 0.0076 |
| **X10** | -0.0544 | -0.0134 | 0.0416 | 0.0164 | -0.0099 | 0.0063 | 0.0531 | 0.0225 | -0.1429 | **0.6560** | -0.1313 |
| **X11** | -0.2000 | -0.1646 | -0.0651 | 0.0859 | 0.0285 | 0.3605 | 0.0024 | 0.2020 | 0.6506 | -0.3859 | **0.9965** |
| **X12** | **-0.2620*** | **-0.1836** | **-0.0208** | **0.1052** | **0.0041** | **0.4560**** | **0.1084** | **0.2523** | **0.535**** | **0.3025**** | **0.9160**** |

* Significance at 5 per cent level and ** Significance at 1 per cent level

X1= Days to first flowering
X2= Days to 50 per cent flowering
X3= Days taken for first picking
X4= Plant height (cm)
X5= Number of primary branches
X6 = Number of secondary branches
X7 = Fruit length (cm)
X8 = Stalk length (cm)
X9= Fruit diameter (cm)
X10 = Number of fruits per plant
X11 = Fruit weight (g)
X12 = Yield per plant (g)

branches (0.0058), green fruit length (0.0046), green fruit stalk length (0.0017), green fruit diameter (0.0011), days to first picking (0.0007) and days to 50 per cent flowering (0.0005). Negative indirect effect was exhibited by days to first flowering (-0.0001).

Number of primary branches exhibited negative direct effect on green fruit yield (-0.1006). Positive indirect effect was through number of secondary branches (0.0765), green fruit weight (0.0285), green fruit length (0.0036), plant height (0.0029), green fruit stalk length (0.0027), green fruit diameter (0.0005), days to first picking (0.0004) and days to first flowering (0.0002). On the other hand, indirect negative effect via number of green fruits per plant (-0.0099) and days to 50 per cent flowering (-0.0008) was recorded for the trait.

Number of secondary branches exhibited positive direct effect on fruit yield (0.1384) whereas, its indirect positive effect via green fruit weight (0.3605), number of green fruits per plant (0.0063), green fruit length (0.0057), green fruit diameter (0.0026) and days to 50 per cent flowering (0.0004) was recorded. On the other hand, negative indirect effect via days to first flowering (-0.0001), days to first picking (-0.0007), green fruit stalk length (-0.0009), plant height (-0.0010) and number of primary branches (-0.0556) was noticed for the trait.

Green fruit length had direct positive effect on green fruit yield (0.0518). Positive indirect effect through number of green fruits per plant (0.0531), number of secondary branches (0.0151), days to first picking (0.0025), green fruit weight (0.0024) and days to first flowering (0.0001). Negative indirect effect was exhibited through days to 50 per cent flowering (-0.0013), green fruit diameter (-0.0017), plant height (-0.0021) green fruit stalk length (-0.0044) and number of primary branches (-0.0070).

The direct effect of green stalk length on fruit yield was negative (-0.0159). Its indirect positive effect through green fruit weight (0.2020), number of green fruits per plant (0.0225), number of primary branches (0.0163), green fruit length (0.0144), number of secondary branches (0.00765), plant height (0.0025), days to 50 per cent flowering (0.0015), green fruit diameter (0.0009) and days to first flowering (0.0003). Negative indirect effect was exhibited via days to first picking (-0.0087).

Green fruit diameter had direct positive effect on green fruit yield (0.0116). Its indirect positive effect through green fruit weight (0.6506), number of secondary branches (0.0307) and days to 50 per cent flowering (0.0019). Negative indirect effect was exhibited through days to first flowering (-0.0002), days to first picking (-0.0010), green fruit stalk length (-0.0012), plant height (-0.0022), number of primary branches (-0.0043) green fruit length (-0.0077) and number of green fruits per plant (-0.1429).

Number of fruits per plant exhibited positive direct effect (0.6560) on fruit yield. This trait exhibited positive indirect effect via, days to first flowering (0.0179), number of secondary branches (0.0155), green fruit length (0.0134), days to first picking

(0.0129), green fruit stalk length (0.0024) and days to 50 per cent flowering (0.0001). However, the effect was negative via, plant height (-0.0012), number of primary branches (-0.0077), green fruit diameter (-0.0209) and green fruit weight (-0.3859).

Fruit weight exhibited very high and positive direct effect (0.9965) on green fruit yield. This trait exhibited positive indirect effect via number of secondary branches (0.0501), green fruit diameter (0.0076), days to 50 per cent flowering (0.0017) and green fruit length (0.0001). However, it’s indirect negative contribution via days to first flowering (-0.0002), days to first picking (-0.0008), plant height (-0.0021), number of primary branches (-0.0029), green fruit stalk length (-0.0032) and number of green fruits per plant (-0.1313).

Days to first flowering exhibited negative direct (-0.0404) effect on red ripe fruit yield. However, the positive and negligible association of this trait with fruit yield may be attributed mainly to its indirect effect through days to first picking (0.0164), days to 50 per cent flowering (0.0153), red ripe fruit length (0.0044), plant height (0.0038) and number of primary branches (0.0013). Indirect negative effect was exhibited via red ripe fruit stalk length (-0.0013), number of secondary branches (-0.0063), red ripe fruit diameter (-0.0122), number of red ripe fruits per plant (-0.0397) and red ripe fruit weight (-0.2217).

Days to 50 per cent flowering on red ripe fruit yield had a direct positive effect (0.0252) and also an indirect positive effect through days to first picking (0.0269), red ripe fruit length (0.0043) and plant height (0.0020). However, it exhibited negative indirect effect through number of secondary branches (-0.0032), number of primary branches (-0.0043), green fruit stalk length (-0.0123), number of red ripe fruits per plant (-0.0125), red ripe fruit diameter (-0.0155), days to first flowering (-0.0245) and red ripe fruit weight (-0.1750).

Days taken for first picking had positive direct effect on red ripe fruit yield (0.0355) whereas, its indirect positive contribution via number of red ripe fruits per plant (0.0437), days to 50 per cent flowering (0.0190) and red ripe fruit length (0.0049). On the other hand, its indirect negative effect via number of primary branches (-0.0018), plant height (-0.0025), number of secondary branches (-0.0044), red ripe fruit diameter (-0.0064) red ripe fruit stalk length (-0.0134), days to first flowering (-0.0186) and red ripe fruit weight (-0.0749) was observed.

Plant height exhibited direct negative (-0.0400) on red ripe fruit yield. However, the positive indirect effect through red ripe fruit weight (0.0936), number of red ripe fruits per plant (0.0106), red ripe fruit diameter (0.0092), red ripe fruit length (0.0078), number of primary branches (0.0072), days to first flowering (0.0039), number of secondary branches (0.0032) and days to first picking (0.0022) was recorded.

**Table 9. Path coefficient analysis among growth and yield parameters in red ripe chilli genotypes.**

| | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **X1** | **-0.0404** | -0.0245 | -0.0186 | 0.0039 | 0.0009 | 0.0033 | -0.0038 | 0.0008 | 0.0080 | 0.0011 | 0.0089 |
| **X2** | 0.0153 | **0.0252** | 0.0190 | -0.0013 | 0.0019 | -0.0011 | 0.0024 | -0.0047 | -0.0063 | 0.0048 | -0.0044 |
| **X3** | 0.0164 | 0.0269 | **0.0355** | 0.0022 | 0.0011 | -0.0021 | 0.0038 | -0.0072 | -0.0037 | -0.0141 | -0.0027 |
| **X4** | 0.0038 | 0.0020 | -0.0024 | **-0.0400** | 0.0049 | -0.0017 | -0.0067 | 0.0077 | -0.0060 | -0.0005 | -0.0037 |
| **X5** | 0.0013 | -0.0043 | -0.0018 | 0.0072 | **-0.0585** | -0.0323 | -0.0008 | 0.0087 | 0.0050 | 0.0002 | -0.0001 |
| **X6** | -0.0063 | -0.0032 | -0.0044 | 0.0032 | 0.0421 | **0.0762** | 0.0028 | 0.0127 | 0.0105 | -0.0192 | 0.0274 |
| **X7** | 0.0044 | 0.0043 | 0.0049 | 0.0078 | 0.0007 | 0.0017 | **0.0464** | 0.0083 | -0.0032 | -0.0205 | -0.0006 |
| **X8** | -0.0013 | -0.0123 | -0.0134 | -0.0126 | -0.0097 | 0.0109 | 0.0118 | **0.0656** | 0.0003 | 0.0011 | 0.0059 |
| **X9** | -0.0122 | -0.0155 | -0.0064 | 0.0092 | -0.0053 | 0.0085 | -0.0042 | 0.0003 | **0.0618** | -0.0652 | 0.0483 |
| **X10** | -0.0397 | -0.0125 | 0.0437 | 0.0106 | 0.0052 | -0.0327 | 0.0086 | 0.0084 | -0.1527 | **0.8517** | -0.1716 |
| **X11** | -0.2217 | -0.1750 | -0.0749 | 0.0936 | 0.0021 | 0.3605 | -0.0136 | 0.0901 | 0.7842 | -0.3883 | **1.000** |
| **X12** | **-0.2810*** | **-0.1890** | **-0.0190** | **0.0840** | **-0.0150** | **0.3910*** | **0.0460** | **0.1910** | **0.6980**** | **0.3512**** | **0.9099**** |

* Significance at 5 per cent level and ** Significance at 1 per cent level

X1= Days to first flowering  X2= Days to 50 per cent flowering  X3= Days to first picking  X4= Plant height (cm)
X5= Number of primary branches  X6 = Number of secondary branches  X7 = Fruit length (cm)  X8 = Stalk length (cm)
X9= Fruit diameter (cm)  X10 = Number of fruits per plant  X11 = Fruit weight (g)  X12 = Yield per plant (g)

Plant height exhibited negative indirect effect via days to 50 per cent flowering (-0.0013) and red ripe fruit stalk length (-0.0126).

Number of primary branches exhibited negative direct effect on fruit yield (-0.0585). Positive indirect effect was exhibited through number of secondary branches (0.0421), number of red ripe fruits per plant (0.0052), plant height (0.0049), red ripe fruit weight (0.0021), days to 50 per cent flowering (0.0019), days to first picking (0.0011), days to first flowering (0.0009) and red ripe fruit length (0.0007). On the other hand, indirect effect via red ripe fruit diameter (-0.0053) and red ripe fruit stalk length (-0.0097) was observed for this trait.

Number of secondary branches exhibited positive direct effect on fruit yield (0.0762) whereas, its indirect positive effect via red ripe fruit weight (0.3605), red ripe fruit stalk length (0.0109), red ripe fruit diameter (0.0085), days to first flowering (0.0033) and red ripe fruit stalk length (0.0017) was observed. On the other hand, negative indirect effect via days to 50 per cent flowering (-0.0011), days to first picking (-0.0021), plant height (-0.0017), number of primary branches (-0.0323) and number of red ripe fruits per plant (-0.0327) was recorded for the trait.

Red ripe fruit length had direct positive (0.0464) on red ripe fruit yield However, the positive association of this trait with fruit yield may be attributed mainly to its indirect effect through red ripe fruit stalk length (0.0118), number of red ripe fruits per plant (0.0086), days to first picking (0.0038), number of secondary branches (0.0028) and days to 50 per cent flowering (0.0024). Negative indirect effect was exhibited through number of primary branches (-0.0008), red ripe fruit diameter (-0.0042), days to first flowering (-0.0038), plant height (-0.0067) and red ripe fruit weight (-0.0136).

The direct effect of red ripe fruit stalk length on fruit yield was positive (0.0656). However, the positive indirect effect through red ripe fruit weight (0.0901), number of secondary branches (0.0127), number of primary branches (0.0087), number of red ripe fruits per plant (0.0084), red ripe fruit length (0.0083), plant height (0.0077), days to first flowering (0.0008) and red ripe fruit diameter (0.0003) was noticed. Negative indirect effect was exhibited through days to 50 per cent flowering (-0.0047) and days to first picking (-0.0072).

Fruit diameter had a positive direct effect on red ripe fruit yield (0.0618). However, the positive association of this trait with fruit yield may be attributed mainly to its indirect effect through red ripe fruit weight (0.7842), number of secondary branches (0.108), number of primary branches (0.0050) and red ripe fruit stalk length (0.0003). Negligible negative indirect effect was exhibited via red ripe fruit length (-0.0032), days to first picking (-0.0037), plant height (-0.0060), days to 50 per cent flowering (-0.0063) and number of red ripe fruits per plant (-0.1527).

Number of fruits per plant exhibited high and positive direct effect (0.8517) on fruit yield. This trait exhibited positive indirect effect via, days to 50 per cent flowering (0.0048), days to first flowering (0.0011), red ripe fruit stalk length (0.0011) and plant height (0.0002). However, the effect was negative via, days to first picking (-0.0005), number of secondary branches (0.0141), number of primary branches (-0.0192), red ripe fruit length (-0.0205), red ripe fruit diameter (-0.0652) and red fruit weight (-0.3883).

Fruit weight exhibited very high and positive direct effect (1.000) on fruit yield. This trait exhibited positive indirect effect via red ripe fruit diameter (0.0483), number of secondary branches (0.0274), days to first flowering (0.0089) and red ripe fruit stalk length (0.0059). However, it's indirect negative contribution via number of primary branches (-0.0001), red ripe fruit length (-0.0006), days to first picking (-0.0027), plant height (-0.0037), days to 50 per cent flowering (-0.0044) and number of red ripe fruits per plant (-0.1716).

**4.5 Genetic divergence**

Sixty-three chilli genotypes were evaluated for sixteen characters to study the divergence and the data obtained was subjected to $D^2$ analysis. Seven clusters were constructed by using Tocher's method.

*4.5.1 Grouping of chilli genotypes*

By using Tocher's method given by Rao (1952), sixty-three genotypes were grouped into seven clusters by treating estimated $D^2$ values as the square of generalized distance. Cluster I was the largest having thirty-eight genotypes followed by cluster II with nineteen genotypes, cluster VI with two genotypes, cluster III, cluster V, cluster VI and cluster VII had one genotype each (Table 10). The tendency of genotypes from different centers to group together in one cluster might be due to similarity in requirements and selection of selection approach followed under domestication.

*4.5.2 Intra and inter-cluster distance*

Intra and inter-cluster values are presented in Table 11. Intra cluster $D^2$ values ranged from 0.00 to 692.59. Among seven clusters, cluster II with nineteen genotypes showed maximum intra cluster distance (692.59) followed by cluster I (590.63) with thirty-eight genotypes, cluster IV (413.05) with two genotypes and clusters III, V, VI, VII had low intra cluster distance (0.00) as they possessed single genotype in each cluster.

The inter cluster distance value was maximum (11578) between cluster IV and cluster V having two and one genotypes respectively followed by cluster IV and cluster VII (7887.45), cluster I and cluster IV (6627.72), cluster II and cluster V (5709.34), cluster III and cluster IV (5047.93), and cluster I had the least inter-cluster (1136.84)

**Table 10. Classification of chilli genotypes into different clusters for various quantitative traits based on Tocher's method of classification.**

| Clusters | Number of genotypes | Genotypes included in the cluster |
|---|---|---|
| **I** | 38 | Green long chilli, IC-545649, IC-545661, IC-111593, IC-545727, Badami local, IC-545664, IC-119547, IC-119590, Gottikunte-1, Gottikunte-2, IC-545730, IC-119587, IC-545733, IC-545668, IC-545734, Hindupur, IC-545729, Srinivaspura, IC-119576, Balapuram, IC-545723, Pusa Jwala, IC-545720, IC-545658, IC-119585, LCA-353, LCA-620, G-4, IC-545725, IC-545653, G-3, IC-545660, Kolar, Chowdampalli-1, IC-545731, IC-545651, IC-119556 |
| **II** | 19 | IC-545669, IC-545665, Byadagi, IC-545655, Piryapattana, Hosahudya local, LCA-235, IC-119563, LCA-625, Bagepalli, IC-119560, LCA-334, IC-545663, IC-545648, IC-545652, IC-545732, IC-545721, IC-545728, IC-119552 |
| **III** | 1 | IC-545724 |
| **IV** | 2 | IC-545667, IC-545735 |
| **V** | 1 | Chowdampalli -2 |
| **VI** | 1 | IC-545662 |
| **VII** | 1 | IC-276117 |

**Table 11. Intra (diagonal) and inter cluster distance for sixteen characters formed by sixty three genotypes of chilli.**

| | Cluster I | Cluster II | Cluster III | Cluster IV | Cluster V | Cluster VI | Cluster VII |
|---|---|---|---|---|---|---|---|
| Cluster I | **590.63** | 2649.89 | 1136.84 | 6627.72 | 1164.47 | 1814.4 | 1205.6 |
| Cluster II | | **692.59** | 2195.21 | 1662.62 | 5709.34 | 1616.63 | 3442.04 |
| Cluster III | | | **0** | 5047.93 | 2379.26 | 2187.37 | 3083.36 |
| Cluster IV | | | | **413.05** | 11578.00 | 3697.7 | 7887.45 |
| Cluster V | | | | | **0** | 4134.66 | 1792.64 |
| Cluster VI | | | | | | **0** | 1551.63 |
| Cluster VII | | | | | | | **0** |

with cluster III, based on distance between clusters, this clearly suggested that the genotypes found in any of these clusters were highly divergent.

### *4.5.3 Percent contribution of different traits towards total divergence*

The relative contribution of different traits for genetic divergence ($D^2$) is presented in Table 12. Red ripe fruit yield per plant (36.61 %) contributed maximum to total divergence followed by green fruit yield per plant (32.97 %), plant height (12.24 %), number of green fruits per plant (5.79 %), number of red ripe fruits per plant (4.25 %), green fruit weight (3.69 %), days to first flowering (1.69 %), red ripe fruit weight (1.13 %), green fruit length (0.97 %), red ripe fruit length (0.46 %), number of secondary branches (0.15 %) and green fruit diameter (0.05 %). However, traits like days to 50 per cent flowering, days taken for first picking, number of primary branches and red ripe fruit diameter had no substantial contribution to total divergence.

### *4.5.4 Mean performance for all the characters in different clusters*

Cluster mean for sixty-three genotypes are tabulated in Table 13. Highest cluster mean for days taken for first flowering was observed in the cluster V (61.00) followed by cluster VII (56.00) and the lowest cluster mean was observed in the cluster III (50.00). Highest cluster mean for days to 50 per cent flowering was observed in the cluster V (71.00) followed by cluster I (66.71) and the lowest cluster mean was observed in the cluster VII (61.00).

The highest cluster mean was recorded in the cluster IV (92.50) followed by cluster V (92.00) and the lowest cluster mean was observed in the cluster VI (89.00) for days taken for first picking. The highest cluster mean for plant height was observed in the cluster VII (80.35 cm) followed by cluster VI (65.45 cm) and the lowest cluster mean was observed in the cluster III (28.95 cm). The highest cluster mean was observed in the cluster II (4.98) followed by cluster I (4.91) and the lowest cluster mean was observed in the cluster IV (3.33) for number of primary branches.

The highest cluster mean for number of secondary branches was observed in the cluster VI (17.99) followed by cluster III and cluster V (10.00) and the lowest cluster mean was observed in the cluster IV (7.77). The highest cluster mean was observed in the cluster VII (13.25 cm) followed by cluster VI (12.95 cm) and the lowest cluster mean was observed in the cluster IV (8.95 cm) for green fruit length. The highest cluster mean was recorded in the cluster VI (2.50 cm) followed by cluster I (2.41 cm) and the lowest cluster mean was observed in the cluster V (1.00 cm) for green fruit diameter.

The highest cluster mean for number of green fruits per plant was observed in the cluster IV (124.73) followed by cluster VI (97.88) and the lowest cluster mean was observed in the cluster I (65.55). The highest cluster mean for green fruit weight was observed in the cluster VI (18.50 g) followed by cluster VII (11.33 g) and the lowest cluster mean was observed in the cluster IV (4.93 g). The highest cluster mean was

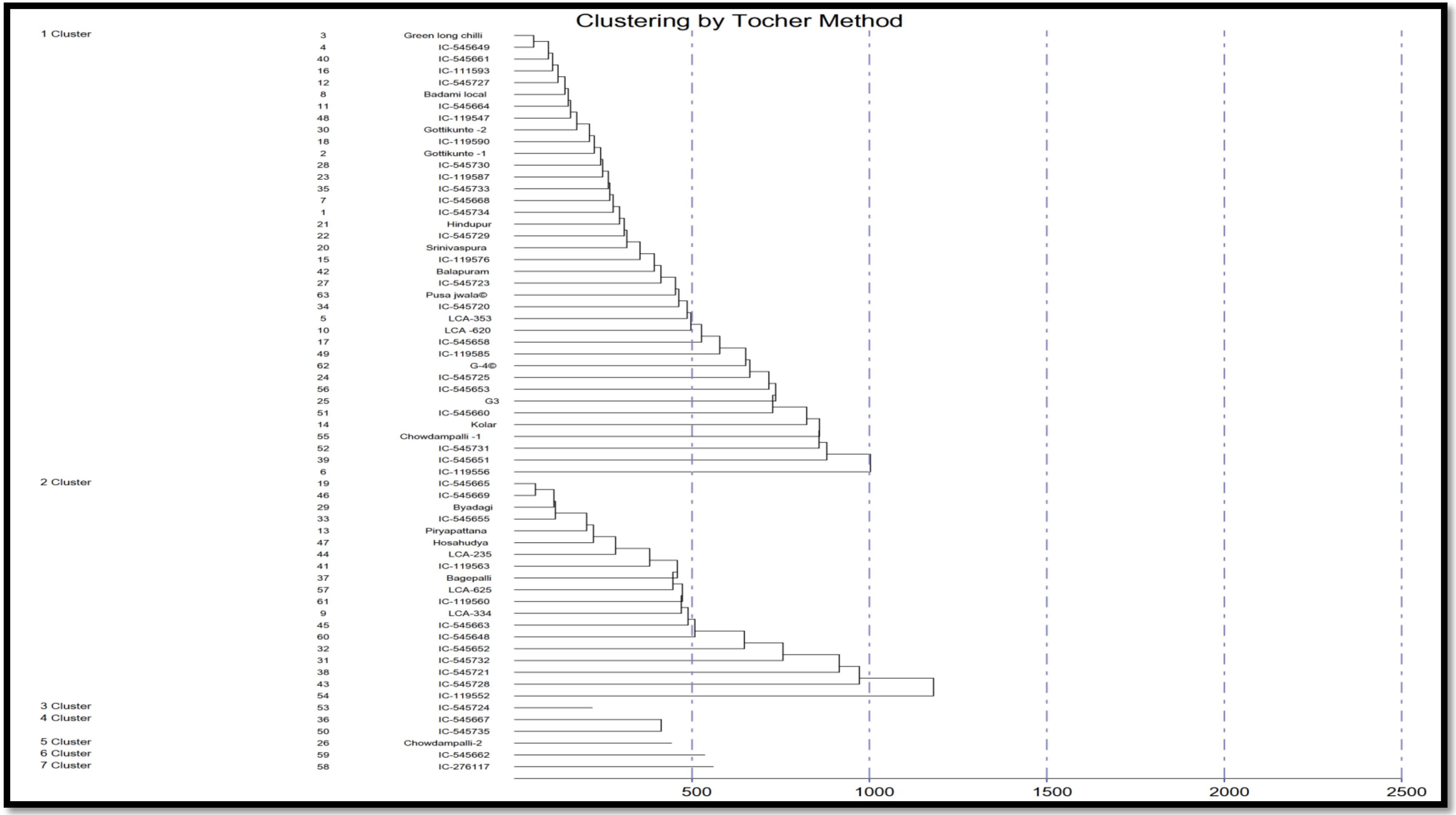



**Figure 1. Dendrogram showing the genetic diversity among 63 genotypes of chilli**

**Table 12. Per cent contribution of different quantitative characters to the total divergence among chilli genotypes.**

| Source | Per cent contribution | Times ranked 1st |
|---|---|---|
| Days to first flowering | 1.69 | 33 |
| Days to 50 per cent flowering | 0.00 | 0.00 |
| Days taken for first picking | 0.00 | 0.00 |
| Plant height (cm) | 12.24 | 239 |
| Number of primary branches | 0 | 0 |
| Number of secondary branches | 0.15 | 3 |
| Green fruit length (cm) | 0.97 | 19 |
| Green fruit diameter (cm) | 0.05 | 1 |
| Number of green fruits per plant | 5.79 | 113 |
| Green fruit weight (g) | 3.69 | 72 |
| Green fruit yield per plant (kg) | 32.97 | 644 |
| Red ripe fruit length (cm) | 0.46 | 9 |
| Red ripe fruit diameter (cm) | 0 | 0 |
| Number of red ripe fruits per plant | 4.25 | 83 |
| Red ripe fruit weight (g) | 1.13 | 22 |
| Red ripe fruit yield per plant (kg) | 36.61 | 715 |

**Table 13. Cluster mean values of sixteen characters for seven clusters among chilli genotypes.**

| | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 | X14 | X15 | X16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cluster I | 54.92 | 66.71 | 90.58 | 52.04 | 4.91 | 9.25 | 9.28 | 2.41 | 65.55 | 9.45 | 600.15 | 8.39 | 2.25 | 55.68 | 8.30 | 451.23 |
| Cluster II | 53.32 | 65.47 | 91.26 | 54.86 | 4.98 | 9.03 | 10.43 | 1.32 | 95.98 | 5.34 | 510.85 | 9.05 | 1.53 | 88.24 | 4.45 | 380.31 |
| Cluster III | 50.00 | 62.00 | 84.00 | 28.95 | 4.50 | 10.00 | 9.55 | 1.35 | 78.70 | 5.50 | 432.85 | 6.90 | 1.07 | 59.70 | 4.30 | 256.71 |
| Cluster IV | 52.00 | 66.50 | 92.50 | 50.10 | 3.33 | 7.77 | 8.95 | 1.30 | 124.73 | 4.93 | 610.18 | 7.07 | 1.22 | 107.40 | 4.56 | 481.51 |
| Cluster V | 61.00 | 71.00 | 92.00 | 50.00 | 4.15 | 10.00 | 9.00 | 1.00 | 45.20 | 6.23 | 326.81 | 9.20 | 1.10 | 36.43 | 4.40 | 160.29 |
| Cluster VI | 55.00 | 64.00 | 89.00 | 65.45 | 4.26 | 17.99 | 12.95 | 2.50 | 97.88 | 18.50 | 1810.78 | 9.33 | 2.03 | 61.28 | 17.55 | 1075.46 |
| Cluster VII | 56.00 | 61.00 | 90.00 | 80.35 | 3.90 | 8.00 | 13.25 | 2.25 | 66.80 | 11.33 | 756.51 | 12.67 | 3.07 | 49.67 | 10.29 | 511.07 |

X1= Days to first flowering
X2= Days to 50 per cent flowering
X3= Days taken for first picking
X4= Plant height
X5=Number of primary branches
X6=Number of secondary branches
X7=Green fruit length (cm)
X8=Green fruit diameter (cm)
X9=Number of green fruits per plant
X10=Green fruit weight (g)
X11=Green fruit yield per plant (g)
X12=Red ripe fruit length (cm)
X13=Red ripe fruit diameter (cm)
X14=Number of red ripe fruits per plant
X15=Red ripe fruit weight (g)
X16=Red ripe fruit yield per plant (g)

recorded in the cluster VI (1810.78 g) followed by cluster VII (756.51 g) and the lowest cluster mean was observed in the cluster V (326.81 g) for green fruit yield per plant.

The highest cluster mean for red ripe fruit length was recorded in the cluster VI (12.67 cm) followed by cluster VI (9.33 cm) and the lowest cluster mean was observed in the cluster III (6.90 cm). The highest cluster mean was observed in the cluster VII (3.07 cm) followed by cluster I (2.25 cm) and the lowest cluster mean was observed in the cluster III (1.07 cm) for red ripe fruit diameter.

The highest cluster mean was recorded in the cluster IV (107.40) followed by cluster II (88.24) and the lowest cluster mean was observed in the cluster V (36.43) for number of red ripe fruits per plant. The highest cluster mean for red ripe fruit weight was observed in the cluster VI (17.55 g) followed by cluster VI (10.29 g) and the lowest cluster mean was observed in the cluster III (4.30 g). The highest cluster mean for was recorded in the cluster VI (1075.46 g) followed by cluster VII (511.07 g) and the lowest cluster mean was observed in the cluster V (160.29 g) for red ripe fruit yield per plant.

# DISCUSSION

# V DISCUSSION

Genetic improvement of any trait of interest in a particular crop is based on the extent of genetic variation, heritable component of variation and the process of the breeding methodology to exploit the available genetic variability present in the crop. The source of genetic variability is either from the germplasm or from the total gene pool available or due to the genetic recombination through hybridization.

As a first step, assessment of genetic variability present in the crop is most important. Germplasm is the source of genetic variability for all the characters including yield and quality. The available variability present in the germplasm can be utilized most efficiently by the plant breeder in crop improvement programme. The quantitative estimation of the genetic variability parameters is made possible through application of statistical tools which indicate not only the available genetic variability but also the extent of heritable portion of the genetic variability.

Crop improvement programme is a continuous process by way of evaluation of germplasm collected from different sources for growth, yield and quality characters and identifying /developing varieties or hybrids suitable to the ever changing climate and demand of the consumer. Thus, in the present study, an attempt has been made to generate basic information on variability, heritability and genetic advance, character association, path analysis and divergence for different characters using 63 genotypes from different locations. The results obtained in the investigation are discussed in this chapter.

## 5.1 Analysis of variance for yield and yield components in chilli

### *5.1.1 Analysis of variance for different character in chilli*

On examining ANOVA (Table 2 and 3), the nature and magnitude of variability for different quantitative characters are clearly observed among the chilli genotypes. The values indicate highly significant differences for all the characters under study, thereby suggesting existence of large amount of variation among the genotypes. So, there is a scope for considerable improvement in this crop through the characters studied. Similar to the present findings, investigations carried out earlier also revealed wide variations for various characters Amith *et al*. (2014), Janaki *et al*. (2015) and Sran and Jindal (2019).

## 5.2 Genetic variability, heritability and genetic advance

One of the ways in which the variability of these characters can be assessed is through a simple approach of examining the range of variation. Range of variation observed for all the traits (Table 2 and 3) 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. Further, the phenotype of crop is influenced by additive gene effect (heritable), dominance (non-heritable) and epistatic (non-allelic interaction). Hence, it becomes necessary to split the observed variability into phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) which indicates the extent of variability existing for various traits.

Heritability of characters can be relied upon, 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 this is prone to change with environments and material. 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 (1957) and Johnson *et al*. (1955) as the heritability is influenced by biometrical method, generation of hybrid, sample size of experimental material and environment. With these points in view, the results of the variability observed in the 63 chilli genotypes evaluated in the present investigation are discussed here under.

*5. 2.1 Estimate of phenotypic and genotypic coefficient of variation*

High PCV and GCV value was recorded for germination percentage, shoot length, seedling vigour index -1, number of primary branches, number of secondary branches, green fruit length, green fruit diameter, number of green fruits per plant, green fruit weight, green fruit yield per plant, green fruit yield per plot, green fruit yield per hectare, red ripe fruit length, red ripe fruit diameter, number of red ripe fruits per plant, red ripe fruit weight, red ripe fruit yield per plant , red ripe fruit yield per plot and red ripe fruit yield per hectare. The similar results were also observed by Kadwey *et al*. (2016), Gobu *et al*. (2017), Kumar *et al*. (2017), Pujar *et al*. (2017), Yogeshkumar *et al*. (2018), Negi and Sharma (2019) and Sreenivas *et al*. (2019).

It indicated that the presence of high variability in the germplasm for selection and the differences between PCV and GCV values were minimum, indicating that traits under study were less influenced by environment. Hence, these characters can be relied upon and simple selection can be practiced for further improvement.

Moderate PCV and GCV were observed for test weight, root length, root to shoot ratio, plant height, green fruit stalk length and red ripe fruit stalk length indicating the little influence of environment. Therefore, phenotypic variability may be a good measure of genotypic variability. The findings of Pandith and Adhikary (2014), Yogeshkumar *et al*. (2018), Kumar *et al*. (2019) and Negi and Sharma (2019) are in conformity with present findings.

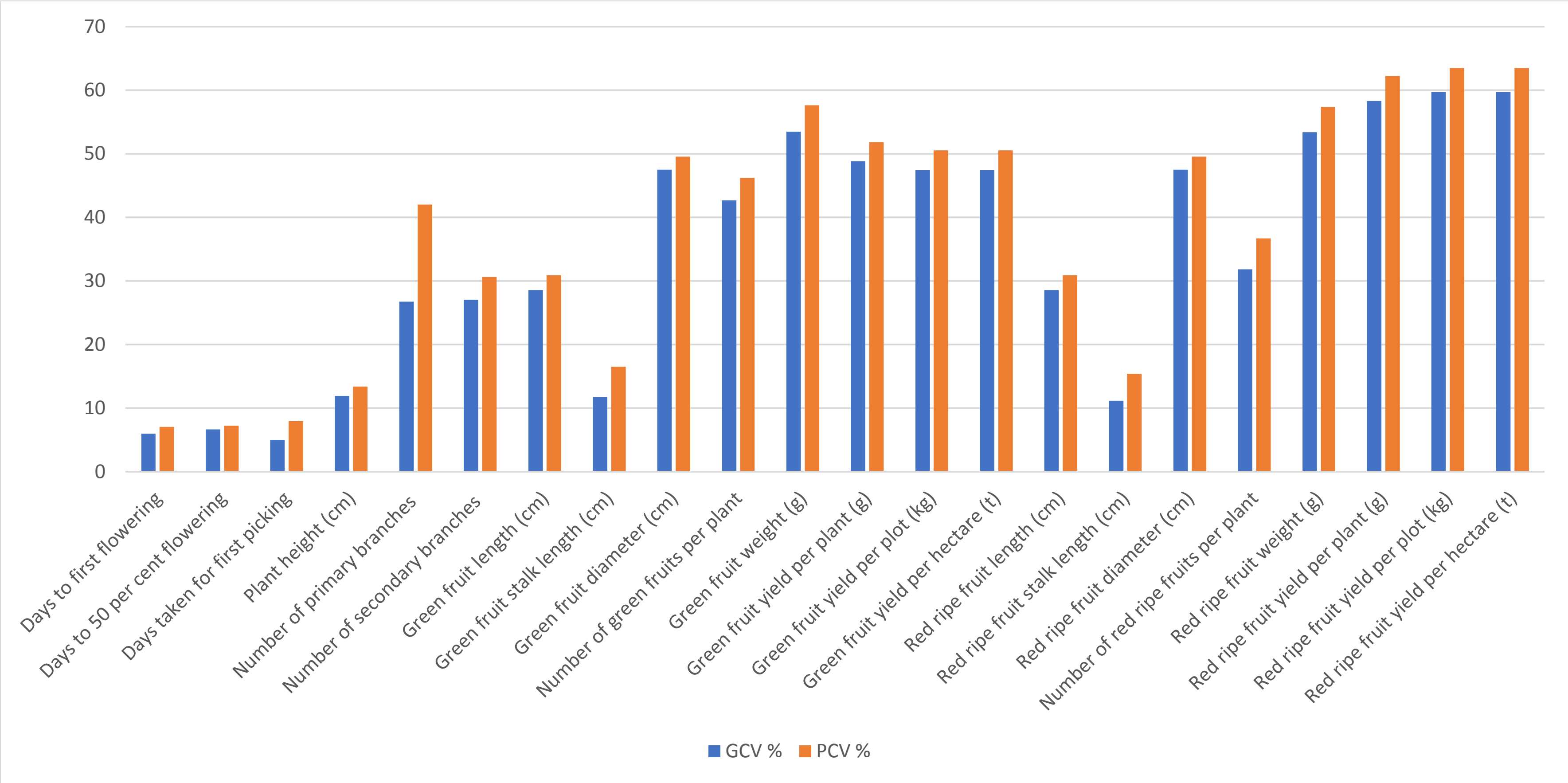



**Figure 2. GCV and PCV with respect to yield and yield contributing characters**

Low PCV and GCV were observed for days to first flowering, days to 50 per cent flowering and days to first picking. Low GCV and PCV indicated the narrow genetic base therefore selection for such traits may not give desirable results. The similar results were also observed by Bijalwan and Madhvi (2015), Meena *et al*. (2016), Pujar *et al*. (2017), Singh *et al*. (2017) and Negi and Sharma (2019).

*5.2.2 Estimates of heritability and genetic advance*

The effectiveness of selection for any character depends not only on the amount of phenotypic and genotypic variability but also on estimates of broad sense heritability.

High heritability was observed for days to first flowering, days to 50 per cent flowering, days to first picking, plant height, number of primary branches, number of secondary branches, green fruit length, green fruit diameter, number of green fruits per plant, green fruit weight, green fruit yield per plant, green fruit yield per plot, green fruit yield per hectare, red ripe fruit length, red ripe fruit diameter, number of red ripe fruits per plant, red ripe fruit weight, red ripe fruit yield per plant, red ripe fruit yield per plot, red ripe fruit yield per hectare, test weight, germination percentage, root length, shoot length root to shoot ratio, seedling vigour index -1 which indicates the prevalence of additive gene actions and lesser influence of environment in the expression of these traits, hence these characters are amenable for selection. The similar results were observed by Amit *et al*. (2014), Pandith and Adhikary (2014), Babu *et al.* (2016), Gobu *et al.* (2017), Kumar *et al.* (2017), Negi and Sharma (2019) and Sreenivas *et al*. (2019).

Heritability in broad sense is not the true indicator of inheritance of traits. Since, only additive component of genetic variance is efficiently transferred from generation to generation. Therefore, heritability in broad sense may mislead in judging the effectiveness of selection for the trait. Considering heritability in broad sense along with genetic advance may reveal the prevalence of specific components (additive or non-additive) of genetic variance and thus, helps in judging the effectiveness of selection for the trait more accurately. High heritability accompanied with high genetic advance indicates the prevalence of additive gene effects and hence, selection would be effective for such traits. From the investigation high heritability coupled with high genetic advance was observed for plant height, number of primary branches, number of secondary branches, green fruit length, green fruit diameter, number of green fruits per plant, green fruit weight, green fruit yield per plant, green fruit yield per plot, green fruit yield per hectare, red ripe fruit length, red ripe fruit diameter, number of red ripe fruits per plant, red ripe fruit weight, red ripe fruit yield per plant and red ripe fruit yield per plot, red ripe fruit yield per hectare, test weight, germination percentage, root length, shoot length root to shoot ratio, seedling vigour index -1. This indicates the predominance of additive gene action and amenable for phenotypic selection in early generations, results are in accordance with the findings of Gobu *et al.* (2017), Pujar *et al*. (2017), Nahak *et al*. (2018), Yogeshkumar *et al*. (2018), Negi and Sharma (2019) and Sreenivas *et al*. (2019).

High heritability coupled with moderate genetic advance over mean was found in traits like days taken for first flowering and days taken for 50 per cent flowering indicating that the expression of this character as governed by non-additive gene action and could be exploited through heterosis breeding. This view was supported by Suryakumari *et al*. (2010), Kumar *et al*. (2012), Janaki *et al*. (2015) Kadwey *et al*. (2016) and Kumar *et al*. (2019).

Low heritability coupled with low genetic advance over mean was observed for days taken for first picking. The characters exhibiting comparatively lower heritability accompanied by low genetic gain indicates that dominance or epistatic effects are of considerable value for these characters and hence little improvement in these characters is possible through selection. The similar results were observed by Suryakumari *et al*. (2010) and Rekha *et al*. (2016).

**5.3 Correlation coefficient analysis for yield and yield attributing traits**

Direct selection for yield and yield component traits is not effective as it is a complex quantitative character and it is highly influenced by environment. High genotype and environment interaction will restrict improvement; if selection is based on yield *per se* performance. Thus, effective improvement in yield may be brought about through selection on yield component characters. Therefore, the correlation between yield and yield components are of considerable importance in selection programme. The aim of correlation studies is primarily to know the suitability of various characters for indirect selection because selection on any particular trait may bring about undesirable changes in other associated characters (Singh and Chaudhary, 1977).

Yield component characters show association among themselves and also with yield. Unfavorable association between the desirable attributes under selection may limit genetic advance. Hence, knowledge of association between the yield and yield components and also among the yield components is essential for planning a sound selection programme (Falconer, 1981). In the present investigation, correlation estimates were obtained from 63 genotypes for yield with the yield components of chilli and are discussed hereunder.

The green fruit yield was found to be positively and significantly associated with number of secondary branches, green fruit diameter, green fruit weight and number of green fruits per plant and red ripe fruit yield was positively and significantly associated with number of secondary branches, red ripe fruit diameter, red ripe fruit weight and number of red ripe fruits per plant indicating a strong association between yield and these characters were positive and high. Therefore, yield can be improved by

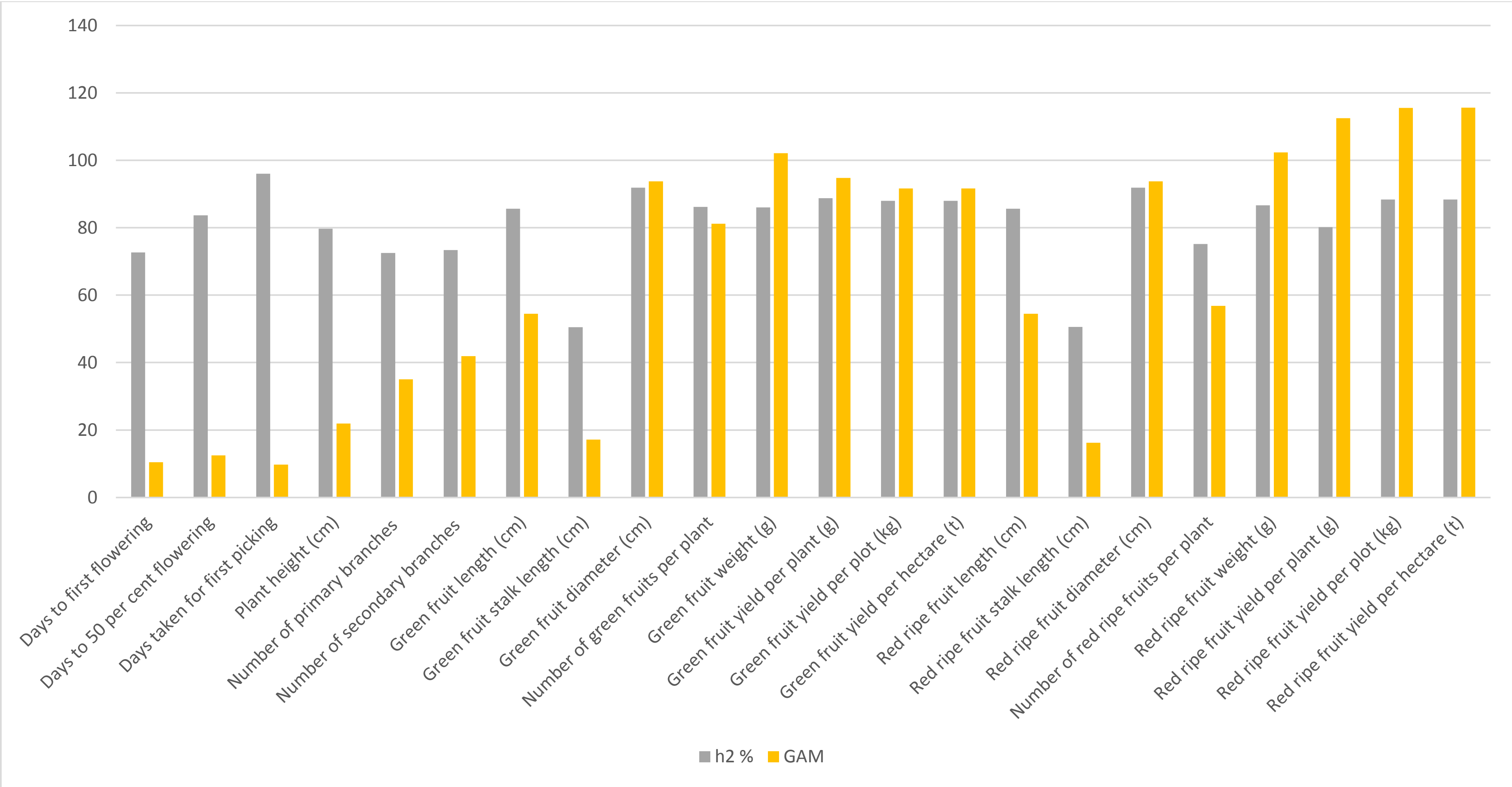



**Figure 3. Heritability and genetic advance as per cent mean with respect to yield and yield contributing characters**


**Plate 2a. Variability for fruit shape among sixty three chilli genotypes**


**Plate 2b. Variability for fruit shape among sixty three chilli genotypes**

direct selection of these characters, as it helps in simultaneous improvement of all characters. The results were in accordance Pujar *et al*. (2017), Singh *et al*. (2018), Swetha *et al*. (2018), Negi and Sharma (2019) and Sreenivas *et al*. (2019).

Days to first flowering had positive significant association with days to 50 per cent flowering followed by days to first picking, this indicated that early flowering induces increased number of flowers per plant. This view was in accordance with Pujar *et al*. (2017), Singh *et al*. (2018), Swetha *et al*. (2018), Vidya *et al*. (2018) and Kumari *et al*. (2019). This trait exhibited negative correlation with green fruit yield per plant and red ripe fruit yield per plant indicating reduction in the vegetative phase and induction of the reproductive phase which ultimately contribute towards increasing yield, similar results were reported by Pandiyaraj *et al*. (2017) and Singh *et al*. (2018).

Green fruit length had significant positive association with green fruit stalk length. Green fruit diameter had positive and significant correlation with green fruit weight. Similarly, red ripe fruit diameter had positive association with red ripe fruit weight. Similar results were observed by Sharma *et al*. (2010), Murmu *et al*. (2017), Pujar *et al*. (2017) and Negi and Sharma (2019). It may be predicted that increased in the fruit diameter causes increased fruit weight and thus leading to increase in the yield.

### 5.4 Path Co-efficient analysis for yield and yield attributing traits

The observed correlation between fruit yield and its component characters is the net result of the direct and indirect effects of the component character through other yield attributes. The total correlation coefficient between yield and its component characters may sometimes be misleading, as it may be an over or under estimate of its association with other characters. In these cases, direct selection on the basis of correlated response may not be fruitful. For critical evaluation, the correlation coefficient needs to be split into direct and indirect effects using path coefficient analysis since, many characters affect a given trait. Thus, the correlation and path coefficients in combination can give a better insight into cause and effect relationship between different pairs of characters.

In this study, the characters subjected to correlations were also subjected to path coefficient analysis for estimating the direct and indirect effects so as to formulate a basis for selection. The results are discussed hereunder.

Among the characters studied for path analysis days to first flowering, days to first picking, number of secondary branches, green fruit length, green fruit diameter, number of green fruits per plant and green fruit weight exhibited direct positive effect on green fruit yield per plant. Similar results were observed Rohini *et al*. (2016), Maurya *et al*. (2017), Pujar *et al*. (2017), Singh *et al*. (2018), Vidya *et al*. (2018) and Sran and Jindal (2019).

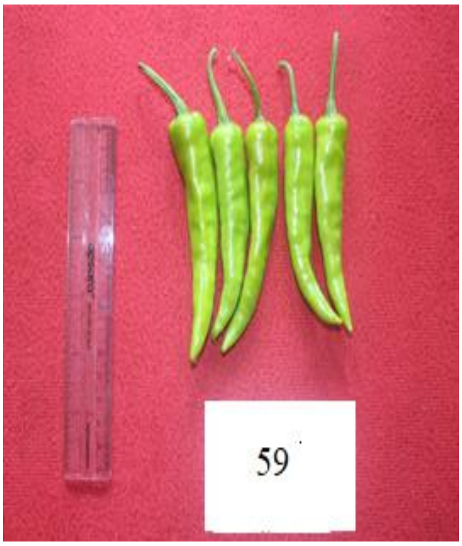
Similarly, days to first flowering, days to 50 per cent flowering, plant height, red ripe fruit length, red ripe fruit stalk length, red ripe fruit diameter, number of red ripe fruits per plant and red ripe fruit weight had positive direct effect on red ripe fruit yield per plant indicating their true positive and significant association with yield. Therefore, direct selection for these traits would be rewarding for improvement of yield. The findings of Kumar *et al*. (2012), Rohini *et al*. (2016), Rekha *et al*. (2016), Negi and Sharma (2019) and Sreenivas *et al*. (2019) are conformity with the present findings.

The characters like days to 50 per cent flowering, plant height, and number of primary branches had direct negative effect on green fruit yield per plant and days to first flowering, plant height and number of primary branches had direct negative effect on red ripe fruit yield per plant. The similar results were observed by Rohini *et al*. (2016), Pandiyaraj *et al*. (2017), Pujar *et al*. (2017), Vidya *et al*. (2018), Negi and Sharma (2019) and Sreenivas *et al*. (2019). The characters having positive direct effect should be selected as for and traits with negative direct effect should be selected against during the crop improvement programme.

**5.5 Divergence study for yield and yield contributing traits.**

Information on genetic divergence among the available germplasm is vital to a plant breeder for an efficient choice of parents for hybridization. It is established fact that genetically diverse parents are likely to contribute desirable segregants. It was also observed that the more diverse parents, greater are the chances of obtaining high heterotic F1s and broad spectrum of variability in the segregating generation. Improvement on yield and quality achieved by selecting genotypes with desirable character combinations existing in the nature or by hybridization. Selection of parents identified on the basis of divergence analysis would be more promising for a hybridization programme. Of the several methods available, Mahalanobis' generalized distances estimated by $D^2$ statistic (Rao, 1952) is a unique method for disseminating populations considering a set of parameters together rather than deciding from indices based upon morphological similarities, eco-geographical diversity and phylogenetic relationship.

The material for the present study includes 63 genotypes, which were grouped into seven clusters using Tocher's method. Of the seven clusters studied Cluster I was the largest having thirty-eight genotypes followed by cluster II with nineteen genotypes, cluster VI with two genotypes, cluster III, cluster V, cluster VI and cluster VII were solitary clusters. Genotypes obtained from different geographical locations were grouped into a single cluster. It indicates that genetic diversity and geographical diversity do not tally. This is in agreement with the findings of Misra *et al*. (2011), Hasan *et al*. (2014), Janaki *et al*. (2016), Farhad *et al*. (2010), Yatung *et al*. (2014b) and Gawande *et al*. (2018).




IC-545662


IC-119556


IC-545660

**Plate 3. Best yielding genotypes among sixty three chilli genotypes**

Among the seven clusters, cluster II with nineteen genotypes showed maximum intra cluster distance (692.59) followed by cluster I (590.63) with thirty-eight genotypes, cluster IV (413.05) with two genotypes and clusters III, V, VI, VII had low intra cluster distance as they possessed single genotype. Indicating existence of wide genetic divergence among the constituent genotypes within the clusters. High degree of divergence among the genotypes within a cluster would produce more segregating breeding material and selection within such cluster might be executed based on maximum mean value for the desirable characters.

The inter cluster distance was maximum (11578) between cluster IV and cluster V followed by cluster IV and cluster VII (7887.45), cluster I and cluster IV (6627.72), cluster II and cluster V (5709.34), cluster III and cluster IV (5047.93), and cluster I had the least inter-cluster (1136.84) with cluster III, based on distance between clusters, Maximum inter-cluster distance was observed between the clusters IV and V indicating that the genotypes in these clusters can be used as parents in hybridization programme to get higher heterotic hybrids and potential transgressive segregants. Similar results were recorded by Farhad *et al.* (2010), Gogate *et al.* (2011) and Yatung *et al.* (2014b).

Red ripe fruit yield per plant (36.61 %) contributed maximum to total divergence followed by green fruit yield per plant (32.97 %), plant height (12.24 %), number of green fruits per plant (5.79 %), number of red ripe fruits per plant (4.25 %), green fruit weight (3.69 %), days to first flowering (1.69 %), red ripe fruit weight (1.13 %), green fruit length (0.97 %), red ripe fruit length (0.46 %), number of secondary branches (0.15 %) and green fruit diameter (0.05 %). However, traits like days to 50 per cent flowering, days taken for first picking, number of primary branches and red ripe fruit diameter had no substantial contribution to total divergence. Similar findings were reported by Hasan *et al*. (2014), Bijalwan *et al*. (2018) and Nahak *et al*. (2018).

The highest cluster mean was recorded in cluster V for days to first flowering (61.00) and days to 50 per cent flowering (71.00). The highest cluster mean was recorded in cluster IV for days to first picking (92.50), number of green fruits per plant (124.73) and number of red ripe fruits per plant (107.40). The highest cluster mean for number of primary branches was observed in the cluster II (4.98) followed by cluster I (4.91) and the lowest cluster mean was observed in the cluster IV (3.33). The highest cluster mean was observed in cluster VI for number of secondary branches (17.99), green fruit diameter (2.50), green fruit weight (18.50), green fruit yield per plant (1810.78), red ripe fruit weight (17.55) and red ripe fruit yield per plant (1075.46). The highest cluster mean was noticed in cluster VII for plant height (80.35), green fruit length (13.25), red ripe fruit length (12.67) and red ripe fruit diameter (3.07).

## CONCLUSION

- In the present investigation, high PCV and GCV were observed for characters like, number of primary branches, number of secondary branches, green fruit length, green fruit diameter, number of green fruits per plant, green fruit weight, green fruit yield per plant, green fruit yield per plot, red ripe fruit length, red ripe fruit diameter, number of red ripe fruits per plant, red ripe fruit weight, red ripe fruit yield per plant and red ripe fruit yield per plot. Thus, there is an ample scope for development of elite genotypes using these characters.
- The parameters like, days to first flowering, days to first picking, number of secondary branches, green fruit length, green fruit diameter, number of green fruits per plant and green fruit weight exhibited direct positive effect on green fruit yield per plant. Thus, these characters accounted to have for improvement in increased fruit yield. Further, the traits like days to 50 per cent flowering, plant height, number of primary branches and green fruit stalk length had shown maximum negative direct effect on fruit yield per plant.
- The traits like days to 50 per cent flowering, number of secondary branches, red ripe fruit length, red ripe fruit stalk length, red ripe fruit diameter, number of red ripe fruits per plant and red ripe fruit weight on red ripe fruit yield per plant exhibited direct positive effect on green fruit yield per plant. Hence, these are the important characters to be accounted for gaining improvement in total yield per plant. Since, these characters had high significant and positive direct effects on yield per plant.
- Divergence study revealed that maximum intra-cluster distance was found in cluster II followed by cluster I. Maximum inter-cluster distance was between clusters IV and V followed by clusters I and IV as well. The crosses between the genotypes of these clusters can be tried for improvement in chilli for fruit yield.
- The best genotypes identified in the present study based on mean yield performance under field condition are, IC-545662, IC-119556, IC-545660, G-3, IC-545731 and IC-545653.

### Future line of work

- High yielding genotypes identified from the study *viz.,* IC-545662, IC-119556, IC-545660 and G-3 may be evaluated for yield stability over the locations.
- Broad divergent parents *viz.,* IC-545667, IC-545735 and Chowdampalli -2 can be utilized for crossing in order to generate more variability for different traits and can be used for selecting better segregants in advanced generations.
- It was witnessed from the trait association analysis and path analysis that the characters like number of secondary branches, fruit diameter, number of fruits per

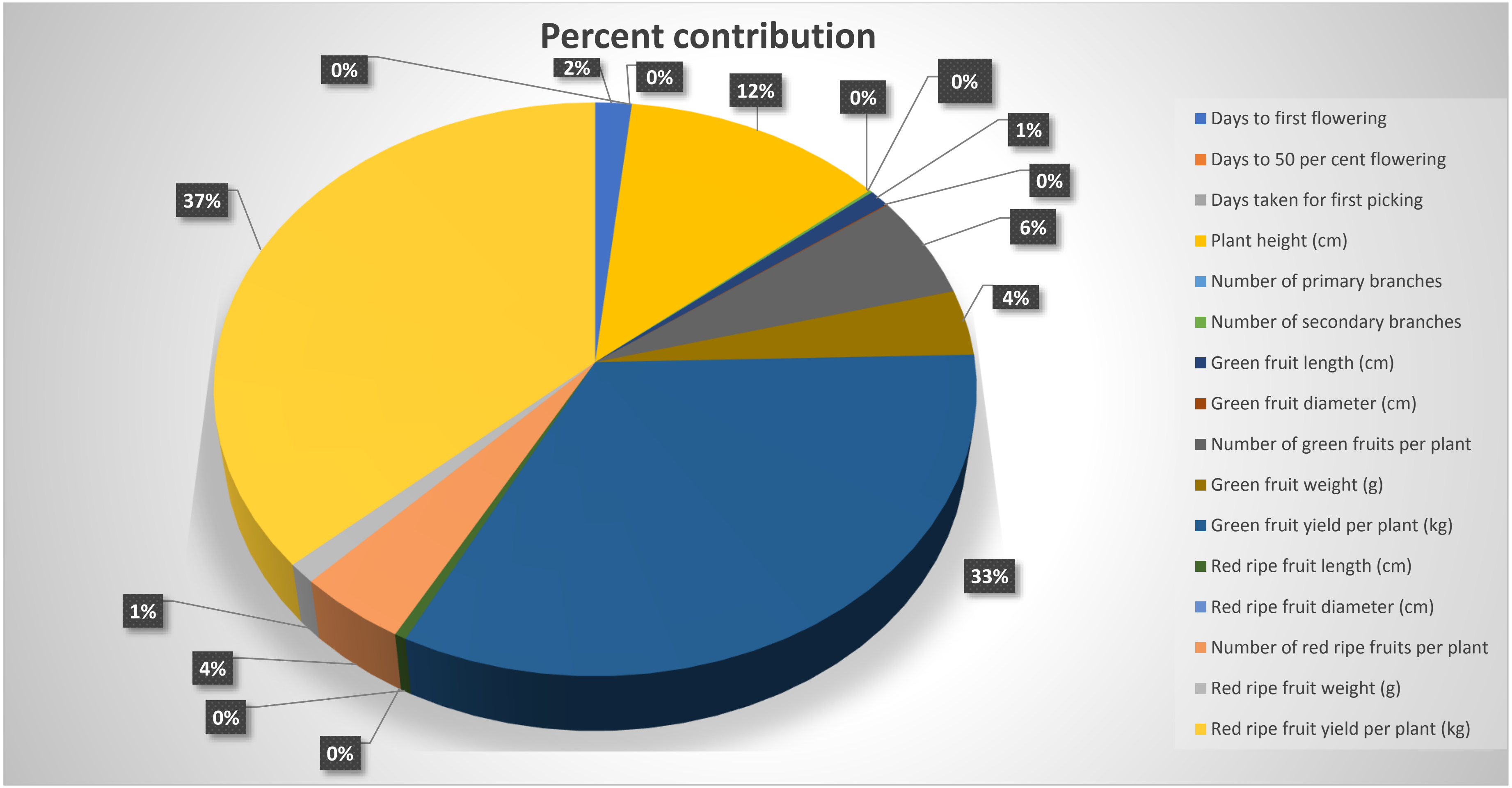



**Figure 4. Per cent contribution of different characters towards total divergence among chilli genotypes**

plant and fruit weight were having maximum positive significant correlation. Traits like fruit weight, fruit diameter, fruit length and number of fruits per plant were having highest direct effect for fruit yield per plant. Therefore, recurrent selection programme can be aimed in this direction on these traits may yield fruitful results.

- The obtained variation and diversity from current study can be validated through molecular characterization and for biotic and abiotic stresses.

# SUMMARY

# VI SUMMARY

The main objectives of the present investigation were to study the nature and extent of genetic variability, association and divergence in chilli germplasm for different quantitative and qualitative parameters. The work was carried out at College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga with 63 genotypes.

Analysis of variance revealed highly significant difference among genotypes for all the characters. The phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the traits. High genotypic coefficient of variation (GCV) and phenotypic coefficient variation (PCV) were recorded for number of primary branches, number of secondary branches, green fruit length, green fruit diameter, number of green fruits per plant, green fruit weight, green fruit yield per plant, green fruit yield per plot, green fruit yield per hectare, red ripe fruit length, red ripe fruit diameter, number of red ripe fruits per plant, red ripe fruit weight, red ripe fruit yield per plant, red ripe fruit yield per plot and red ripe fruit yield per hectare. Moderate PCV and GCV were observed for plant height, green fruit stalk length and red ripe fruit stalk length.

High estimates of heritability coupled with high genetic advance as percent mean (GAM) was observed for plant height, number of primary branches, number of secondary branches, green fruit length, green fruit diameter, number of green fruits per plant, green fruit weight, green fruit yield per plant, green fruit yield per plot, red ripe fruit length, red ripe fruit diameter, number of red ripe fruits per plant, red ripe fruit weight, red ripe fruit yield per plant and red ripe fruit yield per plot.

The character association studies revealed that the total green fruit yield had significant and positive association with green fruit weight followed by number of green fruits per plant, green fruit diameter and number of secondary branches and red ripe fruit yield was positively and significantly associated with red ripe fruit weight, number of red ripe fruits per plant, red ripe fruit diameter and number of secondary branches. Therefore, fruit yield can be improved by direct selection of these characters, as it helps in simultaneous improvement of all the characters. While it was negatively and significantly associated with days to first flowering, Hence, indirect selection for these characters could be made for improving yield.

Path analysis studies revealed that significant positive association at phenotypic level among the traits *viz.*, days to first flowering, days to first picking, number of secondary branches, green fruit length, green fruit diameter, number of green fruits per plant and green fruit weight exhibited direct positive effect on green fruit yield per plant. Similarly, days to 50 per cent flowering, days to first picking, number of secondary branches, red ripe fruit length, red ripe fruit stalk length, red ripe fruit diameter, number of red ripe fruits per plant and red ripe fruit weight which also exhibited true association with direct effect on yield. The direct selection for these traits would be rewarding for improvement in the total yield per plant.

Sixty three genotypes were grouped into seven clusters based on Mahalanobis's $D^2$ statistic. Among the seven clusters, cluster II with nineteen genotypes showed maximum intra cluster distance (692.59) followed by cluster I (590.63) with thirty-eight genotypes, cluster IV (413.05) with two genotypes and clusters III, V, VI, VII had low intra cluster distance (0.00) as they possessed single genotype. Intra-cluster distances revealed that among the seven clusters, Maximum intra-cluster distance was observed in cluster IV and V, indicating the existence of genetic divergence among the constituent genotypes as compared to other clusters. High degree of divergence among the genotypes within a cluster would produce more segregating breeding materials and selection within such cluster might be executed based on maximum mean value for the desirable characters.

The maximum (11578) divergence was observed between cluster IV and cluster V having two and one genotypes respectively followed by cluster IV and cluster VII (7887.45), cluster I and cluster IV (6627.72), cluster II and cluster V (5709.34), cluster III and cluster IV (5047.93), and cluster I had the least inter-cluster (1136.84) with cluster III, based on distance between clusters. This clustering helps the breeders for selection of genotypes for hybridization programmers and can be used as base for patenting or registration.

Among the 16 characters included for $D^2$ analysis, red ripe fruit yield per plant (36.61 %) contributed maximum to total divergence followed by green fruit yield per plant (32.97 %), plant height (12.24 %), number of green fruits per plant (5.79 %), number of red ripe fruits per plant (4.25 %), green fruit weight (3.69 %), days to first flowering (1.69 %), red ripe fruit weight (1.13 %), green fruit length (0.97 %), red ripe fruit length (0.46 %), number of secondary branches (0.15 %) and green fruit diameter (0.05 %). However, traits like days to 50 per cent flowering, days taken for first picking, number of primary branches and red ripe fruit diameter had no substantial contribution to total divergence.

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# APPENDICES

## VIII APPENDICES

**Appendix-I: Monthly mean meteorological data recorded during the experimental year 2019 - 2020 recorded at the ZAHRS, Mudigere.**

| Months | Rainfall (mm) | Relative Humidity (%) | Temperature ($^0$C) | |
|---|---|---|---|---|
| | | | Minimum | Maximum |
| **May-2019** | 83.30 | 82.19 | 18.54 | 34.16 |
| **June-2019** | 273.70 | 80.53 | 18.26 | 32.00 |
| **July-2019** | 740.20 | 75.38 | 19.70 | 30.06 |
| **August-2019** | 1402.70 | 73.61 | 19.74 | 27.03 |
| **September-2019** | 525.30 | 79.83 | 19.83 | 25.16 |
| **October-2019** | 329.30 | 80.19 | 19.58 | 24.62 |
| **November-2019** | 26.30 | 80.26 | 18.93 | 25.26 |
| **December-2019** | 1.40 | 80.12 | 19.00 | 26.25 |
| **January-2020** | 0.00 | 80 | 18.06 | 29.00 |
| **February-2020** | 0.00 | 80.41 | 17.34 | 30.27 |
| **March-2020** | 2.30 | 80.25 | 18.61 | 32.70 |
| **Average** | **307.68** | **86.63** | **18.87** | **28.77** |
| **Total** | **3384.50** | **-** | **-** | **-** |

## Appendix-II: Mean performance of different chilli genotypes for various growth and yield parameters.

| SL. No. | Genotypes | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | IC-545734 | 51.00 | 58.00 | 85.00 | 53.50 | 4.59 | 8.33 | 7.50 | 2.77 | 3.35 | 62.50 | 3.56 |
| 2 | Gottikunte -1 | 53.00 | 67.00 | 92.00 | 56.50 | 6.00 | 11.52 | 8.05 | 3.25 | 6.50 | 65.40 | 3.70 |
| 3 | Green long chilli | 56.00 | 68.00 | 98.00 | 49.00 | 5.50 | 10.26 | 11.50 | 4.15 | 2.10 | 64.00 | 9.51 |
| 4 | IC-545649 | 55.00 | 68.00 | 97.00 | 51.65 | 5.00 | 9.13 | 9.25 | 2.97 | 1.75 | 59.80 | 8.80 |
| 5 | LCA-353 | 50.00 | 70.00 | 89.00 | 57.13 | 4.90 | 6.00 | 10.50 | 2.75 | 2.10 | 54.90 | 9.65 |
| 6 | IC-119556 | 53.00 | 74.00 | 95.00 | 55.50 | 9.21 | 16.37 | 6.85 | 2.50 | 3.90 | 58.40 | 22.33 |
| 7 | IC-545668 | 57.00 | 70.00 | 88.00 | 46.50 | 3.45 | 6.21 | 7.17 | 3.15 | 1.00 | 66.20 | 2.87 |
| 8 | Badami local | 56.00 | 72.00 | 92.00 | 56.00 | 4.45 | 8.50 | 12.83 | 3.55 | 1.80 | 67.50 | 8.74 |
| 9 | LCA-334 | 53.00 | 58.00 | 86.00 | 59.25 | 4.57 | 9.10 | 7.75 | 3.25 | 1.05 | 83.95 | 3.03 |
| 10 | LCA -620 | 53.00 | 72.00 | 90.00 | 64.15 | 4.17 | 9.33 | 10.23 | 3.27 | 1.25 | 59.80 | 4.24 |
| 11 | IC-545664 | 56.00 | 64.00 | 86.00 | 51.37 | 5.25 | 10.50 | 12.50 | 3.75 | 1.35 | 62.60 | 6.39 |
| 12 | IC-545727 | 58.00 | 68.00 | 89.00 | 53.67 | 7.21 | 12.73 | 11.50 | 3.35 | 2.85 | 61.90 | 11.85 |
| 13 | Piryapattana | 55.00 | 60.00 | 86.00 | 57.29 | 4.60 | 12.92 | 12.05 | 4.80 | 1.25 | 104.60 | 6.40 |
| 14 | Kolar local | 65.00 | 75.00 | 91.00 | 49.00 | 5.00 | 9.17 | 9.00 | 3.25 | 1.00 | 79.40 | 3.90 |
| 15 | IC-119576 | 61.00 | 72.00 | 93.00 | 51.27 | 3.21 | 5.12 | 6.00 | 3.10 | 1.65 | 71.70 | 2.20 |
| 16 | IC-111593 | 60.00 | 68.00 | 94.00 | 51.00 | 4.33 | 8.95 | 14.00 | 2.50 | 2.15 | 61.20 | 10.00 |
| 17 | IC-545658 | 56.00 | 68.00 | 89.00 | 53.00 | 5.50 | 8.00 | 8.43 | 3.25 | 3.65 | 54.90 | 16.45 |
| 18 | IC-119590 | 52.00 | 67.00 | 91.00 | 52.50 | 5.50 | 11.56 | 7.07 | 2.25 | 2.35 | 70.30 | 8.90 |
| 19 | IC-545665 | 52.00 | 61.00 | 86.00 | 51.50 | 6.00 | 11.00 | 9.00 | 3.17 | 1.10 | 105.25 | 3.92 |
| 20 | Srinivaspura | 61.00 | 74.00 | 87.00 | 44.00 | 4.50 | 9.50 | 8.30 | 3.20 | 1.10 | 66.10 | 3.45 |
| 21 | Hindupur | 58.00 | 65.00 | 88.00 | 46.50 | 9.17 | 13.50 | 9.00 | 3.25 | 1.00 | 63.30 | 3.15 |
| 22 | IC-545729 | 56.00 | 70.00 | 96.00 | 55.00 | 7.50 | 10.00 | 6.05 | 2.50 | 1.40 | 67.75 | 3.55 |
| 23 | IC-119587 | 52.00 | 58.00 | 85.00 | 57.00 | 4.00 | 8.29 | 11.67 | 2.60 | 2.15 | 61.90 | 10.23 |
| 24 | IC-545725 | 55.00 | 63.00 | 84.00 | 56.50 | 5.31 | 8.26 | 8.25 | 3.50 | 2.85 | 52.10 | 14.20 |
| 25 | G-3 | 48.00 | 57.00 | 86.00 | 50.00 | 3.00 | 6.00 | 9.50 | 3.75 | 3.40 | 65.60 | 18.80 |
| 26 | Chowdampalli-2 | 61.00 | 71.00 | 92.00 | 50.00 | 4.15 | 10.00 | 9.20 | 3.50 | 1.00 | 52.50 | 6.23 |
| 27 | IC-545723 | 50.00 | 69.00 | 84.00 | 51.00 | 3.50 | 6.00 | 7.50 | 3.50 | 3.20 | 66.50 | 13.65 |
| 28 | IC-545730 | 53.00 | 59.00 | 83.00 | 51.00 | 4.00 | 7.00 | 9.00 | 3.00 | 1.50 | 67.50 | 9.05 |
| 29 | Byadagi | 51.00 | 63.00 | 88.00 | 46.00 | 5.68 | 8.33 | 6.50 | 2.51 | 0.80 | 95.00 | 2.65 |
| 30 | Gottikunte -2 | 56.00 | 65.00 | 86.00 | 50.00 | 5.29 | 9.78 | 13.29 | 4.25 | 1.80 | 68.90 | 8.05 |
| 31 | IC-545732 | 61.00 | 74.00 | 98.00 | 59.25 | 4.50 | 7.19 | 8.00 | 3.25 | 1.10 | 103.90 | 5.65 |
| 32 | IC-545652 | 52.00 | 71.00 | 96.00 | 48.50 | 3.97 | 6.00 | 12.50 | 3.50 | 0.80 | 89.20 | 6.33 |
| 33 | IC-545655 | 57.00 | 62.00 | 87.00 | 50.50 | 6.00 | 8.00 | 8.09 | 3.35 | 0.95 | 94.10 | 3.35 |
| 34 | IC-545720 | 48.00 | 59.00 | 88.00 | 48.69 | 3.50 | 12.00 | 7.50 | 4.07 | 3.00 | 66.80 | 16.10 |
| 35 | IC-545733 | 55.00 | 64.00 | 89.00 | 47.50 | 3.67 | 9.52 | 10.75 | 3.27 | 2.45 | 71.00 | 8.65 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 36 | IC-545667 | 49.00 | 65.00 | 88.00 | 56.75 | 3.16 | 16.93 | 8.03 | 3.40 | 1.00 | 126.35 | 2.40 |
| 37 | Bagepalli | 56.00 | 67.00 | 94.00 | 53.52 | 3.50 | 6.00 | 6.25 | 3.00 | 0.95 | 88.50 | 2.10 |
| 38 | IC-545721 | 47.00 | 59.00 | 86.00 | 68.25 | 4.00 | 8.00 | 9.15 | 3.60 | 3.10 | 81.50 | 11.75 |
| 39 | IC-545651 | 60.00 | 68.00 | 96.00 | 48.50 | 4.57 | 6.00 | 12.75 | 3.80 | 3.55 | 80.80 | 6.83 |
| 40 | IC-545661 | 55.00 | 66.00 | 92.00 | 46.00 | 3.50 | 8.00 | 10.50 | 4.97 | 2.55 | 63.50 | 13.00 |
| 41 | IC-119563 | 46.00 | 56.00 | 93.00 | 46.13 | 8.30 | 11.60 | 15.50 | 3.62 | 2.00 | 100.40 | 11.50 |
| 42 | Balapuram | 55.00 | 70.00 | 100.00 | 48.56 | 5.30 | 8.60 | 10.05 | 3.75 | 1.20 | 73.10 | 5.60 |
| 43 | IC-545728 | 55.00 | 72.00 | 99.00 | 60.00 | 6.00 | 10.50 | 12.25 | 3.30 | 0.60 | 106.00 | 3.15 |
| 44 | LCA-235 | 58.00 | 70.00 | 96.00 | 49.13 | 4.50 | 10.67 | 10.25 | 4.15 | 0.90 | 101.80 | 5.93 |
| 45 | IC-545663 | 49.00 | 69.00 | 93.00 | 67.50 | 3.50 | 6.55 | 10.00 | 3.25 | 1.40 | 91.30 | 4.50 |
| 46 | IC-545669 | 52.00 | 60.00 | 90.00 | 47.65 | 8.00 | 12.53 | 8.50 | 3.60 | 1.60 | 105.30 | 4.55 |
| 47 | Hosahudya | 48.00 | 59.00 | 82.00 | 59.95 | 5.05 | 9.22 | 7.00 | 2.90 | 1.00 | 105.30 | 2.45 |
| 48 | IC-119547 | 53.00 | 68.00 | 87.00 | 44.75 | 3.69 | 9.00 | 11.75 | 3.70 | 1.65 | 61.90 | 7.20 |
| 49 | IC-119585 | 59.00 | 71.00 | 100.00 | 58.95 | 3.80 | 7.00 | 12.83 | 3.95 | 2.65 | 57.70 | 12.78 |
| 50 | IC-545735 | 55.00 | 68.00 | 97.00 | 43.45 | 3.50 | 8.60 | 19.65 | 3.85 | 1.60 | 123.10 | 7.45 |
| 51 | IC-545660 | 57.00 | 67.00 | 95.00 | 48.67 | 5.50 | 11.00 | 7.00 | 2.50 | 4.00 | 56.10 | 22.80 |
| 52 | IC-545731 | 54.00 | 71.00 | 97.00 | 64.52 | 4.50 | 15.81 | 9.55 | 3.25 | 3.00 | 78.70 | 15.15 |
| 53 | IC-545724 | 50.00 | 62.00 | 84.00 | 28.95 | 4.50 | 10.00 | 9.55 | 4.23 | 1.35 | 78.70 | 5.50 |
| 54 | IC-119552 | 56.00 | 67.00 | 91.00 | 36.85 | 4.15 | 9.67 | 12.17 | 3.14 | 2.70 | 86.30 | 11.35 |
| 55 | Chowdampalli -1 | 62.00 | 74.00 | 99.00 | 54.35 | 3.20 | 6.96 | 10.00 | 3.00 | 2.60 | 73.10 | 7.43 |
| 56 | IC-545653 | 49.00 | 57.00 | 80.00 | 58.15 | 3.68 | 12.58 | 7.75 | 4.50 | 4.35 | 62.32 | 18.70 |
| 57 | LCA-625 | 59.00 | 69.00 | 97.00 | 61.37 | 4.00 | 8.00 | 9.65 | 3.00 | 1.15 | 92.00 | 3.98 |
| 58 | IC-276117 | 56.00 | 61.00 | 90.00 | 80.35 | 3.90 | 8.00 | 13.25 | 3.40 | 2.25 | 66.80 | 11.33 |
| 59 | IC-545662 | 55.00 | 64.00 | 89.00 | 65.45 | 4.26 | 17.99 | 12.95 | 3.15 | 2.50 | 97.88 | 18.50 |
| 60 | IC-545648 | 56.00 | 74.00 | 101.00 | 59.55 | 3.25 | 7.21 | 6.40 | 2.73 | 1.15 | 99.25 | 2.75 |
| 61 | IC-119560 | 50.00 | 59.00 | 85.00 | 60.18 | 5.00 | 9.00 | 13.25 | 3.00 | 1.40 | 89.90 | 6.20 |
| 62 | Bhagyalakshmi (G-4) | 50.67 | 65.07 | 89.73 | 57.26 | 4.40 | 6.76 | 9.57 | 3.68 | 1.53 | 65.84 | 5.58 |
| 63 | Pusa Jwala | 53.07 | 66.40 | 89.33 | 36.35 | 4.97 | 7.54 | 9.55 | 3.48 | 2.05 | 60.84 | 4.89 |

X1= Days to first flowering
X2= Days to 50 per cent flowering
X3=Days taken for first picking
X4=Plant height (cm)
X5=Number of primary branches
X6=Number of secondary branches
X7=Green fruit length (cm)
X8=Green fruit stalk length (cm)
X9=Green fruit diameter (cm)
X10=Number of green fruits per plant
X11= Green fruit weight (g)

Contd..

| SL. No. | Genotypes | X12 | X13 | X14 | X15 | X16 | X17 | X18 | X19 | X20 | X21 | X22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | IC-545734 | 222.50 | 2.31 | 4.81 | 7.37 | 2.33 | 3.30 | 55.20 | 2.75 | 151.80 | 1.58 | 3.28 |
| 2 | Gottikunte -1 | 241.98 | 2.52 | 5.23 | 7.85 | 2.91 | 1.23 | 53.45 | 2.30 | 122.94 | 1.28 | 2.66 |
| 3 | Green long chilli | 608.32 | 6.33 | 13.16 | 10.87 | 3.67 | 2.27 | 52.11 | 8.81 | 459.09 | 5.37 | 11.17 |
| 4 | IC-545649 | 526.24 | 5.47 | 11.38 | 8.53 | 2.75 | 1.30 | 48.69 | 7.27 | 353.98 | 3.68 | 7.66 |
| 5 | LCA-353 | 529.79 | 5.51 | 11.46 | 8.50 | 2.33 | 2.00 | 47.20 | 8.57 | 404.50 | 4.21 | 8.75 |
| 6 | IC-119556 | 1303.78 | 11.86 | 24.68 | 6.49 | 2.13 | 3.57 | 42.50 | 20.75 | 881.88 | 9.17 | 19.08 |
| 7 | IC-545668 | 189.99 | 1.98 | 4.11 | 6.59 | 3.00 | 1.30 | 62.30 | 2.65 | 165.10 | 1.72 | 3.57 |
| 8 | Badami local | 589.95 | 6.14 | 12.76 | 11.63 | 2.70 | 2.07 | 56.90 | 7.80 | 443.79 | 4.62 | 9.60 |
| 9 | LCA-334 | 254.37 | 2.65 | 5.50 | 7.50 | 2.33 | 1.27 | 85.06 | 2.85 | 242.43 | 2.52 | 5.24 |
| 10 | LCA -620 | 253.55 | 2.64 | 5.48 | 9.50 | 2.59 | 1.33 | 49.26 | 3.85 | 189.65 | 1.97 | 4.10 |
| 11 | IC-545664 | 399.70 | 4.16 | 8.65 | 11.37 | 3.60 | 1.53 | 54.30 | 5.58 | 302.99 | 3.15 | 6.55 |
| 12 | IC-545727 | 733.52 | 7.63 | 15.87 | 10.97 | 3.30 | 1.33 | 58.60 | 9.95 | 583.07 | 6.06 | 12.61 |
| 13 | Piryapattana | 669.44 | 6.96 | 14.48 | 11.73 | 4.19 | 1.43 | 89.25 | 5.62 | 501.59 | 5.22 | 10.85 |
| 14 | Kolar | 309.66 | 3.22 | 6.70 | 8.15 | 3.23 | 1.00 | 65.00 | 2.20 | 143.00 | 1.49 | 3.09 |
| 15 | IC-119576 | 157.74 | 1.64 | 3.41 | 5.37 | 2.84 | 1.60 | 62.18 | 1.75 | 108.82 | 1.13 | 2.35 |
| 16 | IC-111593 | 612.00 | 6.36 | 13.24 | 13.33 | 2.45 | 2.10 | 59.60 | 8.97 | 534.61 | 5.56 | 11.56 |
| 17 | IC-545658 | 903.11 | 9.39 | 19.54 | 7.84 | 2.73 | 4.00 | 47.95 | 15.37 | 736.99 | 7.66 | 15.94 |
| 18 | IC-119590 | 625.67 | 6.51 | 13.53 | 6.95 | 2.21 | 2.17 | 62.39 | 6.75 | 421.14 | 4.38 | 9.11 |
| 19 | IC-545665 | 412.58 | 4.29 | 8.92 | 8.37 | 2.76 | 1.23 | 93.55 | 2.51 | 234.81 | 2.44 | 5.08 |
| 20 | Srinivaspura | 228.05 | 2.37 | 4.93 | 7.53 | 2.85 | 1.17 | 54.45 | 2.55 | 138.85 | 1.44 | 3.00 |
| 21 | Hindupur | 199.40 | 2.07 | 4.31 | 8.76 | 2.83 | 1.10 | 65.86 | 2.48 | 163.33 | 1.70 | 3.53 |
| 22 | IC-545729 | 240.17 | 2.50 | 5.20 | 5.63 | 2.15 | 1.33 | 51.91 | 2.35 | 121.99 | 1.27 | 2.64 |
| 23 | IC-119587 | 632.93 | 6.58 | 13.69 | 9.50 | 2.10 | 2.37 | 54.65 | 8.65 | 472.72 | 4.92 | 10.23 |
| 24 | IC-545725 | 739.82 | 7.69 | 16.00 | 7.67 | 2.67 | 2.90 | 42.89 | 12.25 | 525.40 | 5.46 | 11.37 |
| 25 | G-3 | 1233.28 | 12.83 | 26.68 | 8.17 | 2.17 | 2.87 | 42.12 | 17.48 | 736.26 | 7.66 | 15.93 |
| 26 | Chowdampalli-2 | 326.81 | 3.90 | 8.11 | 9.00 | 3.47 | 1.10 | 36.43 | 4.40 | 160.29 | 1.67 | 3.47 |
| 27 | IC-545723 | 907.73 | 9.44 | 19.64 | 6.33 | 3.23 | 3.03 | 58.63 | 11.91 | 698.28 | 7.26 | 15.11 |
| 28 | IC-545730 | 610.88 | 6.35 | 13.21 | 8.67 | 2.83 | 1.50 | 58.32 | 8.15 | 475.31 | 4.94 | 10.28 |
| 29 | Byadagi | 251.28 | 2.61 | 5.44 | 6.17 | 2.20 | 1.00 | 93.34 | 2.25 | 210.02 | 2.18 | 4.54 |
| 30 | Gottikunte -2 | 554.65 | 5.77 | 12.00 | 12.95 | 3.53 | 1.40 | 60.15 | 7.19 | 432.48 | 4.50 | 9.36 |
| 31 | IC-545732 | 587.04 | 6.11 | 12.70 | 7.00 | 2.87 | 1.20 | 105.50 | 4.89 | 515.90 | 5.37 | 11.16 |
| 32 | IC-545652 | 564.19 | 5.87 | 12.20 | 11.67 | 2.70 | 1.53 | 73.55 | 5.45 | 400.85 | 4.17 | 8.67 |
| 33 | IC-545655 | 315.24 | 3.28 | 6.82 | 7.79 | 3.03 | 1.00 | 96.67 | 2.20 | 212.67 | 2.21 | 4.60 |
| 34 | IC-545720 | 1075.48 | 11.18 | 23.26 | 7.15 | 4.00 | 3.30 | 57.35 | 15.38 | 882.04 | 9.17 | 19.08 |
| 35 | IC-545733 | 614.15 | 6.39 | 13.29 | 10.19 | 3.01 | 2.50 | 66.59 | 7.98 | 531.39 | 5.53 | 11.49 |
| 36 | IC-545667 | 303.24 | 3.53 | 7.35 | 7.90 | 2.70 | 1.00 | 110.30 | 1.90 | 209.57 | 2.18 | 4.53 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 37 | Bagepalli | 185.85 | 1.93 | 4.02 | 6.33 | 3.00 | 0.93 | 83.50 | 1.50 | 125.25 | 1.30 | 2.71 |
| 38 | IC-545721 | 957.63 | 9.96 | 20.72 | 8.17 | 3.15 | 3.50 | 79.56 | 10.28 | 817.88 | 8.51 | 17.69 |
| 39 | IC-545651 | 551.46 | 5.74 | 11.93 | 11.65 | 3.20 | 3.27 | 72.56 | 5.96 | 432.46 | 4.50 | 9.35 |
| 40 | IC-545661 | 825.50 | 8.59 | 17.86 | 10.33 | 4.00 | 1.77 | 55.35 | 12.63 | 699.07 | 7.27 | 15.12 |
| 41 | IC-119563 | 1154.60 | 12.01 | 24.98 | 11.83 | 3.27 | 1.77 | 93.54 | 9.95 | 930.72 | 9.68 | 20.13 |
| 42 | Balapuram | 409.36 | 4.26 | 8.86 | 9.68 | 3.00 | 1.60 | 66.87 | 4.05 | 270.82 | 2.82 | 5.86 |
| 43 | IC-545728 | 333.90 | 3.47 | 7.22 | 11.26 | 3.03 | 0.83 | 93.90 | 2.10 | 197.19 | 2.05 | 4.27 |
| 44 | LCA-235 | 603.17 | 6.27 | 13.05 | 9.50 | 3.17 | 1.73 | 89.98 | 4.50 | 404.91 | 4.21 | 8.76 |
| 45 | IC-545663 | 410.85 | 4.27 | 8.89 | 9.53 | 2.97 | 1.23 | 85.05 | 4.48 | 380.60 | 3.96 | 8.23 |
| 46 | IC-545669 | 479.12 | 4.98 | 10.36 | 6.99 | 3.47 | 1.53 | 96.35 | 4.35 | 419.12 | 4.36 | 9.07 |
| 47 | Hosahudya | 257.99 | 2.68 | 5.58 | 6.19 | 2.77 | 1.97 | 93.33 | 1.50 | 140.00 | 1.46 | 3.03 |
| 48 | IC-119547 | 445.68 | 4.64 | 9.64 | 8.83 | 3.47 | 1.53 | 55.25 | 6.58 | 363.55 | 3.78 | 7.86 |
| 49 | IC-119585 | 737.12 | 7.67 | 15.95 | 11.56 | 3.00 | 3.03 | 46.88 | 10.55 | 494.63 | 5.14 | 10.70 |
| 50 | IC-545735 | 917.10 | 9.54 | 19.84 | 19.15 | 3.03 | 1.43 | 104.50 | 7.21 | 753.45 | 7.84 | 16.30 |
| 51 | IC-545660 | 1279.08 | 13.30 | 27.67 | 6.03 | 2.35 | 4.17 | 47.87 | 19.45 | 931.07 | 9.68 | 20.14 |
| 52 | IC-545731 | 1192.31 | 12.40 | 25.79 | 8.53 | 2.97 | 3.57 | 63.52 | 14.45 | 917.86 | 9.55 | 19.86 |
| 53 | IC-545724 | 432.85 | 4.50 | 9.36 | 6.90 | 3.25 | 1.07 | 59.70 | 4.30 | 256.71 | 2.67 | 5.55 |
| 54 | IC-119552 | 979.51 | 10.19 | 21.19 | 10.96 | 3.03 | 3.27 | 69.80 | 10.15 | 708.47 | 7.37 | 15.33 |
| 55 | Chowdampalli -1 | 542.77 | 5.64 | 11.74 | 9.33 | 2.67 | 2.50 | 73.48 | 7.05 | 518.01 | 5.39 | 11.21 |
| 56 | IC-545653 | 1165.38 | 12.12 | 25.21 | 6.50 | 3.83 | 4.10 | 51.57 | 17.36 | 895.26 | 9.31 | 19.37 |
| 57 | LCA-625 | 365.70 | 3.80 | 7.91 | 8.70 | 2.67 | 1.03 | 86.25 | 2.40 | 207.00 | 2.15 | 4.48 |
| 58 | IC-276117 | 756.51 | 7.87 | 16.36 | 12.67 | 3.35 | 3.07 | 49.67 | 10.29 | 511.07 | 5.32 | 11.06 |
| 59 | IC-545662 | 1810.78 | 17.66 | 36.72 | 11.33 | 3.00 | 2.03 | 61.28 | 17.55 | 1075.46 | 12.05 | 25.05 |
| 60 | IC-545648 | 272.94 | 2.84 | 5.90 | 5.53 | 2.30 | 0.90 | 87.27 | 2.13 | 185.90 | 1.93 | 4.02 |
| 61 | IC-119560 | 557.38 | 5.80 | 12.06 | 12.75 | 3.00 | 1.67 | 81.13 | 5.45 | 442.15 | 4.95 | 10.30 |
| 62 | Bhagyalakshmi (G-4) | 367.48 | 3.82 | 7.95 | 8.89 | 3.48 | 2.18 | 58.05 | 5.08 | 294.89 | 3.07 | 6.38 |
| 63 | Pusa Jwala | 292.88 | 3.05 | 6.34 | 9.26 | 3.14 | 2.01 | 55.90 | 4.15 | 231.98 | 2.41 | 5.02 |

X12=Green fruit yield per plant (g) X13=Green fruit yield per plot (kg) X14= Green fruit yield per hectare (t)
X15=Red ripe fruit length (cm) X16=Red ripe fruit stalk length (cm) X17=Red ripe fruit diameter (cm)
X18=Number of red ripe fruits per plant X19=Red ripe fruit weight (g) X20=Red ripe fruit yield per plant
X21=Red ripe fruit yield per plot (g) X22= Red ripe fruit yield per hectare (t)

## Appendix III. Mean performance of different chilli genotypes for various seed quality parameters.

| SL. No. | Genotypes | Test weight (g) | Germination (%) | Root length (cm) | Shoot length (cm) | Root to shoot ratio | Seedling vigour index-1 |
|---|---|---|---|---|---|---|---|
| 1 | IC-545734 | 0.67 | 98.33 | 10.20 | 4.17 | 2.45 | 1437.00 |
| 2 | Gottikunte -1 | 0.40 | 50.00 | 5.95 | 2.25 | 2.64 | 410.00 |
| 3 | Green long chilli | 0.62 | 95.00 | 11.03 | 3.60 | 3.06 | 1389.85 |
| 4 | IC-545649 | 0.80 | 90.00 | 8.10 | 4.27 | 1.90 | 113.30 |
| 5 | LCA-353 | 0.45 | 95.00 | 10.81 | 5.50 | 1.97 | 1549.45 |
| 6 | IC-119556 | 0.53 | 80.00 | 10.33 | 4.49 | 2.30 | 1185.60 |
| 7 | IC-545668 | 0.68 | 75.00 | 9.68 | 3.21 | 3.02 | 966.75 |
| 8 | Badami local | 0.64 | 90.00 | 11.25 | 5.38 | 2.09 | 1496.70 |
| 9 | LCA-334 | 0.43 | 95.00 | 7.35 | 3.59 | 2.05 | 1039.30 |
| 10 | LCA -620 | 0.54 | 90.00 | 12.60 | 3.98 | 3.17 | 1492.20 |
| 11 | IC-545664 | 0.71 | 60.00 | 9.75 | 3.65 | 2.67 | 804.00 |
| 12 | IC-545727 | 0.61 | 55.00 | 8.01 | 3.48 | 2.30 | 631.95 |
| 13 | Piryapattana | 0.71 | 65.00 | 7.33 | 3.84 | 1.91 | 726.05 |
| 14 | Kolar | 0.63 | 65.00 | 7.27 | 2.69 | 2.70 | 647.40 |
| 15 | IC-119576 | 0.50 | 40.00 | 6.83 | 4.17 | 1.64 | 440.00 |
| 16 | IC-111593 | 0.41 | 75.00 | 6.65 | 3.25 | 2.05 | 742.50 |
| 17 | IC-545658 | 0.61 | 70.00 | 8.15 | 2.94 | 2.77 | 775.30 |
| 18 | IC-119590 | 0.53 | 75.00 | 10.77 | 3.67 | 2.93 | 1083.00 |
| 19 | IC-545665 | 0.68 | 85.00 | 10.53 | 4.83 | 2.18 | 1305.60 |
| 20 | Srinivaspura | 0.57 | 70.00 | 6.95 | 2.76 | 2.52 | 679.70 |
| 21 | Hindupur | 0.58 | 95.00 | 10.25 | 4.32 | 2.37 | 1384.15 |
| 22 | IC-545729 | 0.66 | 80.00 | 9.70 | 3.87 | 2.51 | 1080.00 |
| 23 | IC-119587 | 0.64 | 65.00 | 8.01 | 2.91 | 2.75 | 709.80 |
| 24 | IC-545725 | 0.66 | 98.00 | 7.88 | 3.38 | 2.33 | 1126.00 |
| 25 | G-3 | 0.80 | 85.00 | 9.35 | 5.25 | 1.78 | 1241.00 |
| 26 | Chowdampalli-2 | 0.53 | 90.00 | 11.09 | 3.95 | 2.81 | 1353.60 |
| 27 | IC-545723 | 0.83 | 85.00 | 6.80 | 5.02 | 1.35 | 1004.70 |
| 28 | IC-545730 | 0.76 | 85.00 | 8.53 | 4.42 | 1.93 | 1100.75 |
| 29 | Byadagi | 0.66 | 97.67 | 11.60 | 5.02 | 2.31 | 1662.00 |
| 30 | Gottikunte -2 | 0.54 | 70.00 | 6.60 | 3.05 | 2.16 | 675.50 |
| 31 | IC-545732 | 0.58 | 70.00 | 7.70 | 4.40 | 1.75 | 847.00 |
| 32 | IC-545652 | 0.71 | 80.00 | 9.10 | 3.79 | 2.40 | 1031.20 |
| 33 | IC-545655 | 0.68 | 75.00 | 8.13 | 3.10 | 2.62 | 842.25 |
| 34 | IC-545720 | 0.69 | 90.00 | 9.40 | 4.21 | 2.23 | 1224.90 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 35 | IC-545733 | 0.60 | 98.67 | 8.75 | 4.30 | 2.03 | 1305.00 |
| 36 | IC-545667 | 0.69 | 75.00 | 9.35 | 3.87 | 2.42 | 991.50 |
| 37 | Bagepalli | 0.35 | 85.00 | 9.27 | 3.90 | 2.38 | 1119.45 |
| 38 | IC-545721 | 0.75 | 45.00 | 8.42 | 3.90 | 2.16 | 554.40 |
| 39 | IC-545651 | 0.73 | 70.00 | 5.39 | 1.87 | 2.88 | 508.20 |
| 40 | IC-545661 | 0.61 | 60.00 | 7.67 | 3.35 | 2.29 | 661.20 |
| 41 | IC-119563 | 0.59 | 45.00 | 6.90 | 2.83 | 2.44 | 437.85 |
| 42 | Balapuram | 0.54 | 95.00 | 10.50 | 5.45 | 1.93 | 1515.25 |
| 43 | IC-545728 | 0.76 | 90.00 | 7.87 | 4.21 | 1.87 | 1087.20 |
| 44 | LCA-235 | 0.43 | 95.00 | 10.60 | 4.12 | 2.57 | 1398.40 |
| 45 | IC-545663 | 0.76 | 60.00 | 11.25 | 4.50 | 2.50 | 945.00 |
| 46 | IC-545669 | 0.80 | 80.00 | 7.28 | 3.31 | 2.20 | 847.20 |
| 47 | Hosahudya | 0.45 | 90.00 | 9.50 | 5.25 | 1.81 | 1327.50 |
| 48 | IC-119547 | 0.51 | 85.00 | 8.75 | 2.75 | 3.18 | 977.50 |
| 49 | IC-119585 | 0.66 | 70.00 | 8.20 | 4.68 | 1.75 | 901.60 |
| 50 | IC-545735 | 0.56 | 98.00 | 10.70 | 5.75 | 1.86 | 1645.00 |
| 51 | IC-545660 | 0.69 | 50.00 | 6.33 | 2.13 | 2.97 | 423.00 |
| 52 | IC-545731 | 0.66 | 75.00 | 7.75 | 3.37 | 2.30 | 834.00 |
| 53 | IC-545724 | 0.72 | 49.00 | 7.67 | 2.76 | 2.78 | 511.07 |
| 54 | IC-119552 | 0.52 | 90.00 | 10.35 | 3.59 | 2.88 | 1254.60 |
| 55 | Chowdampalli -1 | 0.61 | 98.33 | 10.40 | 4.20 | 2.48 | 1460.00 |
| 56 | IC-545653 | 0.80 | 85.00 | 9.15 | 4.02 | 2.28 | 1119.45 |
| 57 | LCA-625 | 0.61 | 97.33 | 12.20 | 4.90 | 2.49 | 1710.00 |
| 58 | IC-276117 | 0.45 | 95.00 | 10.40 | 3.83 | 2.72 | 1351.85 |
| 59 | IC-545662 | 0.67 | 80.00 | 7.80 | 3.57 | 2.18 | 909.60 |
| 60 | IC-545648 | 0.68 | 60.00 | 9.75 | 3.43 | 2.84 | 790.80 |
| 61 | IC-119560 | 0.54 | 70.00 | 6.60 | 3.05 | 2.16 | 675.50 |
| 62 | G-4 | 0.46 | 99.00 | 9.55 | 4.76 | 2.01 | 1431.00 |
| | Mean | 0.617 | 78.168 | 8.904 | 3.872 | 2.355 | 1014.38 |
| | SEM± | 0.007 | 0.926 | 0.105 | 0.046 | 0.028 | 0.078 |
| | CD @ 5% | 0.019 | 2.594 | 0.293 | 0.129 | 0.078 | 34.878 |

**Appendix IV: List of symbols and abbreviations**

| ***Abbreviations*** | **Full form** |
|---|---|
| *et al.* | And other |
| cm | Centimeter |
| CD | Critical difference |
| CV | Coefficient of variation |
| $^0$C | Degree centigrade |
| Df | Degree of freedom |
| DAT | Days after transplanting |
| G | Gram |
| Kg | Kilogram |
| No. | Number |
| % | Percent |
| PCV | Phenotypic coefficient of variation |
| GCV | Genotypic coefficient of variation |
| $h^2$ (b) | Heritability in broad sense |
| GA | Genetic advance |
| GAM | Genetic advance over mean |
| SE | Standard error |
| *Via.* | Through |
| @ | At the rate of |
| *Viz.* | For example |
| MSS | Mean sum of square |
| *i.e.* | That is |