EVALUATION OF GENOTYPES FOR YIELD AND RESISTANCE TO LEAF CURL IN BIRD CHILLI (*Capsicum frutescens* L.)

by

BANDLA SRINIVAS

(2013 - 11 - 197)

THESIS

Submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF PLANT BREEDING AND GENETICS

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM – 695 522

KERALA, INDIA

2015

DECLARATION

I, hereby declare that this thesis entitled **"EVALUATION OF GENOTYPES FOR YIELD AND RESISTANCE TO LEAF CURL IN BIRD CHILLI (*Capsicum frutescens* L.)"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani, **Bandla Srinivas**

Date: **(2013 -11-197)**

CERTIFICATE

Certified that this thesis entitled **"EVALUATION OF GENOTYPES FOR YIELD AND RESISTANCE TO LEAF CURL IN BIRD CHILLI (*Capsicum frutescens* L.)"** is a record of research work done independently by Mr. Bandla Srinivas under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Vellayani,
Date:

Dr. Beena Thomas
(Major Advisor, Advisory Committee)
Assistant Professor (Plant Breeding and Genetics)
College of Agriculture
Vellayani.

CERTIFICATE

We, the undersigned members of the advisory committee of Mr. Bandla Srinivas, a candidate for the degree of **Master of Science in Agriculture** with major in Plant Breeding and Genetics, agree that the thesis entitled **"EVALUATION OF GENOTYPES FOR YIELD AND RESISTANCE TO LEAF CURL IN BIRD CHILLI (*Capsicum frutescens* L.)"** may be submitted by Mr. Bandla Srinivas, in partial fulfilment of the requirement for the degree.

Dr. Beena Thomas
(Chairman, Advisory Committee)
Assistant Professor (Plant Breeding and Genetics)
Department of Plant Breeding and Genetics
College of Agriculture, Vellayani.

Dr. D. Wilson
(Member, Advisory Committee)
Professor & Head
Department of Plant Breeding and Genetics
College of Agriculture, Vellayani.

Dr. Arya. K
(Member, Advisory Committee)
Professor
Department of Plant Breeding and Genetics
College of Agriculture, Vellayani.

Dr. K. Umamasheswaran
(Member, Advisory Committee)
Professor
Department of Plant Pathology
College of Agriculture, Vellayani

Dr. Vijayaraghavakumar
(Member, Advisory Committee)
Professor and Head
Department of Agricultural Statistics
College of Agriculture, Vellayani.

EXTERNAL EXAMINER

ACKNOWLEDGEMENT

Life is a matter of moments, then of milestones. I would like to thank all the people around me for making those moments meaningful.

With immense pleasure I avail this opportunity to express my deep sense of gratitude and indebtedness to my major advisory ***Dr. Beena Thomas****, Assistant professor, Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, for her expert guidance, constructive suggestions, motherly approach, constant encouragement, affectionate advice, extreme patience, understanding and wholehearted co-operation rendered throughout the course of my study. I consider myself very fortunate in having the privilege of being guided by her.*

I am thankful to ***Dr. Wilson****, Professor and Head (Plant Breeding and Genetics), College of Agriculture, Vellayani and member of my Advisory Committee whose vision, guidance and timely involvement helped me to complete the thesis successfully.*

I express my note of thanks to ***Dr. Arya. K****., Professor (Plant Breeding and Genetics), College of Agriculture, Vellayani and member of advisory committee for wholehearted support, constructive ideas, healthy criticisms and care which persuaded me to sail towards completion of thesis.*

I thankfully acknowledge ***Dr. K. M. Abdul Khader****, Professor (Plant Breeding and Genetics), College of Agriculture, Vellayani, for his meticulous help, unwavering encouragement, forbearance, well timed support and critical scrutiny of the manuscript which has helped a lot for the improvement and preparation of the thesis.*

I wish to take this opportunity to express my profound gratitude and appreciation to the member of my advisory committee, ***Dr. Vijayaraghavakumar****, Professor and Head (Agricultural Statistics), College of Agriculture, Vellayani, for his keen interest, explicit instructions, affectionate advices and unaccountable help rendered throughout the course of work, field experiment, data analysis and interpretation of the experimental data.*

I cordially offer my sincere and heartfelt gratitude to ***Dr. K. Umamasheswaran****, Professor (Plant Pathology) College of Agriculture, Vellayani and member of advisory committee for erudite suggestions, astute remarks and wondrous guidance in conducting the research work and thesis preparation.*

My heartfelt thanks are due to Plant Breeding and Genetics teaching staff, ***Dr. D.S. Radha Devi****,* ***Dr. Maya Devi****,* ***P.****,* ***Dr. P. Manju****,* ***Dr. Sunny K. Oommen****,* ***Dr. Jayalekshmi****,* ***V. G.****,* ***Dr. Lekha Rani****,* ***Dr. Mareen Abraham*** *and* ***Ms. Seeja*** *for their friendly approach, continuous and timely advice, constructive criticisms and constant encouragement rendered to me during the course of my study and research work.*

My heart never forget ***Anju Vijayan****,* ***Anamika Sahithi****,* ***Shruthy A.S.****,* ***Soumya B Nair****, my department batch-mates, whose cooperation, love and affection helped me in my difficult time.*

I wish to place on record the help rendered and moral support to me by loving seniors, ***Sreenivas Gogineni****,* ***Sainath Nagula****,* ***Palli Rajashekar****,* ***Pavankumar Reddy****,* ***Jayanth Reddy****,* ***Kishore****,* ***Darshan****,* ***Gangadhar****,* ***Ramling****,* ***Rajib****,* ***Kranthi, Pritin, Siddesh, Vinay, Bibhishan*** *and also my friends* ***Murali Krishna****,* ***Murali Nagaraju****,* ***Dheeraj Chatti****,* ***Akshay****,* ***Nithya*** *and* ***Lishma****.*

My wholehearted thanks to my juniors ***Sathishkumar****,* ***Reshma Gopi****,* ***Aasha****,* ***Athul****,* ***Nikhitha****,* ***Jeena*** *and* ***Sharanya*** *for their help to complete my thesis work.*

I sincerely acknowledge the Kerala Agricultural University for the financial support in the form of KAU Junior Research Scholarship during my study period.

I express my affection and thanks to my beloved parents, sister, brother and relatives for their unbound love, support, encouragement and care given to me at all times.

Finally, I intensely grateful to one and all for being a part in the triumphant completion of the study.

BANDLA SRINIVAS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

%	-	per cent
^{0} C	-	Degree Celsius
&	-	and
ANOVA	-	Analysis of Variance
DAP	-	Days After Planting
CD (0.05)	-	Critical Difference at 5 % level
cm	-	centimeter
m	-	meter
d.f	-	degrees of freedom
et al.	-	and co-workers/co-authors
Fig.	-	Figure
F_1	-	First filial generation
g	-	gram
kg	-	kilogram
GCV	-	Genotypic Coefficient of Variation
PCV	-	Phenotypic Coefficient of Variation
ECV	-	Environmental Coefficient of Variation
GA	-	Genetic Advance

GAM	-	Genetic Advance as percentage of Mean
V.I	-	Vulnerability Index
H^2	-	Heritability
V_G	-	Genotypic Variance
V_P	-	Phenotypic Variance
V_E	-	Environmental Variance
ha	-	hectare
i.e.	-	that is
KAU	-	Kerala Agricultural University
per se	-	in itself
SE	-	Standard Error
S.E.D	-	Standard Error Difference
S.E.M	-	Standard Error Mean
viz.	-	namely

Introduction

1. INTRODUCTION

Chilli is a widely used vegetable / spice crop cultivated throughout India. It is consumed both in unripe (green) and ripe (red) forms. It is a rich source of vitamin C. It also contains vitamin A, vitamin B and minerals (Singh, 2007). Vitamin C content of fresh Chilli is 50 mg per 100 g and that of dry chilli is 111 mg per 100 g. It can also provide Carotene, Thiamine, Riboflavin and Niacin. High carbohydrate content is observed in dry chilli (31.6g/100g) compared to green chilli (3g/100g). Pungency in chilli is due to presence of an alkaloid “capsaicin” contained in the pericarp and placenta of fruits (Pandit and Adhikary, 2014).

Bird chilli (*Capsicum frutescens* L.) or bird’s eye chilli is a stimulating herb renowned for aroma, taste, flavour and pungency. It is Kerala’s “kanthari mulaku”. Besides its culinary use, it possesses many medicinal and nutritional values. It contains vitamin A and act as an anti-oxidant and anti-inflammatory agent. Bird chilli or cayenne pepper is widely used to treat stomach ulcers, cold, sore throat, fevers and cholesterol aggregation, thus prevents the risk of heart attacks and strokes. Most important thing is that chilli helps to fight prostate cancer by killing prostate cancer cells themselves. Some hot varieties of chilli can be used as a remedy for painful joints and to stop bleeding. Daily use of this hot chillies can stimulate blood flow to the affected area and reduce discomfort and inflammation. Thus bird chilli has a beneficial effect on the circulatory system (Kang, 1992).

Chilli belongs to the family Solanaceae, and is indigenous to Central and South America. The genus *Capsicum* includes 22 wild species, many varieties (Bosland, 1994) and five domesticated species namely *Capsicum annuum*, *C. frutescens, C. chinense, C. pubescens* and *C. baccatum* (Pozzobon *et al.*, 2006; Moscone *et al.*, 2007). Chilli (*Capsicum frutescens* L.; 2n = 2x = 24) is a self-pollinated vegetable; but a few percentage of cross pollination (15-16%) may happen by insects (Ullah *et al.*, 2011).

India is the leading country in the production of chillies contributing 41.11 per cent of the world's production. India is the only country which is rich in many varieties of chilli with different quality factors. It is presently grown extensively throughout the country under rainfed and irrigated conditions (Kallu and Ravindran, 2004). In India chilli is cultivated in 7. 94 lakhs hectare, its production is 1304 million tonnes and productivity is 1.6 million tonnes per hectare (Kumar, 2013). Bird chilli (*C. frutescens* L.) is commercially cultivated only in Mizoram (approximately 140 hectare with annual production of 560 tonnes) and in some areas of Manipur (approximately 122 hectare with annual production of 488 tonnes) whereas in other areas it is widely grown as a homestead crop (Baruah and Baruah, 2004).

Even though chilli is an important vegetable crop some major factors responsible for the low productivity are lack of varieties adapted to different agro-climatic conditions and resistant to pests and diseases. Among pathogenic diseases, more than 45 viruses have been reported infecting chilli worldwide (Green and Kim, 1991). 'Leaf curl' is considered to be one of the major limiting factors in chilli production. The damage starts at nursery stage and causes considerable yield loss in chilli up to 50 % (Meena *et al*., 2006). Growing resistant or tolerant varieties is the best option to control the danger. Collection and evaluation of genotypes for high yield and resistance to biotic stress are important in crop improvement. According to Konai and Nariani (1980) only limited research work has been done in bird chilli. Among 33 indigenous and exotic collections of chilli including five *Capsicum* spp., IC 31339 *(C. frutescens*), Pant C-1, Pant C-2 (*Capsicum annuum* L.) and *C. angulosum* were tolerant to leaf curl virus.

The present investigation is aimed at developing breeding materials in bird chilli, which can be further utilised for production of high yielding leaf curl complex resistant varieties in bird chilli.

Hence the present investigation was undertaken with the following objectives:

1. To study variability and heritability for yield and yield components in *Capsicum frutescens* genotypes.
2. To estimate the genotypic correlations and direct and indirect effects of component characters on yield by path analysis.
3. To identify high yielding genotypes of bird chilli resistant to leaf curl.

Review of Literature

2. REVIEW OF LITERATURE

The literature available on various aspects of the present investigation "Evaluation of genotypes for yield and resistance to leaf curl in bird chilli (*Capsicum frutescens* L.)" is reviewed here.

2. 1 GENETIC DIVERGENCE

Genetic improvement in any crop mainly depends upon the amount of genetic variability present in the population. The importance of genetic diversity in crop plants was first realized by Darwin (1859) and the term "morphism" employing genetic morphs was given by Huxley (1955) which means the existence of distinct genetic forms in balance in a population.

Ortiz *et al.* (2010) studied dendrogram by using average linkage clustering method in 42 Capsicum accessions and these accessions are grouped into five cluster groups. Fourth Group had highest accessions (24) followed by third group (8), second group (6), fifth group (3) and first group with single accession.

Thirteen wheat genotypes were grouped into four clusters based on dendrogram analysis and Euclidian distance matrix and reflected highest diversity was between PBW343 and HS375 while minimum was between RSP564 and RSP561 (Singh *et al.*, 2014).

Prasad *et al.* (2013) studied 10 chilli pepper varieties and reported four cluster groups are generated by dendrogram. Average genetic similarity index revealed 100% similarity between first cluster varieties, 50% similarity between second cluster varieties and fourth cluster varieties and 32% genetic similarity between varieties of third cluster.

Indigenous and exotic origin of 40 *C. annuum* genotypes were subjected to diversity analysis and based on D^2 values the genotypes were grouped into 8 clusters. Fresh fruit weight and number of fruits per plant had the highest contribution towards divergence (Karad *et al*., 2002).

Senapati *et al*. (2003) reported genetic divergence in chilli and the genotypes were clustered into 6 groups with maximum divergence between clusters II and V. The characters contributing towards divergence were fresh fruit weight, fruit girth, fruit length and number of fruits per plant.

Sreelathakumary and Rajamony (2004) studied genetic diversity in 35 chilli genotypes for various characters. Based on D^2 values, the genotypes were clustered into 6 clusters. The maximum inter cluster distance was observed between cluster II and cluster VI. The cluster V recorded maximum intra cluster distance. The characters viz., fruits per plant, yield per plant, fruit length, fruit girth and fruit weight were contributing maximum divergence.

Smitha and Basavaraja (2006) revealed by using Mahalanobis D^2 analysis that 40 chilli genotypes were grouped into 8 clusters. The maximum intra and inter cluster distance were observed for cluster A and between cluster E and H respectively. The maximum relative contribution to the total divergence was made by number of fruits per plant, fruit yield, number of primary branches, number of secondary branches, seeds per fruit, plant spread, fruit weight and fruit length.

Forty nine bird chilli genotypes were grouped into five clusters based on Mahalanobis D^2 values. The inter cluster distance was maximum between cluster I and III and minimum was between clusters III and IV. Cluster III had least intra cluster distance and cluster I had highest intra cluster distance (Mathew, 2006).

Thul *et al.* (2009) studied phenotypic divergence of 24 chilli accessions and carried out multivariate analysis for 12 quantitative traits and one qualitative trait and these were grouped into 6 clusters with distinct identity of clusters V and VI. Fruit diameter, number of fruits per plant and leaf diameter played the greatest role in differentiation.

Farhad *et al*. (2010) studied 14 quantitative characters and genetic diversity analysis was conducted with 45 chilli genotypes which were fallen into six clusters. The maximum inter cluster distance was observed between clusters II and IV and minimum was between clusters I and IV. Maximum intra cluster distance was for cluster II and minimum was for cluster I. Plant height and number of secondary branches contributed maximum divergence.

Kumari *et al*. (2010) evaluated 94 paprika (*Capsicum annuum*) accessions for 17 characters based on D^2 values and they were grouped into 10 clusters. Cluster I was the largest which comprised of 24 genotypes and the cluster distances ranged from 856.7 to 15789.6.

Datta and Jana (2011) reported genetic divergence of 65 chilli genotypes which were grouped into 11 clusters. The clustering pattern revealed that there was no association of' species and geographical distribution for the formation of cluster in genetic divergence. The characters that contributed to maximum divergence were number of primary branches per plant, days to first flowering, ascorbic acid content in fruit and extractable fruit colour.

Hasanuzzaman and Golam (2011) reported that 20 accessions of chilli were grouped into 6 clusters. The highest intra cluster divergence (1.7153) for cluster VI was invariably smaller than the lowest inter cluster divergence between cluster III and cluster VI (3.247). Yield per plant, plant height, days to 50% flowering and fruits per plant were played the greatest role in differentiation.

Eleven landraces of *Capsicum annuum* were quantified by multivariate analysis for phenotypic divergence in 7 morphological traits. By using generalized Mahalanobis distances genotypes were grouped into 3 clusters. Accessions FTC-6 (cluster II) and FTC-11 (cluster III) had distinct identity. The characters that played greatest role in divergence were number of fruits per plant, fruit diameter, placenta weight and fruit length (Lahbib *et al*., 2013).

Yatung *et al*. (2014) studied genetic diversity in 30 chilli genotypes by grouping into 6 clusters. Cluster III contained highest number of genotypes (14) followed by cluster I (9), cluster VI (3), cluster II (2) and cluster IV and V which had one genotype each. The highest inter cluster distance was reported between clusters II and IV and the lowest was between cluster I and IV. Cluster III has exhibited highest intra cluster distance and the lowest was in cluster II. Capsaicin content and ascorbic acid content were the main contributors towards divergence.

Fifty four chilli (*Capsicum annuum* L.) genotypes were found to be fallen into seven clusters based on Mahalanobis D^2 statistics. Cluster II contained the highest number of chilli genotypes (thirteen), followed by cluster I constituted by ten chilli genotypes. Cluster III was composed of single genotype BSMRAU Sel-7, which indicated that this genotype is totally different from other genotypes. Cluster IV, VI and VII constituted of nine genotypes each. Cluster V comprised of three chilli genotypes. The highest inter cluster distance was between cluster I and cluster III and the lowest was between cluster II and VII. The characters which contributed more divergence were yield per plant, canopy breadth, number of secondary branches per plant, plant height and number of seeds per fruit (Hasan *et al*., 2014).

2. 2. VARIABILITY

For the selection of superior genotypes from a population, variability with respect to different characters is an essential requisite. A number of workers analysed variability for different characters in chilli (*Capsicum spp.*) and their findings are presented below.

Munshi and Behera (2000) concluded existence of considerable amount of genetic variability for number of fruits per plant, fruit weight, fruit length and yield per plant in a study involving 30 chilli (*C. annuum*) genotypes.

Ibrahim *et al*. (2001) studied 17 genotypes of chilli and reported high variability for fruit length followed by dry fruit weight and number of branches per plant. Mishra *et al*. (2001) studied nine genotypes of chilli for fruit characters and found considerable variability for number of fruits per plant and fruit length.

Gogoi and Gautam (2002) studied 52 chilli (*Capsicum spp.*) cultivars and lines with regard to yield components and observed significant variation for all the characters.

Analysis of variance of eight yield components in 13 chilli cultivars revealed considerable variability among various components (Rathod *et al*., 2002). Acharya *et al.* (2002), Nandadevi and Hosamani (2003a) and Prabhudeva (2003) also reported wide range of variation for most of the characters studied in chilli.

Sreelathakumary and Rajamony (2003b) observed variation for all the characters studied in bird pepper (*Capsicum frutescens* L.). Analysis of variance showed significant differences among the accessions for plant height, stem girth, leaf area, leaf petiole length, number of fruits per plant, fruit length, fruit girth, fruit weight and yield per plant. High genotypic and phenotypic variances were recorded for fruit yield per plant.

Khurana *et al*. (2003) reported highly significant variation among 46 *C. annuum* genotypes for fruit yield, fruit length, fruit thickness and number of fruits per plant.

Nandadevi and Hosamani (2003a) observed high variability in 26 chilli genotypes, for number of primary branches, fruit length, number of fruits per plant and green fruit yield.

Reddy *et al.* (2006) evaluated 50 genotypes of chilli for yield and yield components and found significant differences among genotypes for all the sixteen characters studied.

Ukkund *et al*. (2007) observed high range of variation for all the characters and maximum was in the case of the total green chilli yield per plant and minimum was for the fruit girth.

Gupta *et al*. (2009) reported high range of variation for the characters such as days to 50% fruits harvest, fruit length, fruit breadth, number of fruits per plant, fruit weight, fruit yield per plant, plant height, number of branches per plant, capsaicin content and oleoresin content in chilli.

High range of variability for number of fruits per plant, weight of fruits per plant and fruit yield was observed among 30 chilli genotypes (Singh and Singh, 2011).

Julia *et al*. (2012) reported that a wide range of variability was found in chilli for fruit morphology, pungency, bearing habit and crop duration throughout in India.

In a study of bird chilli (*Capsicum frutescens* L.), wide variability was found to exist in flowering and fruiting pattern (Idowu *et al*., 2012). Krishnamurthy *et al*. (2013) reported that genotypic variances had higher magnitude than the corresponding environmental variances for number of days to first fruit maturity, 50 per cent flowering, plant height and fruit length in chilli. However environmental variances were higher magnitude than the corresponding genotypic variances for polygenic traits viz., fruit width, 100 seed weight, red fruit yield per plant, green fruit yield per plant and number of fruits per plant.

Pandit and Adhikary (2014) recorded moderate to high range of variation in all characters of 41 chilli genotypes, which indicated better scope for improvement through selection. Amit *et al*. (2014) studied extent of variability present in 23 genotypes of chilli and significant differences were obtained among these genotypes for all the characters.

2. 3 COEFFICIENT OF VARIATION

The coefficient of variation allows the comparison of variability among different characters. It is a unit free measurement of variation.

Munshi and Behera (2000) studied 30 chilli genotypes and obtained genotypic coefficient of variation ranging from 5.32 per cent (days to first fruit harvest) to 54.94 per cent (number of fruits per plant).

Sreelathakumary and Rajamony (2002) observed high GCV (genotypic coefficient of variation) and PCV (phenotypic coefficient of variation) for fruit length in chilli. High GCV estimates for number of fruits per plant, fresh red chilli yield per plant and plant height were observed by Rathod *et al*. (2002).

Thirty two genotypes of hot chilli (*Capsicum chinense* Jacq.) were evaluated to estimate variation. High phenotypic and genotypic coefficients of variation were observed for number of fruits per plant, yield per plant, seeds per fruit and fruit weight (Manju and Sreelathakumary, 2002).

Nandadevi and Hosamani (2003a) reported high degree of PCV and GCV for number of primary branches, fruit length, pericarp thickness, number of fruits per plant and green fruit yield per plant in chilli.

Higher phenotypic and genotypic coefficients of variation were observed for yield per plant, fruit weight, number of fruits per plant, fruit length and fruit girth in chilli accessions (Sreelathakumary and Rajamony, 2003).

Sreelathakumary and Rajamony (2004) studied 35 chilli (*Capsicum annuum* L.) genotypes to assess genetic variability, heritability and genetic advance. Higher phenotypic and genotypic coefficients of variation were observed for leaf area, number of fruits per plant, fruit weight, fruit length, fruit girth and fruit yield per plant.

High values of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were recorded for fruit yield per plant and individual fruit weight respectively. Low values of PCV and GCV recorded for number of days to first flowering in 49 genotypes of bird chilli (Mathew, 2006).

Reddy (2006) reported high estimates of phenotypic coefficient of variation along with genotypic coefficient of variation for number of fruits per plant, fruit yield per plant, number of secondary branches per plant and number of primary branches per plant in chilli.

Sandeep (2007) reported low phenotypic and genotypic coefficients of variation for number of days to flowering in paprika. Gupta *et al*. (2009) reported highest phenotypic coefficient of variation for incidence of virus, number of fruits per plant, fruit yield per plant, fruit weight, fruit length and capsaicin content in chilli.

Kumari *et al.* (2010) reported higher phenotypic and genotypic coefficients of variation for plant height and plant spread and suggested the possible role of environment in expression of these characters while fruit diameter exhibited moderate PCV and GCV.

Sharma *et al.* (2010) found significant differences among the 94 chilli genotypes for fruit yield per plant, average fruit weight and number of fruits per plant. The phenotypic coefficient of variation and genotypic coefficient of variation were high for fruit yield per plant indicating that these traits had wide genetic variability and would respond better to selection.

Anandhi (2010) crossed three susceptible high yielding chilli genotypes (*Capsicum annuum*) and five resistant chilli genotypes (*Capsicum frutescens*) in a line × tester fashion and reported higher estimates of PCV and GCV for vulnerability index and green fruit yield per plant in chilli.

Ullah *et al.* (2011) tested 12 selected open pollinated genotypes of chilli (*Capsicum frutescens L.*) and found high genotypic coefficient of variations for fruit yield per plant, number of fruits per plant, average fruit weight and fruit length.

According to Singh and Singh (2011) high PCV and GCV were estimated for number of fruits per plant, weight of fruits per plant and red ripen fruit yield in 30 diverse chilli genotypes. Moderate PCV and GCV were obtained for plant height and fruit length, whereas PCV and GCV were low for number of primary branches per plant.

Krishnamurthy *et al*. (2013) reported high phenotypic co-efficient of variation and genotypic co-efficient of variation for red fruit yield per plant, green fruit yield per plant, fruits per plant and fruit length in chilli. Moderate PCV and GCV were estimated for fruit width and these were low for days 50 per cent flowering and days to first fruit maturity.

Amit *et al*. (2014) studied 23 genotypes of chilli and found high phenotypic coefficient of variation and genotypic coefficient of variation for number of fruits per plant, fruit weight and dry (red) yield.

Genotypic coefficient of variation and phenotypic coefficient of variation of 41 chilli genotypes closely corresponded with regard to number of days to 50 per cent flowering, fruit length, placenta length and 1000 seed weight (Pandit and Adhikary, 2014).

2. 4 HERITABILITY AND GENETIC ADVANCE

Heritability in broad sense refers to the genetic variation present in the population in relation to the total observed variance. Genetic advance refers to the improvement in the mean genotypic value of the selected plants over the base population.

High heritability coupled with high genetic advance suggests that character improvement could be made by selection based on phenotypic performance. The estimation of broad sense heritability and genetic advance for different characters by different workers is reviewed below.

Chaim and Paran (2000) studied ten quantitative traits in chilli and reported high heritability values for fruit weight, fruit diameter, fruit length and pericarp thickness but low heritability for plant height.

Ibrahim *et al*. (2001) reported highest heritability for plant height followed by fruit length and number of fruits per plant in chilli.

High heritability coupled with high genetic advance were recorded for number of fruits per plant, fresh red chilli yield per plant and plant height. (Rathod *et al*., 2002).

Acharyya *et al*. (2002) reported high heritability coupled with high genetic advance for total fresh yield per plant under both leaf curl infected and non-infected environments in chilli.

Manju and Sreelathakumary (2002) studied 32 chilli genotypes and reported high heritability coupled with high genetic advance for number of fruits per plant, yield per plant, seeds per fruit and fruit weight.

Sreelathakumary and Rajamony (2003b) observed high values of heritability for the characters studied in 20 accessions of bird pepper. Higher magnitude of heritability (>90%) was registered for number of fruits per plant, fruit length, fruit girth, fruit weight and yield per plant. High heritability coupled with high genetic advance was obtained for number of fruits per plant, fruit weight, fruit length, fruit girth and yield per plant.

In a study of 35 genotypes of chilli Sreelathakumary and Rajamony (2004) reported high heritability coupled with high genetic advance for leaf area, fruits per plant, fruit weight, fruit length, fruit girth and yield per plant.

Nandadevi and Hosamani (2003a) reported in 26 chilli genotypes that high heritability was coupled with high genetic advance for fruit length and green fruit yield per plant.

Prabhakaran *et al.* (2004) studied 97 genotypes of chilli and reported high heritability coupled with high genetic advance for yield per plant, mean fruit weight, placenta length and capsaicin content.

Varkey *et al.* (2005) studied 45 genotypes of chilli and reported high heritability coupled with high genetic advance for number of fruits per plant, number of seeds per fruit and dry weight per plant.

High heritability coupled with high genetic advance was noticed for average fruit weight, yield per plant, dry weight of plant, seeds per fruit and number of fruits per plant in chilli (Bendale *et al*., 2006).

Mathew (2006) studied 49 genotypes of bird chilli and observed significant difference for all the 14 biometric characters. All the 49 genotypes showed high heritability coupled with high genetic advance except for number of days to first flowering.

Reddy (2006) recorded high estimates of heritability for number of days to 50% flowering in chilli. High heritability coupled with high genetic advance was observed for number of fruits per plant, yield per plant and secondary branches per plant.

In a study of 27 genotypes of chilli, high heritability coupled with high genetic advance was observed for number of fruits per plant (Bharadwaj*et al.,* 2007).

Sood *et al.* (2007) reported high heritability coupled with high genetic advance for yield and capsaicin content in chilli.

Ukkund *et al.* (2007) observed high estimates of heritability for plant height, number of days to first flowering, percent fruit set, number of fruits per plant , fruit length , 10 fruit weight and total green fruits per plant in 80 chilli genotypes.

Gupta *et al*. (2009) studied 11 quantitative characters in chilli and reported high heritability coupled with high genetic advance for number of fruits per plant, fruit yield per plant, fruit length, fruit weight and capsaicin content. Sarkar *et al*. (2009) reported high heritability coupled with high genetic advance for fruit weight in chilli.

High heritability coupled with high genetic advance was noticed for average fruit weight, fruit yield per plant, fruit diameter, number of lobes per fruit, number of days to first harvest, leaf area and ascorbic acid content in 23 genotypes of bell pepper (Sharma *et al*., 2009).

According to Sharma *et al.* (2010) high heritability coupled with high genetic advance was obtained in chilli for average fruit weight, fruit yield per plant and fruit diameter, indicating the role of additive gene action for the inheritance of these traits.

Kumari *et al.* (2010) evaluated 94 paprika (*Capsicum annuum*) accessions and reported high heritability coupled with high genetic advance for number of fruits plant, fresh fruit yield per plant, seed weight and number of seeds per fruit.

Anandhi (2010) crossed three susceptible high yielding chilli genotypes (*Capsicum annuum*) and five resistant chilli genotypes (*Capsicum frutescens*) in a line × tester fashion and reported high heritability coupled with high genetic advance for the characters viz., number of days to first flowering, duration of flowering, number of fruits per plant, green fruit yield per plant, number of seeds per fruit, duration of crop and vulnerability index.

Ullah *et al.* (2011) studied 12 open pollinated varieties of chilli and reported high heritability coupled with high genetic advance in percentage of mean for fruit yield per plant, fruits per plant, plant height and number of days to 50% flowering.

Krishnamurthy *et al.* (2013) used 24 Indian chilli inbred lines of different regions and six inbred lines of Taiwan as pollen parents and five CMS lines from Taiwan as female parents for crossing and observed high heritability coupled with high genetic advance for green fruit yield per plant and red fruit yield per plant.

Amit *et al*. (2014) studied 23 genotypes of chilli and reported that all the characters showed high heritability. Also, number of fruits per plant, green fruit yield per plant, dry yield per plant, number of seeds per plant and plant height exhibited high genetic advance as percentage of mean indicating additive gene effect.

Pandit and Adhikary (2014) studied 41 chilli genotypes and observed very high genetic advance for fruit yield per plant and high genetic advance for number of days to 50% 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 would be rewarding in selection.

2. 5 ASSOCIATION OF CHARACTERS

Study of character association helps the breeder in fixing a selection criteria for grain yield in parental lines, such that selections will be effective in isolating the plants with desired combination of characters. Phenotypic correlation is the correlation of phenotypic values and is subjected to changes in the environment. It measures the environment deviation together with non-additive gene action. Genotypic correlation is the correlation of breeding value. Hence, knowledge of association between different characters is highly essential for planning a successful breeding programme.

2. 5. 1 Correlation coefficient analysis

A thorough understanding of correlation between yield and its component traits is essential for choosing the character for selection.

Yield per plant was negatively correlated with plant height in a study of 13 chilli genotypes (Aliyu *et al*., 2000). Munshi *et al*. (2000) reported positive association of yield with fruit weight and fruit number in chilli. Fruit weight had positive correlation with fruit length and negative correlation with fruit number.

Wyrzykowska *et al*. (2000) studied correlation for quantitative traits in sweet paprika and reported that fruit yield per plant depended significantly on mean fruit weight and fruits per plant.

Ibrahim *et al*. (2001) studied 17 accessions of chilli and reported significant positive correlation of dry fruit weight per plant with number of fruits per plant, number of branches, fruit length, fruit width and plant height.

According to Chatterjee *et al*. (2001) fruit weight, pericarp thickness, number of seeds per fruit and 1000 seed weight showed positive significant association with fruit yield per plant in chilli.

Sreelathakumary and Rajamony (2002) studied correlations in chilli genotypes and reported significant positive correlation with yield for fruits per plant, fruit length and fruit weight.

Fresh red chilli yield had significant positive association with number of fruits per plant, hundred seed weight and harvest index (Rathod *et al*., 2002).

Acharya *et al*. (2002) reported that total fresh chilli yield had positive effect and significant correlation with total dry yield per plant.

Positive correlation was observed in chilli by Jose and Khader (2002) for fruit yield with fruit weight, number of fruits per plant, number of primary branches, number of secondary branches, plant height, 100 seed weight, fruit length, fruit girth and crop duration.

Sreelathakumary and Rajamony (2003a) studied 20 accessions of bird pepper (*Capsicum frutescens*). Fruit yield per plant showed highly significant positive correlation with number of fruits per plant, fruit length, fruit girth and fruit weight.

According to Khurana *et al*. (2003) fruit yield per plant was positively correlated with number of fruits per plant, fruit length, fruit diameter, plant height, capsaicin content and colouring matter in chilli. Fruit yield per plant was negatively correlated with number of days to flowering.

Muthuswamy (2004) studied correlations in chilli accessions and reported negative association of number of days to first flowering with many of the characters studied and its positive association with fruit length. Number of fruits per plant was positively correlated with harvest index, capsaicin content and oleoresin content. Capsaicin content was positively correlated with number of primary branches, fruit weight, fruit yield per plant, fruit length, number of seeds per fruit, plant height, crop duration and harvest index.

Ajjapplavara *et al*. (2005) evaluated 36 genotypes in chilli for 18 different quantitative characters and reported positive correlation for ten dry fruit weight with all fruit related traits viz., fruit length, fruit surface area, fruit volume, stalk length,single green fruit weight and ten green fruit weight.

Significant positive correlation existed in chilli for number of days to 50% flowering with plant height and branch number, between plant height and fruit number, branch number and fruit number, average fruit length and flesh to seed ratio, average fruit length and average fruit weight, fruit girth and pungency and flesh to seed ratio with average fruit weight and average seed weight (Ahmed *et al*., 2006).

Positive correlation of fruit yield was observed by Mathew (2006) among 49 bird chilli accessions with number of fruits per plant, number of secondary branches, plant spread, 100-seed weight, number of primary branches, number of seeds per fruit, individual fruit weight, fruit length, fruit width and plant height. Yield per plant was negatively correlated with vulnerability index.

Reddy (2006) revealed that fruit yield per plant showed high positive genotypic correlation with number of fruits per plant, duration, length of fruit bearing period, plant canopy width and number of secondary branches in chilli.

Ukkund *et al.* (2007) studied 80 indigenous and exotic genotypes of chilli and assessed the correlation among 13 important characters. The phenotypic and genotypic association of fruit yield was significantly positive with all the characters except for number of days to first flowering and ten fruit weight.

In a study of 25 chilli genotypes, yield per plant exhibited highly significant positive correlation with number of fruits per plant, branches per plant and plant height (Jabeen *et al*., 2009).

According to Gupta *et al*. (2009) correlation coefficients in chilli at phenotypic levels between yield and yield components indicated that fruit yield per plant had positive and highly significant correlation with number of fruits per plant and fruit length.

Among 23 genetically diverse genotypes of bell pepper, fruit yield per plant had positive correlation with fruit length, fruit diameter and number of fruits per plant (Sharma *et al.*, 2009).

Chattopadhyay *et al*. (2011) studied 34 chilli genotypes and reported that number of days to 50% flowering, number of fruits per plant and ascorbic acid content had significantly positive correlation with green fruit yield per plant. Hence selection based on these characters would be rewarding.

Kumari *et al*. (2011) studied correlation in 94 diverse genotypes of paprika. Dry fruit yield per plant showed significant and positive association with plant height, plant spread, number of fruits per plant, fruit girth, number of seeds per fruit and capsanthin content.

Singh and Singh (2011) studied 30 diverse chilli genotypes and observed significant positive correlation of number of fruits per plant with fruit yield per plant and red ripen fruit yield.

Ullah *et al.* (2011) evaluated 12 open pollinated varieties of chilli. The characters viz., number of fruits per plant, fruit length and fruit diameter had significant positive association with fruit yield per plant.

Krishnamurthy *et al*. (2013) reported correlations in Indian and Taiwan genotypes of hot pepper (*Capsicum annuum*). The character, number of fruits per plant had positive correlation with green fruit and red fruit yield per plant at genotypic and phenotypic level.

Jogi *et al*. (2013) studied 50 genotypes of chilli for 16 important characters. The phenotypic and genotypic correlation of fruit yield were significantly positive with all the characters except number of days to first flowering and ten fruit weight. Early fruit yield and late fruit yield per plant were found to have highly significant and positive correlation with total fruit yield.

Amit *et al*. (2014) conducted studies on 23 chilli genotypes to assess the correlation of growth and yield contributing characters. Fruit yield per plant was positively and significantly correlated with number of fruits per plant and fruit length.

2. 6. PATH COEFFICIENT ANALYSIS

Path coefficient analysis, a statistical device developed by Wright (1921) helps in partitioning of the correlation coefficients into direct and indirect effects of independent variable on dependent variable. As fruit yield is a complex character influenced by several factors, selection based on simple correlation without considering the component characters is not effective. Hence, path analysis is of much importance in any plant breeding programme. Correlation in combination with path analysis would give a better insight into cause and effect relationship between different pairs of characters. Aliyu *et al*. (2000) selected characters with high genotypic correlation to assess the path analysis in chilli. Fruit diameter and number of seeds per plant showed high positive direct effect on yield while plant height had a negative direct contribution to final yield.

In a study which involved 30 chilli genotypes, Munshi *et al*. (2000) observed direct positive effect of number of fruits per plant, fruit weight and fruit girth on yield per plant.

Jose and Khader (2002) conducted path analysis in chilli and observed low residual value. Number of fruits per plant had high positive direct effect on yield.

Sreelathakumary and Rajamony (2003a) studied 20 accessions of bird pepper (*Capsicum frutescens*) and revealed that fruits per plant, fruit length, plant height and stem girth had positive direct effect on yield while leaf area, number of days to first flowering, fruit girth and fruit weight exerted negative direct effect on yield.

Mini (2003) found that direct effect of number of fruits per plant and average fruit weight were high and positive in chilli, while that of plant height was high and negative.

According to Ajith (2004) number of fruits per plant had positive direct effect on yield in bell pepper and negative direct effect on number of branches and fruit girth.

Ajjapplavara *et al*. (2005) studied in 36 genotypes of chilli and reported that direct effects were high and positive for 10 dry fruit weight, 10 green fruit weight, number of fruits per plant, fruit length and fruit diameter on yield. Days to 50 per cent flowering showed negative direct effect on yield.

In a study of 49 genotypes of bird chilli Mathew (2006) noticed high positive direct effect of individual fruit weight and number of fruits per plant on fruit yield per plant.

Reddy (2006) revealed that number of fruits per plant had highest direct effect on fruit yield in chilli. Plant canopy width showed relatively high direct effect as well as positive indirect effect on number of fruits per plant and fruit weight.

Ukkund *et al*. (2007) studied path analysis in eighty diverse indigenous and exotic genotypes of chilli for 13 important characters. It was revealed that total green chilli yield had high direct positive effect from early and late fruit yield. So selection based on early and late fruit yield would be rewarding.

Sharma *et al*. (2010) carriedout path analysis among 23 genetically diverse genotypes of bell pepper. Number of fruits per plant had highest positive direct effect on yield per plant followed by average fruit weight, number of branches, pedicel length and harvest duration at genotypic level.

Ullah *et al*. (2011) observed high direct effect of fruits per plant, average fruit weight, number of days to first flowering and fruit length with fruit yield in 12 open pollinated varieties of chilli.

Chattopadhyay *et al*. (2011) reported that residual effect of the path analysis was low in 34 chilli genotypes. Number of fruits per plant and green fruit length showed high positive direct effects on green fruit yield per plant.

In a study of Indian and Taiwan genotypes of hot pepper (*Capsicum annuum*) Krishnamurthy *et al*. (2013) revealed that number of fruits per plant (0.819) had highest positive direct effect on yield per plant followed by fruit length (0.311), fruit width (0.243) and red fruit yield (0.215).

The genotypic path co-efficient analysis in 50 genetically diverse indigenous and exotic genotypes of chilli revealed that ascorbic acid and chlorophyll content had high direct positive effect on total fruit yield (Jogi *et al*., 2013).

Pandit and Adhikary (2014) studied 41 chilli genotypes and observed that number of fruits per plant, 1000 seed weight and placental length had high direct positive effects on yield.

2. 6 SCREENING FOR LEAF CURL DISEASE RESISTANCE

Peter and Mc Cullum (1984) reported *Capsicum frutescens* as a source of multiple disease resistance. Rishi and Dhavan (1988) exposed seedlings of 72 lines of *Capsicum frutescens* to infection by cucumber mosaic virus, potato x virus, potato y virus, TMV and chilli leaf curl virus and found that disease occurred in all genotypes.

Resistant sources against virus disease were reported in different species of chilli; especially *Capsicum frutescens* and these were utilized in improving the cultivated chilli (Bosland and Votava, 2000 and Grube *et al*., 2000).

Reddy *et al*. (2000) reported screening of 33 genotypes of chilli against leaf curl caused by thrips and mites. Sel 7-11-13-1 exhibited highest tolerance to leaf curl while the lowest was recorded by Sel 4-1.

Jadhav *et al*. (2000) observed that "Phule Sai' (GCH-8), selection from advanced generations of Pant C1 x Kamandalow, was moderately resistant to leaf curl virus under field conditions.

In a study on 6 x 6 diallel analysis, Nandadevi and Hosamani (2003b) reported that RHRC-Cluster-Erect, Pant C-1 and PMR-52/88/K had significant *gca* effects for resistance to leaf curl complex in chilli. The magnitude of estimated components of dominance variance was more than additive variance for resistance to leaf curl complex.

Mallapur (2000) evaluated 62 chilli genotypes for resistance to *Scirtothrips dorsalis* and yellow mite and reported that 13 varieties showed lower percentage of leaf curl than local checks.

Tatagar *et al*. (2001) screened 24 chilli genotypes against thrips and mites to identify sources of resistance in chilli. The Cultivars Pant C1, LCA-304 and LCA-312 were found to be promising sources of resistance against chilli thrips and mites.

Khalid *et al*. (2001) evaluated 77 chilli cultivars to identify yellow mite resistance sources. Based on population count, injury grade and damage index, these varieties were grouped into three categories (resistant, susceptible and highly susceptible). Nine cultivars namely, LCA235, LCA330, EC128946, Cluster Mutant, LIC19, LCA312, Yellow Anther Mutant, LIC13 and LIC45 were considered as resistant.

Babu *et al*. (2002) evaluated 308 chilli varieties for resistance to chilli thrips and yellow mites and identified 17 promising types based on visual rating of leaf curl caused by thrips and mites. Most of the germplasm accessions reacted independently to leaf curl caused by thrips and mites. They found one exotic entry EC-391082 a paprika type), as resistant to leaf curl caused by both thrips and mites.

Echer *et al*. (2002) evaluated fifteen capsicum accessions in greenhouse condition for resistance to mite and ranked the accessions BGH/UFV 1774 (*C. annuum*) and BGH/UFV 5086 (*C. frutescens*) as resistant and highly resistant respectively to *Polyphagotarsonemus latus* under severe testing conditions.

Kalaiyarasan *et al*. (2002) reported that accession PS 64 had lower thrips population (average of 0.47 and 0.81 thrips/leaf) in the field and in pot culture. Thrips infestation was lower in accessions PS 64, PS 69, PS 177, PS 166, PS 4, PS 171 and PS 173 in the range of 12.9 to 17.4 per cent as compared to the other accessions.

Jose *et al*. (2003) studied 37 genotypes of chilli to evaluate leaf curl virus infection under natural field conditions in Kerala. It was observed that the genotypes Alampady local-1, Nayattinkara local, Kottiyam local, Haripuram local, Pant C-1, Chandera local, Mangalapuram local and Kottikulam local were tolerant, 27 were susceptible and two were highly susceptible to the disease.

Singh and Chowdhury (2005) evaluated 10 chilli cultivars and reported that two cultivars had minimum incidence of chilli leaf curl virus incidence.

Kumar *et al*. (2006) screened 307 genotypes belonging to four cultivated and one wild species of *Capsicum* and identified only three genotypes, *viz.*, GKC-29, BS-35 and EC-497636 as symptom-less resistant sources.

Khader *et al.* (2007) evaluated one hundred and fifteen genotypes of bird pepper (*Capsicum frutescens*) for leaf curl virus resistance and among them two genotypes were reported to be resistant and eight were tolerant.

Twenty one chilli genotypes evaluated against yellow mite and ACG 77 was found to be a promising one, on account of low pest population count and leaf curl intensity (Desai *et al.,* 2006).

Mathew (2006) screened 49 accessions of bird chilli (*Capcicum frutescens* L.) for leaf curl virus resistance and reported that 5 genotypes were highly tolerant, 14 genotypes were susceptible and 30 genotypes were highly susceptible to the disease.

Jayaramegowda (2009) crossed five susceptible high yielding chilli genotypes (lines) and three chilli thrips and mite tolerant chilli genotypes (testers), in a line × tester fashion. Considering both yield and resistance simultaneously, the hybrids

Jwalasakhi × Bhagyalakshmi and Vellayani Athulya × Kiran were high yielding and relatively resistant to chilli thrips and yellow mite respectively. The hybrid Jwalasakhi × Kiran was identified as relatively resistant to both chilli thrips and yellow mite and was remarkable with respect to yield.

Kumar *et al*. (2011) evaluated 321 genotypes of chilli against leaf curl. Based on mean coefficient of infection, the genotypes viz., BS 35, CV 2, EC 497636, GKC 29, IC 3640632, IC 383072 and PunjabLal had no symptoms.

Screening of 29 chilli accessions against ChiVMV based on symptomatology and disease incidence (%) under screenhouse conditions showed that the genotypes, IPB C1, IPB C10 and PBC 521were highly resistant (Hidayat *et al*., 2012).

Ashfaq *et al*. (2014) evaluated 40 chilli genotypes by virus inoculation. Resistance to CMV isolate was examined by visual observations and enzyme-linked immune sorbent assay (DAS-ELISA). On the basis of 0-5 disease rating scale and ELISA, nine genotypes viz., C-2, CV-2, CV-5, BSS-269, PGRI, M-2001, CM-2001, M-97 and CP-328 had no infection and catalogued as highly resistant.

Materials and Methods

3. MATERIALS AND METHODS

The study was undertaken in the Department of Plant Breeding and Genetics. College of Agriculture, Vellayani, Thiruvananthapuram during 2013-2015 to estimate the genetic variability in bird chilli (*Capsicum frutescens* L.). The research was done by conducting two field experiments where in experiment-I was to evaluate the germplasm accessions for yield and experiment-II was to evaluate the genotypes for high yield and reistance to leaf curl.

3.1 EXPERIMENT I: EVALUATION OF GENOTYPES FOR YIELD AND LEAF CURL RESISTANCE

3.1.1 Materials

The materials for the experiment were selected from the project, "Collection, evaluation and utilization of native types and develop high yielding leaf curl complex resistant drought tolerant varieties in chilli through interspecific hybridization", in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani.

Seventy eight accessions of bird chilli, collected from different parts of Kerala were evaluated in the above project (Table 1).

3.1.2 Methods

3.1.2.1 Design and layout

The experiment was conducted as unreplicated field trial. Plot size was 5.0 m×0.75 m with spacing of 50 cm×75 cm. Ten plants were maintained in each plot.

Table 1. List of chilli genotypes (*Capsicum frutescens* L.)

Acces sion No	Name of genotype	Leaf pubescence	Acces sion No	Name of genotype	Leaf pubescence
A1	Padinjarekkalam-I	3	A22	Anchampeedika	3
A2	Nellivila	3	A23	Kottakkal-I	3
A3	Sreekurumbakkavu-I	3	A24	Kakkamoola-IX	3
A4	Vandithadam-I	3	A25	Kottakkal-II	3
A5	Palappuru	3	A26	Kinanoor	5
A6	Pachalloor-I	3	A27	Kottakkal-III	3
A7	Vandithadam-II	3	A28	Kottakkal-IV	3
A8	Vellayani-II	3	A29	Chattiparambu-I	3
A9	Kakkamoola-I	3	A30	Chattiparambu-II	3
A10	Kakkamoola-II	3	A31	Vandithadam-III	3
A11	Padinjarekkalam-II	3	A32	Karamana	3
A12	Sreekurumbakkavu-II	3	A33	Vellayani-II	3
A13	Kakkamoola-III	3	A34	Kozhencheri	3
A14	Sreekurumbakkavu-III	3	A35	Mandhathupara-I	3
A15	Kakkamoola-IV	3	A36	Padinjarekkalam-III	3
A16	Kakkamoola-V	3	A37	Mandhathupara-II	3
A17	Kakkamoola-VI	3	A38	Palakkad-I	5
A18	Chempra	3	A39	Palakkad-II	3
A19	Kakkamoola-VII	3	A40	Palakkad-III	3
A20	Peruvannamuzhi	3	A41	Palakkad-IV	3
A21	Kakkamoola-VIII	3	A42	Ilavumthitta	3

Table 1. Continued

Accession No	Name of genotype	Leaf pubescence	Accession No	Name of genotype	Leaf pubescence
A43	Sreekurumbakkavu-IV	3	A61	Chappanangadi-II	3
A44	Sreekurumbakkavu-V	3	A62	Chappanangadi-III	3
A45	Mandhathupara-III	3	A63	Chappanangadi-IV	3
A46	Mandhathupara-IV	3	A64	Chappanangadi-V	3
A47	Mandhathupara-V	3	A65	Naduvannur-I	3
A48	Pachalloor-II	3	A66	Thirur-I	3
A49	Pachalloor-III	3	A67	Thirur-II	3
A50	Kumarapuram-I	3	A68	Changuvetti-I	3
A51	Kanjikuzhi	3	A69	Changuvetti-II	3
A52	Kumarapuram-II	3	A70	Narikkuni-II	3
A53	Cherthala	3	A71	Narikkuni-III	3
A54	Nenmara	3	A72	Narikunni-IV	3
A55	Thamallakkal	3	A73	Chattipparambu-I	3
A56	Kanichukulangara	3	A74	Chattipparambu-II	3
A57	Kalitthatu	3	A75	Chattipparambu-III	5
A58	Vandithadam-IV	3	A76	Kuroorkundu-I	3
A59	Vykathannu	3	A77	Kuroorkundu-II	3
A60	Chappanangadi-I	3	A78	Kuruvakundu-IV	3

3.1.2.2 Sowing and cultural operations

Seeds were sown on raised nursery beds during September 2013 and seedlings were transplanted when they were 40 days old, with one seedling per pit.

Cultural operations were carried out as per the package of practices recommendations of the Kerala Agricultural University (KAU, 2011).

3.1.2.3 Biometric observations

Five plants were selected randomly from each genotype to record the following biometric observations and mean values were taken for statistical analysis.

1. Number of days to first flowering

Number of days taken from sowing to the appearance of first flower was recorded.

2. Number of primary branches

Branches originating from the main stem were counted and recorded as the number of primary branches at full maturity of the plant.

3. Number of secondary branches

The branches borne on the primary branches were counted and recorded as the secondary branches at full maturity of the plant.

4. Number of fruits per plant

Total number of fruits at each harvest was recorded from each observational plant and the average was worked out.

5. Average fruit length (cm)

Average length of five mature fruits with pedicel was recorded from the observational plants and expressed in centimeters.

6. Average fruit width (cm)

The fruit width was measured at the broadest part of the five mature fruits from observational plants and mean expressed in centimeters.

7. Individual fruit weight (g)

Average weight of the five fruits taken at random from the observational plants over different harvests was recorded and expressed in grams.

8. Fruit yield per plant (g)

Weight of fresh fruits was recorded from the five observational plants at each harvest and mean value expressed in grams.

9. Fruit yield per plot (kg)

Total weight of fruits harvested from each plot was recorded and expressed in kilograms.

10. Number of seeds per fruit

Number of seeds were recorded from ten ripe fruits at random from each observational plant during second harvest and mean values were calculated.

Plate 1. General view of experiment I

Plate 2. General view of experiment II

11. Plant height (cm)

The height of plant was measured from the base of the plant to the tip of the longest branch from each observational plant before the last harvest of fruits and expressed in centimeters.

12. Leaf pubescence

Leaf pubescence was observed on the youngest mature leaves. It is classified as follows (Mathew, 2006).

Score	Type of pubescence
3	Sparse
5	Intermediate
7	Dense

13. Incidence of leaf curl disease

Leaf curl disease scoring was done at 30th, 60th and 90th days after planting (DAP) based on visual symptoms of each observational plant. The scoring was based on 0 to 4 scale developed by Rajamony *et al*., (1990) in melons with slight modification as given below.

Score Index	Symptoms
0	No symptoms
1	Slight curling of terminal leaves
2	Curling of terminal and adjacent leaves
3	Curling and appearance of blisters on leaves
4	Severe curling and puckering of leaves; stunted appearance of plants

Plate 3. Scoring chart for leaf curl disease

The individual plant score was utilized to work out the ‘severity index’ or ‘vulnerability’ index so as to measure the degree of resistance. The index was calculated using an equation adopted by Silbernagel and Jafri (1974) to measure the degree of resistance in snap bean (*Phaseolus vulgaris)* against beet curly top virus and later modified by Bos (1982).

$$\text{Vulnerability index (V.I.)} = \frac{(0n_o+1n_1+2n_2+3n_3+4n_4)}{n_t\,(n_c-1)} \times 100$$

Where,

$n_o, n_1, ---, n_4$ = number of plants in the category 0, 1, - - -, 4 respectively

n_t = total number of plants

n_c = total number of categories = (5)

The genotypes were classified according to vulnerability index as given below (Mathew, 2006).

V.I	**Category**
0.00	Resistant(R)
1.00-25.00	Tolerant (T)
25.01- 50.00	Susceptible(S)
>50.00	Highly susceptible (HS)

14. Number of white flies per plant

White flies present on lower side of the top five leaves in observational plants were counted at three intervals (30^{th}, 60^{th} and 90^{th} days after planting) without disturbing the plant and average worked out.

15. Number of aphids per plant

Number of aphids on six terminal leaves of five randomly selected plants in each plot was recorded at 30^{th}, 60^{th} and 90^{th} days after planting (DAP) and mean value was expressed.

16. Number of thrips per leaf

Number of thrips from three leaves per plant, one each from top, middle and bottom regions of five plants selected at random was counted using stereo binocular microscope. Adults are swift in movement and fly away while counting. Therefore to avoid errors in values nymphs were considered and counted for recording observations at 30^{th}, 60^{th} and 90^{th} days after planting (DAP).

17. Number of mites per leaf

Number of mites on six terminal leaves of five randomly selected plants in each plot at 30^{th}, 60^{th} and 90^{th} days after planting (DAP) was recorded using stereo binocular microscope.

3.1.2.4 Statistical analysis

The mean data recorded from the experiment was statistically analysed.

3.1.2.5 Clustering using dendrogram

The genetic divergence between the groups was studied using dendrogram (Jain, 1982).

3.2 EXPERIMENT II: CONFIRMATION STUDY

3.2.1 Materials

The materials for the study consisted of ten genotypes of bird chilli (*Capsicum frutescens* L.) identified as high yielding with resistance to leaf curl from experiment I (Table 2). Leaf curl was ensured by growing infected susceptible varieties of *C. annuum* in the experimental field.

3.2.2 Methods

3.2.2.1 Design and layout

The experiment was conducted in Randamised Block Design (RBD) with three replications. Plot size was 5.0 m×0.75 m with spacing of 50 cm×75 cm. Ten plants were maintained in each plot.

3.2.2.2 Sowing and cultural operations

Seeds were sown on raised nursery beds during April 2014 and the seedlings were transplanted when they were 45 days old, with one seedling per pit.

Cultural operations were carried out as per the package of practices recommendations of the Kerala Agricultural University (KAU, 2011).

Table 2. List of genotypes selected from experiment I

Treatment Number	Name of genotypes	Leaf pubescence
T1 (A04)	Vandithadam-I	3
T2 (A24)	Kakkamoola-IX	3
T3(A28)	Kottakkal-IV	3
T4 (A34)	Kozhencheri	3
T5 (A50)	Kumarapuram-I	3
T6 (A52)	Kumarapuram-II	3
T7 (A55)	Thamallakkal	3
T8 (A57)	Kalitthatu	3
T9 (A62)	Chappanangadi-III	3
T10 (A70)	Narikkuni-II	3

3.2.2.3 Biometric observations

All the biometrical observations recorded for the first experiment were observed and recorded for this experiment also.

3.2.2.4 Statistical analysis

3.2.2.4.1 Analysis of variance (ANOVA)

Analysis of variance (ANOVA) (Panse and Sukhatme. 1967) for individual character was carried out on the basis of mean value per treatment per replication as given below.

Sources of variation	**Degrees of freedom**	**Sum of squares**	**Mean square**	**F ratio**
Replications	t-1	SSR	MSR	MSR/MSE
Treatment	r-1	SST	MST	MST/MSE
Error	(r-1)(t-1)	SSE	MSE	
Total	rt-1			

Where,

r = number of replications t = number of treatments

SSR =sum of squares for replications MSR=mean squares for replication

SST =sum of squares for treatments MST=mean squares for treatments

SSE =sum of squares for error MSE=mean squares for error

$$\text{Critical difference (CD)} = t\alpha \sqrt{\frac{2 \times MSE}{r}}$$

Where,

tα is the table value of students't distribution at error degrees of freedom and α is the level of significance (5 % or 1%).

3.2.2.4.2 Estimation of genetic parameters

a. Genetic components of variance

For each character, the phenotypic and genotypic components of variance were estimated by equating the expected value of mean squares (MS) to the respective variance components (Jain, 1982). Based on this, the following variance components were estimated.

i. Genotypic variance (V_G) $$V_G = \frac{MST - MSE}{r}$$

ii. Phenotypic variance (V_P) $$V_P = V_G + V_E$$

iii. Environmental variance (V_E) $$V_E = MSE$$

b. Coefficient of variation

Genotypic, phenotypic and environment co efficient of variation were worked out using the estimates of V_G, V_P and V_E and expressed in percentage for each trait.

i. Genotypic coefficient of variation, $$GCV = \frac{\sqrt{V_G}}{\overline{X}} \times 100$$

ii. Phenotypic coefficient of variation, $$PCV = \frac{\sqrt{V_P}}{\overline{X}} \times 100$$

$$\sqrt{V_E}$$

iii. Environmental coefficient of variation, ECV = ------------- x 100

$$\overline{X}$$

Where, $\overline{X}$ = grand mean

Categorization of the range of variation was followed as reported by Sivasubramanian and Menon (1973).

Low	:	Less than 10%
Moderate	:	10 to 20%
High	:	More than 20%

c. Heritability in broad sense [H^2]

Heritability in the broad sense refers to the proportion of genotypic variance to the total observed variance in the total population. Heritability in the broad sense was calculated and expressed in percentage (Allard, 1960).

$$H^2 = \frac{V_G}{V_P} \times 100$$

As suggested by Johnson *et al.* (1955) the range of heritability estimates were categorized as:

Low	:	Less than 30%
Medium	:	30 to 60%
High	:	Above 60%

d. Genetic advance (GA)

Genetic advance refers to the expected genetic gain or improvement in the next generation by selecting superior individuals under certain amount of selection pressure. From the heritability estimates the genetic advance was estimated by the following formula given by Burton (1952).

$$GA = K H^2 \sqrt{V_P}$$

Where K= Selection differential, the value of which is 2.06 at 5% selection intensity.

In order to visualize the relative utility of genetic advance among the characters, genetic advance as percent for mean (GAM) was also computed.

$$GAM = \frac{GA}{(\bar{X})} \times 100$$

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

Low	:	Less than 10 %
Moderate	:	10-20 %
High	:	More than 20 %

3.2.2.4.3 Estimation of correlation

Character association refers to the association of characters *i.e*., a change in one character is accompanied by a change in the other character.

Correlation coefficients were calculated at genotypic and phenotypic level using the formulae suggested by Falconer (1964).

$$\text{Genotypic coefficient of correlation } (r_g) = r\,(x_i.\ x_j)_g = \frac{Cov.\,(x_i.x_j)_g}{\sqrt{V\,(x_i)_g.\ V\,(x_j)_g}}$$

$$\text{Phenotypic coefficient of correlation } (r_p) = r\,(x_i.\ x_j)_p = \frac{Cov.\,(x_i.x_j)_p}{\sqrt{V\,(x_i)_p.\ V\,(x_j)_p}}$$

$$\text{Error coefficient of correlation } (r_e) = r\,(x_i.\ x_j)_e = \frac{Cov.\,(x_i.x_j)_e}{\sqrt{V\,(x_i)_e.\ V\,(x_j)_e}}$$

3.2.2.4.4 Path co-efficient analysis

The use of path coefficient analysis explains cause and effect relationship among the variables. It is a standardized partial regression coefficient and as such measures the direct influence of one variable upon another and permits the separation of the correlation coefficients into components of direct and indirect effects (Dewey and Lu, 1959). This method permits the breeder to identify relatively important components of a variable, on the basis of their direct and indirect influences.

The direct and indirect effects both at genotypic and phenotypic level were estimated by taking grain yield per plant as dependent variable using path coefficient analysis suggested by Wright (1921) and Dewey and Lu (1959).

$$r_{1y} = P_{1y}\ r_{11} + P_{2y}\ r_{12} + P_{3y}\ r_{13} \ldots\ldots\ldots\ldots + P_{ny}\ r_{1n}$$

$$r_{2y} = P_{1y}\ r_{21} + P_{2y}\ r_{22} + P_{3y}\ r_{23} \ldots\ldots\ldots\ldots + P_{ny}\ r_{2n}$$

: : : : :

$$r_{ny} = P_{1y}\ r_{n1} + P_{2y}\ r_{n2} + P_{3y}\ r_{n3} \ldots\ldots\ldots\ldots + P_{ny}\ r_{3n}$$

Where;

$1, 2 \ldots\ldots n$ = Independent variables

y = Dependent variable

$r_{1y}, r_{2y} \ldots\ldots r_{ny}$ = Coefficient of correlation between casual factors `1` to `n` on dependent character 1

$P_{1y}, P_{2y} \ldots\ldots P_{ny}$ = Direct effect of character 1 to n on character Y

The above question can be written in matrix form as:

$$
\underset{A}{\begin{pmatrix} r_{1y} \\ r_{2y} \\ \cdot \\ \cdot \\ \cdot \\ r_{ny} \end{pmatrix}}
\qquad
\underset{C}{\begin{pmatrix} 1 & r_{12} & r_{13} & \ldots\ldots r_{1n} \\ r_{21} & 1 & r_{23} & \ldots\ldots r_{2n} \\ \cdot & \cdot & \cdot & \\ \cdot & \cdot & \cdot & \\ \cdot & \cdot & \cdot & \\ r_{n1} & r_{n2} & r_{n3} & \ldots\ldots 1 \end{pmatrix}}
\qquad
\underset{B}{\begin{pmatrix} P_{1y} \\ P_{2y} \\ \cdot \\ \cdot \\ \cdot \\ P_{ny} \end{pmatrix}}
$$

Then

$$
B = (C)^{-1} A \text{ where } C^{-1} = \begin{pmatrix} c_{11} & c_{12} & c_{13} \ldots\ldots & c_{1n} \\ c_{21} & c_{22} & c_{23} \ldots\ldots & c_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots \\ c_{n1} & c_{n2} & c_{n3} \ldots\ldots & c_{nn} \end{pmatrix}
$$

Direct effects were as follows:

$$P_{1y} = \sum_{i=1}^{k} c_{1i} \; r_{iy}$$

$$P_{2y} = \sum_{i=1}^{k} c_{2i} \; r_{iy}$$

$$P_{ny} = \sum_{i=1}^{k} c_{nj} \; r_{iy}$$

Residual effect (PR_y), which measures the contribution of characters not considered, in the causal scheme was obtained as:

$$\text{Residual effect } (PR_y) = \sqrt{(1 - r^2)}$$

Where,

r^2 = ($P_{1y}\, r_{1y}$ + $P_{2y}\; r_{2y}$ + --------- $P_{ny}\; r_{ny}$)

P_{iy} = Direct effect of xi on Y

r_{iy} = Correlation coefficient of x_i on y

i = 1, 2, 3 …….n

Results

4. RESULTS

Seventy eight bird chilli genotypes were evaluated for various characters viz., morphological, yield and reaction to leaf curl. The field experiment was conducted in two parts. First experiment dealt with evaluation of 78 bird chilli genotypes and clustering them using dendrogram. In the second experiment, 10 selected genotypes were studied to conform the resistance reaction for leaf curl. The results of the study are presented in this chapter.

4.1 EXPERIMENT I

4.1.1 Evaluation of genotypes for yield and leaf curl resistance

4.1.1.1 Mean performance of accessions

Among the seventy eight genotypes evaluated in field experiment, a considerable variation for all the characters studied was noticed (Table 3).

The accession A24 was the earliest to flowering (95.6) followed by A78 (96.1), A70 (96.3), A28 (99), A53 (99.3), A66 (99.6) and A22 (99.7). The accession A50 (133.2) was late in flowering.

Regarding number of primary branches per plant, the range was between 5.5 (A41) to 15.8 (A4). Accession A4 had highest number of primary branches per plant followed by A12 (15.6), A50 (15.1), A24 (14.9), A13 (14.6), A34 (14.5) and A6 (14.5).

The Maximum number of secondary branches per plant was recorded for accession A4 (45.2) followed by A28 (41.7), A50 (41.1) and A55 (40.1). The Minimum number of secondary branches per plant was recorded for accession A14 (12.5).

Accession A50 (335.1) produced highest number of fruits per plant followed by A70 (324.3) and A4 (313). Accession A23 (75) recorded the lowest number of fruits per plant.

Average fruit length exhibited significant variation among the genotypes with a range of 2.9cm (A73) to 7.5cm (A4). The longest fruits were produced by accession A4 (7.5cm) and accession A50 (7.5cm) followed by A55 (7.3cm), A24 (7.2cm), A1 (7.1cm), A52 (7.1cm) and A62 (7.1cm) whereas accession A73 (2.9cm) had the smallest fruits.

The maximum average fruit width was observed for accession A50 (3.9cm) followed by A4 (3.6cm), A28 (3.4cm) and A34 (3.2cm). The minimum average fruit width was observed for accession A48 (1.4cm), accession A72 (1.4cm) and accession A77 (1.4cm).

The highest individual fruit weight was recorded for accession A43 (2.1g) and accession A51 (2.1g) and the lowest was recorded for accession A7 (0.4g) and accession A8 (0.4g).

Fruit yield per plant ranged from 70.1g (A7) to 667.1g (A50). The highest fruit yield was recorded in A50 and it was followed by A4 (624.1g), A52 (433.6g), A55 (398.3g) and A24 (355.1g).

The highest number of seeds per fruit recorded in A55 (54.3) followed by A40 (52.8) and A1 (40). The lowest number of seeds per fruit recorded in A5 (9.3).

Significant variation was noticed for plant height which ranged between 31cm (A25) and 131.2cm (A4). Highest plant height was recorded for A4 and it was followed by A50 (112.7cm), A24 (101.3cm) and A34 (99.6cm).

Vulnerability index calculated on the basis of disease scoring and showed a range of 0 (A50) to 98.2 (A40) and the accessions were classified as tolerant viz.,

Table 3. Mean performance of 78 genotypes

Accession	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
A1	109.8	7.8	24.6	140.1	7.1	3.1	2.0	276.1	0.280	40.0	67.2	31.2	0.27	0.00	2.34	3.64
A2	106.8	10.5	34.5	101.5	3.1	2.9	1.1	109.8	0.111	21.5	51.2	56.2	0.23	0.00	3.14	3.51
A3	102.1	8.6	19.4	129.3	6.2	2.1	1.1	138.2	0.140	25.8	48.9	66.6	0.25	0.00	2.88	2.99
A4	110.6	15.8	45.2	313.0	7.5	3.6	2.0	624.1	0.632	45.1	131.2	6.2	0.11	0.00	0.19	1.09
A5	104.6	12.6	31.1	88.6	3.3	2.1	1.4	124.4	0.126	9.3	45.6	33.3	0.32	0.00	2.98	2.22
A6	109.2	14.5	29.1	93.6	5.6	2.2	1.1	100.5	0.101	13.6	54.3	66.6	0.35	0.00	3.45	3.84
A7	116.3	8.6	24.3	175.7	4.3	2.0	0.4	70.1	0.071	28.1	59.2	12.5	0.41	0.00	2.99	4.61
A8	109.3	7.9	35.2	181.3	6.2	2.0	0.4	70.9	0.071	23.2	63.2	66.6	0.32	0.00	2.61	4.51
A9	103.8	12.3	31.4	96.3	4.6	1.9	0.9	80.2	0.081	11.3	59.3	75.0	0.25	0.00	2.66	2.95
A10	100.7	6.8	18.5	214.3	5.0	2.2	0.5	102.7	0.104	17.5	48.5	53.5	1.25	0.00	1.74	3.14
A11	112.5	9.5	29.4	126.0	5.7	2.5	1.3	162.1	0.164	32.6	43.3	75.0	1.35	0.00	1.98	3.74
A12	107.5	15.6	22.5	115.3	6.5	2.3	1.7	195.3	0.198	28.6	51.8	60.7	0.89	0.00	3.25	3.64
A13	114.4	14.6	32.8	255.5	3.0	3.0	1.2	302.9	0.307	10.8	49.2	12.5	0.75	0.00	3.47	2.86
A14	114.8	8.9	12.5	113.0	5.8	2.9	1.2	132.2	0.134	22.8	69.2	75.0	0.34	0.00	2.65	2.81
A15	103.6	6.7	19.6	79.0	5.0	2.6	1.0	75.3	0.076	10.7	43.5	54.1	1.95	0.00	3.98	3.41
A16	101.5	8.8	22.2	147.6	6.1	2.1	1.7	244.2	0.247	26.0	58.9	55.0	2.31	0.00	1.11	4.61
A17	105.8	9.7	30.4	114.0	5.1	2.2	1.1	122.4	0.124	9.9	49.2	75.0	0.99	0.00	2.56	4.91
A18	112.9	12.6	28.5	83.5	5.1	1.9	1.0	80.3	0.081	12.5	41.2	62.5	0.79	0.00	3.14	3.41
A19	103.4	11.5	30.2	97.3	4.3	1.8	1.3	122.1	0.123	20.7	64.2	75.0	0.25	0.00	3.24	3.85
A20	114.3	7.7	26.4	95.6	4.8	2.2	1.0	92.5	0.093	15.4	45.7	65.0	0.34	0.00	2.88	3.91
A21	114.9	5.6	14.5	100.5	4.5	2.4	1.4	136.9	0.138	10.8	51.0	75.0	0.89	0.00	1.45	3.73

Table 3. Continued

Accession	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
A22	99.7	6.8	21.1	78.0	3.8	2.6	0.9	71.1	0.072	15.6	44.8	66.6	1.42	0.00	2.75	2.91
A23	108.6	13.3	31.7	75.0	4.5	2.5	1.7	124.1	0.125	34.5	77.0	50.0	1.32	0.00	3.54	0.99
A24	95.6	14.9	38.9	221.0	7.2	3.0	1.6	355.1	0.360	30.1	101.3	12.5	0.16	0.00	1.01	1.91
A25	104.7	10.5	31.7	88.8	3.1	2.9	1.0	81.7	0.082	25.4	31.0	70.0	0.23	0.00	2.54	3.81
A26	117.8	9.6	21.7	112.5	3.6	3.0	1.4	157.6	0.159	19.5	43.2	62.5	0.89	0.00	3.64	2.94
A27	109.4	12.3	30.4	75.3	3.7	2.8	1.0	72.2	0.073	29.0	33.6	66.6	0.54	0.00	2.71	2.86
A28	99.0	10.6	41.7	254.8	6.6	3.4	1.2	302.7	0.306	21.0	86.0	10.0	0.14	0.00	0.12	0.98
A29	109.8	8.9	22.2	116.5	3.6	1.9	1.2	138.8	0.140	30.1	49.2	66.6	0.16	0.00	2.98	2.61
A30	108.7	10.6	30.7	136.5	3.1	1.5	1.0	133.1	0.134	29.2	40.2	62.5	0.16	0.00	2.64	4.94
A31	104.6	7.5	19.7	181.0	3.6	1.8	0.6	106.2	0.107	30.0	52.0	62.5	0.25	0.00	2.41	4.11
A32	108.9	6.9	14.8	209.2	4.0	2.9	1.1	225.9	0.229	31.0	42.0	15.0	0.17	0.00	2.64	3.55
A33	106.7	12.3	21.7	103.0	3.6	2.8	0.8	82.1	0.083	25.8	40.8	58.3	0.89	0.00	3.46	2.11
A34	108.9	14.5	39.4	235.6	6.4	3.2	1.2	283.1	0.287	29.9	99.6	10.0	0.12	0.00	1.21	1.53
A35	105.4	9.7	22.7	112.7	5.2	2.5	1.2	136.2	0.138	24.0	71.6	53.5	0.14	0.00	2.84	2.91
A36	109.0	5.9	20.4	105.3	5.0	2.6	1.7	179.1	0.181	16.0	80.3	62.5	0.16	0.00	3.64	3.46
A37	107.8	10.7	32.7	136.8	5.8	2.5	1.5	204.3	0.207	24.2	66.2	70.0	1.32	0.00	3.97	3.84
A38	106.0	9.8	26.4	132.8	5.3	2.3	1.3	171.6	0.174	32.1	44.0	70.0	1.89	0.00	3.46	0.93
A39	107.2	11.1	32.4	107.6	5.6	2.8	1.2	129.8	0.131	29.8	59.1	75.0	1.75	0.00	4.61	4.62
A40	105.4	12.4	24.7	129.0	5.3	2.7	1.1	140.9	0.142	52.8	58.0	98.2	1.42	0.00	3.84	4.51
A41	111.4	5.5	16.8	104.0	6.2	2.1	1.1	115.1	0.116	39.6	36.0	55.0	0.75	0.00	2.98	5.88
A42	108.3	6.7	22.8	205.0	6.5	2.2	1.1	220.3	0.223	34.7	50.2	10.0	0.48	0.00	2.64	2.81
A43	107.2	12.4	34.9	130.2	5.3	2.3	2.1	273.5	0.277	28.3	45.9	58.3	1.46	0.00	3.41	2.93

Table 3. Continued

Accession	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
A44	106.4	9.9	26.4	110.2	5.6	2.1	1.1	120.9	0.122	13.2	53.1	50.0	0.79	0.00	1.62	4.81
A45	112.5	7.6	22.8	96.8	5.6	2.4	0.9	87.3	0.088	20.0	38.3	50.0	0.42	0.00	2.55	3.33
A46	104.6	10.8	34.7	90.3	5.2	1.8	1.1	98.8	0.100	27.3	71.2	58.3	0.33	0.00	3.44	2.81
A47	107.8	13.4	30.4	121.6	5.1	1.5	1.5	181.9	0.184	25.1	65.2	64.2	0.14	0.00	4.55	2.95
A48	105.1	5.9	22.8	144.6	5.6	1.4	1.3	186.8	0.189	26.6	35.0	83.3	0.33	0.00	3.41	3.84
A49	106.1	6.7	21.7	79.5	4.5	1.7	1.2	94.4	0.095	28.7	43.2	75.0	0.42	0.00	2.55	3.44
A50	133.2	15.1	41.1	335.1	7.5	3.9	2.0	667.1	0.676	10.9	112.7	0.0	0.18	0.00	0.13	1.22
A51	108.4	9.6	22.6	133.8	6.2	2.1	2.1	280.8	0.284	30.8	60.0	75.0	0.21	0.00	2.95	2.99
A52	110.8	13.9	39.4	242.6	7.1	3.0	1.8	433.6	0.439	17.8	98.5	9.3	0.11	0.00	1.62	1.01
A53	99.3	5.8	18.6	172.8	4.0	2.4	0.7	117.8	0.119	15.3	52.0	68.7	0.25	0.00	2.31	2.61
A54	113.4	6.8	22.4	104.0	4.8	2.7	1.1	113.4	0.115	10.0	48.6	60.0	0.22	0.00	4.61	2.55
A55	108.4	10.9	40.1	262.9	7.3	3.1	1.5	398.3	0.403	54.3	95.3	10.7	0.14	0.00	1.64	1.23
A56	116.9	9.8	20.3	92.5	4.5	2.4	1.6	147.8	0.149	14.0	57.8	62.5	0.89	0.00	2.64	1.89
A57	107.3	11.9	35.4	210.8	6.5	3.0	1.1	228.3	0.231	32.3	89.1	12.5	0.12	0.00	1.12	1.34
A58	102.4	12.7	28.5	111.6	4.0	2.4	1.0	109.9	0.111	24.1	41.9	75.0	0.23	0.00	2.31	2.95
A59	111.8	10.7	27.6	116.3	4.8	1.8	1.0	115.7	0.117	9.6	45.0	66.6	0.89	0.00	3.65	2.83
A60	102.9	13.3	30.8	206.0	5.1	2.1	0.5	100.1	0.101	10.8	69.3	83.3	0.33	0.00	4.11	3.72
A61	106.7	12.8	29.8	100.6	6.3	1.6	1.0	101.1	0.102	25.4	82.0	33.3	0.16	0.00	2.14	3.92
A62	110.7	9.6	32.4	220.2	7.1	2.5	1.1	240.1	0.243	29.0	85.5	13.8	0.16	0.00	0.94	1.56
A63	111.7	7.8	18.9	119.3	4.2	1.5	1.0	118.9	0.120	21.3	67.0	58.3	0.78	0.00	2.98	2.33
A64	111.1	12.5	24.7	102.4	4.5	2.8	1.1	112.6	0.114	10.3	62.5	60.7	0.14	0.00	2.54	3.88
A65	117.3	9.5	30.4	123.5	4.1	1.6	1.2	147.2	0.149	14.5	48.0	62.5	0.47	0.00	2.82	3.46

Table 3. Continued

Accession	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
A66	99.6	10.4	32.7	88.5	6.0	1.7	1.7	149.4	0.151	10.3	59.9	87.5	0.78	0.00	0.99	2.64
A67	103.4	7.7	20.9	181.0	4.5	2.4	0.5	88.1	0.089	9.5	43.8	75.0	0.65	0.00	2.64	2.98
A68	110.2	10.8	28.7	92.0	3.8	2.9	1.2	116.3	0.117	17.5	47.1	66.6	0.16	0.00	4.61	2.43
A69	107.1	8.9	18.5	80.0	4.7	1.7	1.2	95.5	0.096	14.2	42.1	87.5	0.79	0.00	3.01	2.11
A70	96.3	13.7	39.9	324.33	5.4	2.1	0.9	293.1	0.297	24.0	88.8	8.3	0.33	0.00	1.02	1.51
A71	100.3	9.8	22.5	151.8	3.9	1.9	0.9	130.9	0.132	14.3	66.6	50.0	0.89	0.00	2.62	2.94
A72	104.1	5.6	19.8	124.8	4.0	1.4	2.0	243.5	0.246	28.9	51.3	50.0	1.23	0.00	2.94	3.11
A73	108.3	6.7	21.7	126.1	2.9	2.7	1.1	141.1	0.143	30.1	47.8	46.4	0.14	0.00	3.16	3.66
A74	107.2	8.7	18.6	100.9	4.0	1.8	1.1	111.1	0.112	24.6	60.8	57.1	1.47	0.00	4.62	3.76
A75	104.7	7.6	24.6	197.0	4.1	2.8	0.4	75.3	0.076	28.1	97.3	70.8	1.89	0.00	3.71	1.62
A76	107.6	9.7	27.6	182.4	4.2	2.6	0.8	144.3	0.146	9.9	66.3	65.0	1.56	0.00	3.95	1.88
A77	107.9	8.2	20.7	170.0	3.3	1.4	1.1	185.9	0.188	10.2	43.0	55.0	1.88	0.00	2.94	2.99
A78	96.1	10.5	15.6	90.5	5.0	2.8	1.3	118.1	0.119	20.4	78.5	75.0	0.78	0.00	2.81	2.86
Mean	107.65	10.06	26.86	142.54	5.02	2.36	1.19	168.76	0.170	22.85	59.77	54.43	0.65	0.00	2.74	3.02

X_1 Number of days to first flowering
X2 Number of primary branches
X3 Number of secondary branches
X4 Number of fruits per plant
X5 Average fruit length (cm)
X6 Average fruit width (cm)
X7 Individual fruit weight (g)
X8 Fruit yield per plant (g)
X9 Fruit yield per plot (kg)
X10 Number of seeds per fruit
X11 Plant height (cm)
X12 Incidence of leaf curl disease
X13 Number of white flies per plant
X14 Number of aphids per plant
X15 Number of thrips per leaf
X16 Number of mites per leaf

A4, (6.2), A70 (8.3), A52 (9.3), A34 (10), A42 (10), A28 (10), A55 (10.7), A7 (12.5), A13 (12.5), A24 (12.5), A57 (12.5), A62 (13.8) and A32 (15) (Table 4).

Accession A4 (0.11) and accession A52 (0.11) had the lowest number of white flies per plant and it was followed by A34 (0.12), A57 (0.12), A28 (0.14), A55 (0.14), A24 (0.16), A61 (0.16), A62 (0.16) and A50 (0.18). Accession A16 (2.31) had the highest number of white flies per plant.

Number of thrips per leaf varied from 0.12 (A28) to 4.62 (A74). Accession A28 had the lowest number of thrips per leaf and it was followed by A50 (0.13), A4 (0.19), A62 (0.94) and A66 (0.99).

Accession A38 had the lowest number of mites per leaf (0.93) and it was followed by A28 (0.98) and A23, (0.99). The highest number of mites per leaf observed in A41 (5.88).

No aphids were observed in any accessions studied.

4.1.1.2 Genetic divergence analysis

The quantitative assessment of genetic divergence was for 78 genotypes and the results obtained from the study are presented below.

4.1.1.2.1 Grouping of genotypes into various clusters

The seventy eight genotypes were subjected to clustering using dendrogram. Based on dendrogram the genotypes were grouped into different clusters at Euclidean variance 20 (Fig. 1).

Cluster II was the largest group with 24 genotypes followed by cluster IV with 13 genotypes, cluster I with 11 genotypes, cluster V with 9 genotypes, cluster IX with 8 genotypes, cluster VI with 7 genotypes, cluster VII with 3 genotypes, cluster VIII with 2 genotypes and cluster III with 1 genotype (Table 5).

Table 4. Categorization of accessions based on vulnerability index of leaf curl disease incidence

Sl. No.	V. I	Category	Genotypes
1.	0.00	Resistant(R)	A50
2.	1.00-25.00	Tolerant (T)	A4, A7, A13, A24, A28, A32, A34, A42, A52, A55, A57, A62 and A70
3.	25.01- 50.00	Susceptible(S)	A1, A5, A23, A44, A45, A61, A71, A72 and A73
4.	>50.00	Highly susceptible (HS)	A2, A3, A6, A8, A9, A10, A11, A12, A14, A15, A16, A17, A18, A19, A20, A21, A22, A25, A26, A27, A29, A30, A31, A33, A35, A36, A37, A38, A39, A40, A41, A43, A46, A47, A48, A49, A51, A53, A54, A56, A58, A59, A60, A63, A64, A65, A66, A67, A68, A69, A74, A75, A76, A77 and A78

Fig. 1. Dendrogram of 78 genotypes of bird chilli

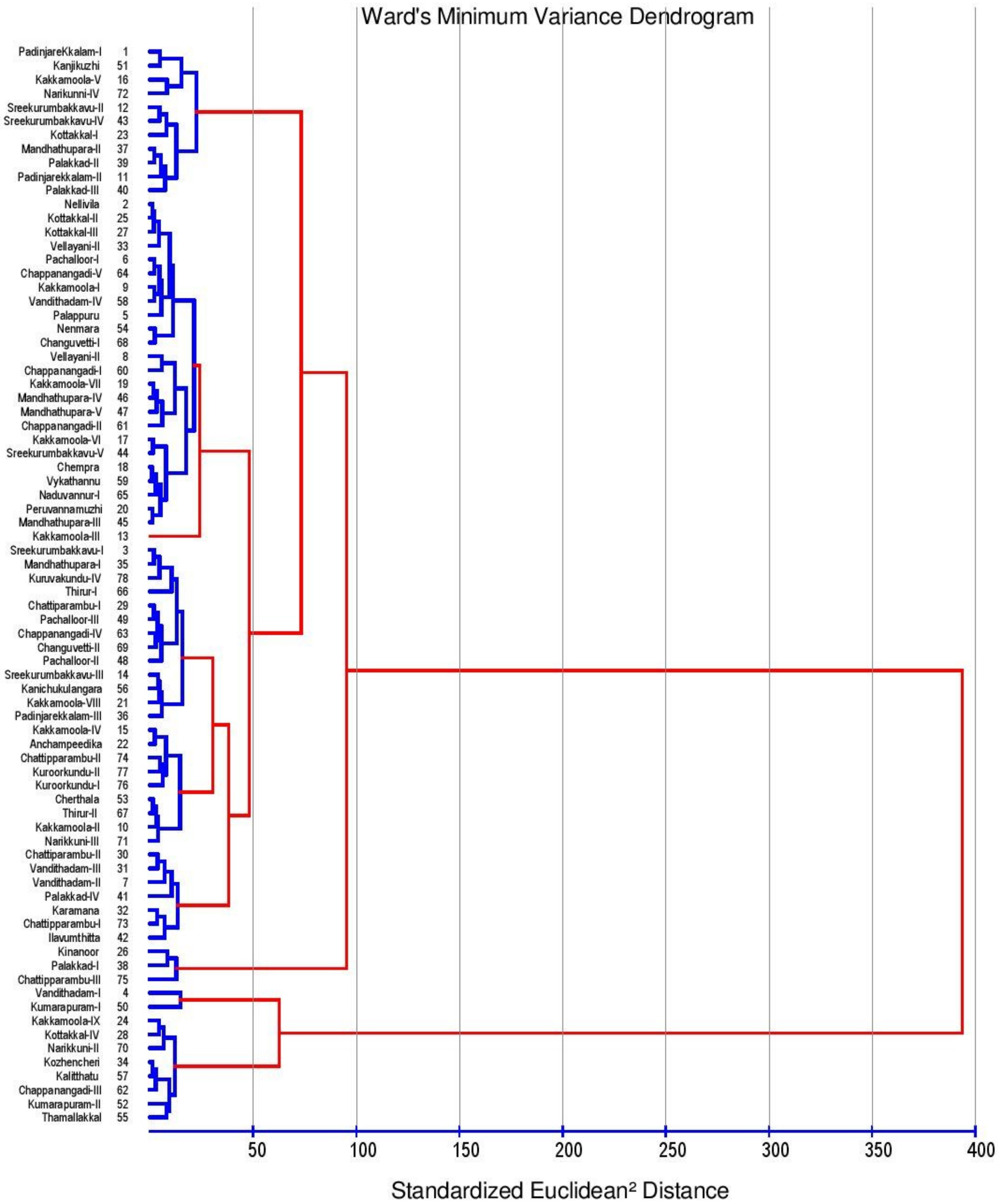


Table 5. Distribution of 78 chili genotypes in different clusters

Cluster No	No of genotypes	Cluster members
I	11	A1, A51, A16, A72, A12, A43, A23, A37, A39, A11, A40
II	24	A2, A25, A27, A8, A6, A64, A9, A58, A5, A54, A68, A8, A60, A19, A46, A47, A61, A17, A44, A18, A59, A65, A20, A45
III	1	A13
IV	13	A3, A35, A78, A66, A29, A49, A63, A69, A48, A14, A56, A21, A36,
V	9	A15, A22, A74, A77, A76, A53, A67, A10, A71
VI	7	A30, A31, A7, A41, A32, A73, A42
VII	3	A26, A38, A75
VIII	2	A4, A50
IX	8	A24, A28, A34, A52, A55, A57, A62, A70

4.1.1.2.2 Cluster means of the characters

The cluster means for 15 characters are furnished in Table 6. Cluster VIII had the maximum cluster mean for fruit yield per plant (645.60), followed by number of fruits per plant (324.05), plant height (121.95), number of days to first flowering (121.90), number of secondary branches (43.15), number of primary branches (15.45), average fruit length (7.50), average fruit width (3.75) and individual fruit weight (2.00).

The genotypes in cluster V exhibited lowest number of days to first flowering (103.30) while in cluster VIII it was the highest (121.90). The maximum number of primary branches per plant was observed in cluster VIII (15.45) and the minimum number in cluster VI (7.50). The highest number of secondary branches per plant was recorded for cluster VIII (43.15) and the lowest for cluster IV (20.17). The maximum number of fruits per plant was recorded in cluster VIII (324.05) and the minimum in cluster IV (105.55). Fruit length varied from 7.50 in cluster VIII to 3.00 in cluster III. The maximum fruit width was observed in cluster VIII (3.75) and the minimum was in cluster IV (2.12). The highest individual fruit weight was observed for cluster VIII (2.00) and lowest was in cluster V (0.83). The maximum fruit yield per plant was reported in cluster VIII (645.60) while the minimum was in cluster II (106.01). The maximum number of seeds per fruit was shown by cluster I (32.41) and the minimum was in cluster III (10.80). Cluster VIII reported the maximum plant height (121.95) while cluster VI exhibited the minimum (46.77). The highest and the lowest incidence of leaf curl disease was recorded for cluster IV (71.41) and VIII (3.10) respectively. Cluster VII recorded the highest number of white flies per plant (1.56) while the lowest was in cluster VIII (0.15). Cluster VII had the highest number of thrips per leaf (3.60) while genotypes in cluster VIII exhibited the lowest (0.16). The highest number of mites per leaf was observed for cluster VI (4.22) and the lowest was for cluster VIII (1.15).

Table 6. Cluster mean values of 15 different characters of 78 bird chili genotypes

Cluster means	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
Cluster -I	107.27	10.62	27.05	124.20	5.65	2.39	1.67	206.78	32.41	58.06	3	63.50	1.23	3.09	3.51
Cluster -II	108.25	11.05	29.08	108.09	4.64	2.22	1.03	106.01	17.72	52.15	3	62.52	0.41	3.10	3.40
Cluster -III	114.40	14.60	32.80	255.50	3.00	3.00	1.20	302.90	10.80	49.20	3	12.50	0.75	3.47	2.86
Cluster -IV	107.58	8.28	20.17	105.55	4.98	2.12	1.32	136.33	20.38	57.98	3	71.41	0.52	2.68	2.89
Cluster -V	103.30	7.80	20.90	147.80	4.19	2.21	0.83	114.13	14.18	52.14	3	60.56	1.26	3.06	2.96
Cluster -VI	109.50	7.50	21.54	162.51	4.37	2.17	0.91	144.54	31.81	46.77	3	37.70	0.34	2.78	4.22
Cluster -VII	109.50	9.00	24.23	147.43	4.33	2.70	1.03	134.83	26.57	61.50	5	67.77	1.56	3.60	1.83
Cluster -VIII	121.90	15.45	43.15	324.05	7.50	3.75	2.00	645.60	28.00	121.95	3	3.10	0.15	0.16	1.15
Cluster -IX	104.63	12.50	38.40	246.53	6.70	2.91	1.30	316.79	29.80	93.01	3	10.89	0.16	1.09	1.38

X_1 Number of days to first flowering

X2 Number of primary branches

X3 Number of secondary branches

X4 Number of fruits per plant

X5 Average fruit length (cm)

X6 Average fruit width (cm)

X7 Individual fruit weight (g)

X8 Fruit yield per plant (g)

X9 Number of seeds per fruit

X10 Plant height (cm)

X11 Leaf pubescence

X12 Incidence of leaf curl disease

X13 Number of white flies per plant

X14 Number of thrips per leaf

X15 Number of mites per leaf

4.2 EXPERIMENT II

4.2.1 Confirmation study

The performance of 10 genotypes was evaluated for various characters.

4.2.1.1 Variability

The genotypes showed significant differences for all the traits under study.

4.2.1.2 Mean performance

Table 7 gives the mean values of the genotypes for yield and other traits.

The genotype T2 took only 91.30 days to produce the first flower and it was on par with 6 other genotypes viz., T6 (91.33), T4 (91.40), T7 (91.53), T3 (91.57), T9 (91.70) and T10 (92.07). The genotype T8 took the longest duration for first flowering i.e. 99.27 days.

Number of primary branches varied from 11.37 (T9) to 21.27 (T1). The genotype T1 was on par with T2 (19.77).

The genotype T5 had the highest number of secondary branches per plant (49.97) and T5 was on par with T10 (47.70). The genotype T9 had the lowest number of secondary branches per plant (33.47).

The genotype T5 was produced the largest number of fruits per plant (391.03) and it was significantly superior to all other genotypes. The genotype T8 produced less number of fruits per plant (209.83).

The highest average fruit length was observed for T1 (7.53cm) and it was on par with T5 (7.40 cm) and T7 (7.43 cm). The lowest fruit length was for T10 (5.43 cm).

Table 7. Mean performance of 10 genotypes for different characters

Treatment Number	Genotype	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
T1	Vandithadam-I	98.47	21.27	45.97	355.70	7.53	3.67	2.13	757.73	0.765	47.80	133.97	2.77	0.67	0.00	2.31	1.50
T2	Kakkamoola-IX	91.30	19.77	40.40	279.77	7.27	3.03	1.47	409.10	0.413	31.83	103.47	5.53	0.67	0.00	2.87	2.40
T3	Kottakkal-IV	91.57	13.50	42.13	298.13	6.57	3.47	1.50	445.67	0.451	21.20	87.80	10.27	1.34	0.00	2.57	1.93
T4	Kozhencheri	91.40	15.63	39.50	285.80	6.63	3.30	1.03	294.20	0.298	31.30	102.10	13.87	1.27	0.00	2.16	2.21
T5	Kumarapuram-I	98.73	17.60	49.97	391.03	7.40	3.97	2.07	807.60	0.815	12.27	113.80	0.00	0.45	0.00	1.91	1.78
T6	Kumarapuram-II	91.33	15.53	42.50	314.77	7.10	3.10	1.73	544.40	0.551	18.60	96.10	12.50	1.43	0.00	2.95	2.09
T7	Thamallakkal	91.53	12.47	41.07	301.73	7.43	3.17	1.73	522.67	0.528	52.17	98.07	11.07	1.59	0.00	2.31	2.14
T8	Kalitthatu	99.27	12.23	40.00	209.83	6.50	3.03	1.03	216.97	0.219	30.73	89.00	8.87	0.92	0.00	1.90	2.18
T9	Chappanangadi-III	91.70	11.37	33.47	239.83	7.17	2.57	1.00	237.03	0.241	29.00	86.23	13.87	0.85	0.00	2.26	2.01
T10	Narikkuni-II	92.07	17.40	47.70	356.13	5.43	2.13	0.93	329.93	0.334	26.27	85.93	10.27	1.06	0.00	2.41	2.02
	Mean	93.74	15.68	42.27	303.27	6.90	3.14	1.46	456.53	0.461	30.12	99.65	8.90	1.03	0.00	2.37	2.02
	C.V.	0.77	8.35	4.96	1.84	1.46	1.91	3.55	3.59	3.6379	1.00	1.45	35.37	6.50	0.00	5.44	5.38
	F ratio	70.73	19.47	15.01	290.41	121.13	228.26	225.05	467.73	451.9	4981.21	324.64	6.69	95.72	0.00	22.89	15.79
	S.E.	0.42	0.76	1.21	3.22	0.06	0.03	0.03	9.46	0.01	0.17	0.83	1.82	0.04	0.00	0.07	0.06
	C.D. 5%	1.24	2.25	3.59	9.55	0.17	0.10	0.09	28.09	0.03	0.52	2.48	5.40	0.11	0.00	0.22	0.19

X_1 Number of days to first flowering
X2 Number of primary branches
X3 Number of secondary branches
X4 Number of fruits per plant
X5 Average fruit length (cm)
X6 Average fruit width (cm)
X7 Individual fruit weight (g)
X8 Fruit yield per plant (g)
X9 Fruit yield per plot (kg)
X10 Number of seeds per fruit
X11 Plant height (cm)
X12 Incidence of leaf curl disease
X13 Number of white flies per plant
X14 Number of aphids per plant
X15 Number of thrips per leaf
X16 Number of mites per leaf

Plate 4. Fruit character of 10 selected bird chilli genotypes

The genotype T5 showed highest fruit width (3.97 cm) and it was significantly superior to all other genotypes. Fruit width was the lowest for T10 (2.13cm).

Individual fruit weight ranged from 0.93 g (T10) to 2.13 g (T1). T1 was on par with the genotype T5 (2.07 g).

Fruit yield per plant was the highest for T5 (807.60 g) and the lowest for T8 (216.97 g). The genotype T5 was significantly superior to all other genotypes.

Number of seeds per fruit ranged from 12.27 (T5) to 52.17 (T7). The genotype T7 was found superior to all other genotypes.

Plant height was the highest for T1 (133.97 cm) and it was significantly superior to all other genotypes. The genotype T10 had the lowest plant height (85.93 cm).

Vulnerability index was calculated on the basis of disease scoring and showed a range of 0 (T5) to 13.87 (T4 and T9). The genotype T5 was on par with T1 (2.77).

The genotype T5 had the lowest number of white flies per plant (0.45) and was significantly superior to all other genotypes. The genotype T7 had the highest number of white flies per plant (1.59).

Number of thrips per leaf varied from 1.90 (T8) to 2.95 (T6) and T8 was on par with T5 (1.91).

The genotype T1 had the lowest number of mites per leaf (1.50) and it was significantly superior to all other genotypes. The genotype T2 had the highest number of mites per leaf (2.40).

Table 8. Genetic parameters

Character	Variance			Coefficient of variation			Heritability	Genetic advance (as % of mean)
	Phenotypic	Genotypic	Environmental	PCV	GCV	ECV		
Number of days to first flowering	12.75	12.22	0.53	3.81	3.73	0.77	95.88	7.52
Number of primary branches	12.27	10.56	1.71	22.34	20.72	8.35	86.03	39.60
Number of secondary branches	24.90	20.51	4.39	11.80	10.71	4.96	82.37	20.03
Number of fruits per plant	3022.78	2991.77	31.01	18.13	18.04	1.84	98.97	36.96
Average fruit length (cm)	0.41	0.40	0.01	9.33	9.22	1.46	97.56	18.76
Average fruit width (cm)	0.28	0.27	0.00	16.71	16.60	1.91	98.70	33.97
Individual fruit weight (g)	0.20	0.20	0.00	30.91	30.71	3.55	98.68	62.84
Fruit yield per plant (g)	41999.21	41730.98	268.23	44.89	44.75	3.59	99.36	91.88
Number of seeds per fruit	150.11	150.02	0.09	40.68	40.67	1.00	99.94	83.75
Plant height (cm)	227.56	225.47	2.09	15.14	15.07	1.45	99.08	30.90
Incidence of leaf curl disease (V.I)	28.70	18.80	9.91	60.20	48.71	35.37	65.48	81.20
Number of white flies per plant	0.14	0.14	0.00	37.10	36.53	6.50	96.93	74.09
Number of thrips per leaf	0.14	0.12	0.02	15.65	14.68	5.44	87.95	28.36
Number of mites per leaf	0.07	0.06	0.01	13.09	11.94	5.38	83.13	22.42

4.2.1.3. Coefficient of variation

The phenotypic, genotypic and environmental coefficients of variations were worked out and are presented in Table 8.

4.2.1.3.1 Phenotypic coefficient of variation

The phenotypic coefficient of variation (PCV) was the highest for incidence of leaf curl disease (60.20), fruit yield per plant (44.89), number of seeds per fruit (40.68), number of white flies per plant (37.10), individual fruit weight (30.91) and number of primary branches (22.32). Moderate phenotypic coefficient of variation was observed for number of fruits per plant (18.13), average fruit width (16.71), number of thrips per leaf (15.65), plant height (15.14), number of mites per leaf (13.09) and number of secondary branches (11.80). The characters number of days to first flowering (3.81) and average fruit length (9.33) had low phenotypic coefficient of variation.

4.2.1.3.2 Genotypic coefficient of variation

Genotypic coefficient of variation (GCV) ranged from 3.73 for number of days to first flowering to 48.71 for incidence of leaf curl disease. It was the highest for incidence of leaf curl disease (48.71), fruit yield per plant (44.75), number of seeds per fruit (40.67), number of white flies per plant (36.53), individual fruit weight (30.71) and number of primary branches (20.72). Moderate genotypic coefficient of variation was observed for number of fruits per plant (18.04), average fruit width (16.60), plant height (15.07), number of thrips per leaf (14.68), number of mites per leaf (11.94) and number of secondary branches (10.71). The characters number of days to first flowering (3.73) and average fruit length (9.22) had low genotypic coefficient of variation.

4.2.1.3.3 Environmental coefficient of variation

In general, the environmental coefficient of variation (ECV) was low for most of the characters. However, incidence of leaf curl disease (35.37), number of primary branches (8.35) and number of white flies per plant (6.50) showed comparatively higher ECV indicating the influence of environment on these characters.

4.2.1.4 Heritability

High heritability (in broad sense) estimate was recorded for all the characters under study (Table 8). The highest heritability was obtained for number of seeds per fruit (99.94 %) followed by fruit yield per plant (99.36 %), plant height (99.08 %), number of fruits per plant (98.97 %), average fruit width (98.70 %), individual fruit weight (98.68 %), average fruit length (97.56 %), number of white flies per plant (96.93 %), number of days to first flowering (95.88 %), number of thrips per leaf (87.95 %), number of primary branches (86.03 %), number of mites per leaf (83.13 %), number of secondary branches (82.37 %) and incidence of leaf curl disease (65.48 %).

4.2.1.5 Genetic advance (as percentage of mean)

All the characters exhibited high genetic advance except for number of days to first flowering 7.52 % (low genetic advance) and average fruit length 18.76 % (moderate genetic advance). The highest estimate of genetic advance obtained was 91.88 % (fruit yield per plant) followed by 83.75 % (number of seeds per fruit), 81.20 % (incidence of leaf curl disease) and 74.09% (number of white flies per plant) (Table 8).

Table 9. Genotypic correlation coefficients

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	1.0000	0.2398	0.4614*	0.1725	0.1982	0.4939**	0.3754*	0.4164*	-0.0053	0.5247**	-0.7821**	-0.6324**	-0.6885**	-0.5770**
X2		1.0000	0.6658**	0.6680**	0.1408	0.2937	0.4895**	0.5864**	0.0502	0.7714**	-0.7239**	-0.5517**	0.2701	-0.3516
X3			1.0000	0.9092**	-0.1423	0.3590	0.5609**	0.7340**	-0.2389	0.4750**	-0.7936**	-0.2982	-0.1447	-0.5494**
X4				1.0000	0.0601	0.3536	0.6321**	0.8073**	-0.1677	0.5488**	-0.6155**	-0.2192	0.0447	-0.6181**
X5					1.0000	0.6483**	0.7186**	0.5733**	0.2865	0.6138**	-0.4158*	-0.2333	0.0519	-0.2182
X6						1.0000	0.7773**	0.7324**	-0.0494	0.6900**	-0.6501**	-0.2328	-0.2524	-0.4571*
X7							1.0000	0.9610**	0.1087	0.7697**	-0.7401**	-0.2084	0.1092	-0.5988**
X8								1.0000	-0.0037	0.7856**	-0.8042**	-0.2970	0.0102	-0.6962**
X9									1.0000	0.3239	0.0702	0.2091	-0.0590	-0.0524
X10										1.0000	-0.7749**	-0.4848**	-0.1202	-0.6210**
X11											1.0000	0.8204**	0.2743	0.5512**
X12												1.0000	0.3431	0.3605
X13													1.0000	0.3247
X14														1.0000

X_1 Number of days to first flowering
X2 Number of primary branches
X3 Number of secondary branches
X4 Number of fruits per plant
X5 Average fruit length (cm)
X6 Average fruit width (cm)
X7 Individual fruit weight (g)
X8 Fruit yield per plant (g)
X9 Number of seeds per fruit
X10 Plant height (cm)
X11 Incidence of leaf curl disease
X12 Number of white flies per plant
X13 Number of thrips per leaf
X14 Number of mites per leaf

* significant at 5% level ** significant at 1% level

4.2.1.6 Correlation coefficient analysis

The correlation between different traits was computed as genotypic, phenotypic and environmental correlation coefficients and presented here under.

4.2.1.6.1 Genotypic correlation coefficient

The Genotypic correlation coefficients are given in Table 9. High positive correlation was recorded for fruit yield per plant with individual fruit weight (0.9610), number of fruits per plant (0.8073), plant height (0.7856), number of secondary branches (0.7340), average fruit width (0.7324), number of primary branches (0.5864), fruit length (0.5733) and number of days to first flowering (0.4164). The association was significantly negative with incidence of leaf curl disease (-0.8042) and number of mites per leaf (-0.6962).

Number of days to first flowering showed significant positive correlation with plant height (0.5247), fruit width (0.4939), number of secondary branches (0.4614), fruit yield per plant (0.4164) and individual fruit weight (0.3754). It had negative association with incidence of leaf curl disease (-0.7821), number of thrips per leaf (-0.6885), number of white flies per plant (-0.6324) and number of mites per leaf (-0.5770).

Number of primary branches per plant was negatively correlated with incidence of leaf curl disease (-0.7239), number of white flies per plant (-0.5517) and number of mites per leaf (-0.3516) while it was positive with rest of the characters. It showed high positive genotypic correlation with plant height (0.7714), number of fruits per plant (0.6680), number of secondary branches (0.6658), fruit yield per plant (0.5864) and individual fruit weight (0.4895).

Number of secondary branches had high positive correlation with number of fruits per plant (0.9092) followed by fruit yield per plant (0.7340), number of primary branches (0.6658), individual fruit weight (0.5609) and number of days to first flowering (0.4614). The correlation was negative with incidence of leaf curl disease (-0.7936) and number of mites per leaf (-0.5494).

Number of fruits per plant had high positive correlation with number of secondary branches (0.9092) followed by fruit yield per plant (0.8073), number of primary branches (0.6680), individual fruit weight (0.6321) and plant height (0.5488). It had negative association with number of mites per leaf (-0.6181) and incidence of leaf curl disease (-0.6155).

Fruit length had the maximum positive genotypic correlation with individual fruit weight (0.7186), average fruit width (0.6483), plant height (0.6138) and fruit yield per plant (0.5733). It had significant negative correlation with incidence of leaf curl disease (-0.4158).

Fruit width had strong positive correlation with individual fruit weight (0.7773), fruit yield per plant (0.7324), plant height (0.6900), fruit length (0.6483) and number of days to first flowering (0.4939). The correlation was strong and negative with incidence of leaf curl disease (-0.6501) and number of mites per leaf (-0.4571).

Individual fruit weight had strong and positive correlation with fruit yield per plant (0.9610), fruit width (0.7773), plant height (0.7697), fruit length (0.7186), number of fruits per plant (0.6321), number of secondary branches (0.5609), number of primary branches (0.4895) and number of days to first flowering (0.3754). The value was strong and negative with incidence of leaf curl disease (-0.7401) and number of mites per leaf (-0.5988).

Number of seeds per fruit had no significant correlation, though it was positive with plant height (0.3239) and fruit length (0.2865). It was negative with number of secondary branches (-0.2389) and number of fruits per plant (-0.1677).

Plant height had positive correlation with all the characters except for incidence of leaf curl disease (-0.7749), number of mites per leaf (-0.6210), number of white flies per plant (-0.4848) and number of thrips per leaf (-0.1202). High positive correlation was obtained for fruit yield per plant (0.7856), number of primary branches (0.7714), individual fruit weight (0.7697), fruit width (0.6900), fruit length (0.6138), number of fruits per plant (0.5488), number of days to first flowering (0.5247) and number of secondary branches (0.4750).

Incidence of leaf curl disease had negative genotypic correlation with most of the characters. The genotypic correlation was significantly positive with number of white flies per plant (0.8204) and number of mites per leaf (0.5512).

Number of white flies per plant had negative genotypic correlation with most of the characters while it was significantly positive with incidence of leaf curl disease (0.8204).

The genotypic correlation of number of thrips per leaf was significantly negative with number of days to first flowering (-0.6885) while it was positive with majority of the characters.

Number of mites per leaf had negatively significant correlation with fruit yield per plant (-0.6962), plant height (-0.6210), number of fruits per plant (-0.6181), individual fruit weight (-5988), number of days to first flowering (-0.5770), number of secondary branches (-0.5494) and fruit width (-0.4571). It had significant positive correlation with incidence of leaf curl disease (0.5512).

4.2.1.6.2 Phenotypic correlation coefficient

The phenotypic correlation coefficients are presented in Table 10. High positive correlation was recorded for fruit yield per plant with individual fruit weight (0.9599), number of fruits per plant (0.7992), plant height (0.7775), average fruit width (0.7222), number of secondary branches (0.6555), number of primary branches (0.5519), fruit length (0.5668) and number of days to first flowering (0.4052). The association was significantly negative with incidence of leaf curl disease (-0.6543) and number of mites per leaf (-0.6419).

Table 10. Phenotypic correlation coefficients

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	1.0000	0.2357	0.4086*	0.1660	0.1941	0.4781**	0.3651*	0.4052*	-0.0045	0.5061**	-0.6050**	-0.6143**	-0.6291**	-0.5107**
X2		1.0000	0.5418**	0.6145**	0.1406	0.2567	0.4690**	0.5519**	0.0453	0.7002**	-0.5966**	-0.4902**	0.2182	-0.3196
X3			1.0000	0.8179**	-0.1297	0.3453	0.4971**	0.6555**	-0.2151	0.4365*	-0.5404**	-0.2461	-0.0638	-0.4543*
X4				1.0000	0.0630	0.3495	0.6213**	0.7992**	-0.1668	0.5416**	-0.5015**	-0.2118	0.0332	-0.5666**
X5					1.0000	0.6280**	0.7100**	0.5668**	0.2839	0.6025**	-0.3147	-0.2158	0.0273	-0.2294
X6						1.0000	0.7614**	0.7222**	-0.0495	0.6813**	-0.5298**	-0.2355	-0.2064	-0.4192*
X7							1.0000	0.9599**	0.1080	0.7606**	-0.6023**	-0.2024	0.0975	-0.5558**
X8								1.0000	-0.0040	0.7775**	-0.6543**	-0.2930	0.0076	-0.6419**
X9									1.0000	0.3230	0.0582	0.2059	-0.0545	-0.0493
X10										1.0000	-0.6262**	-0.4664**	-0.1127	-0.5667**
X11											1.0000	0.6655**	0.1793	0.4411*
X12												1.0000	0.2935	0.3075
X13													1.0000	0.2457
X14														1.0000

X_1 Number of days to first flowering
X2 Number of primary branches
X3 Number of secondary branches
X4 Number of fruits per plant
X5 Average fruit length (cm)
X6 Average fruit width (cm)
X7 Individual fruit weight (g)
X8 Fruit yield per plant (g)
X9 Number of seeds per fruit
X10 Plant height (cm)
X11 Incidence of leaf curl disease
X12 Number of white flies per plant
X13 Number of thrips per leaf
X14 Number of mites per leaf

* significant at 5% level ** significant at 1% level

Number of days to first flowering showed significant positive correlation with plant height (0.5061), fruit width (0.4781), number of secondary branches (0.4086), fruit yield per plant (0.4052) and individual fruit weight (0.3651). It had negative association with number of thrips per leaf (-0.6291), number of white flies per plant (-0.6143), incidence of leaf curl disease (-0.6050) and number of mites per leaf (-0.5107).

The interrelationship of number of primary branches was negative with incidence of leaf curl disease (-0.5966), number of white flies per plant (-0.4902) and number of mites per leaf (-0.3196) while it was positive for rest of the characters. It showed high positive phenotypic correlation with plant height (0.7002), number of fruits per plant (0.6145), fruit yield per plant (0.5519), number of secondary branches (0.5418) and individual fruit weight (0.4690).

Number of secondary branches had positive correlation with number of fruits per plant (0.8179), fruit yield per plant (0.6555), number of primary branches (0.5418), individual fruit weight (0.4971), plant height (0.4365) and number of days to first flowering (0.4086). It was negative with incidence of leaf curl disease (-0.5404) and number of mites per leaf (-0.4543).

Number of fruits per plant had positive correlation with number of secondary branches (0.8179), fruit yield per plant (0.7992), individual fruit weight (0.6213), number of primary branches (0.6145) and plant height (0.5416). It had negative correlation with incidence of leaf curl disease (-0.5015) and number of mites per leaf (-0.5666).

Fruit length had the maximum positive phenotypic correlation with individual fruit weight (0.7100), average fruit width (0.6280), plant height (0.6025) and fruit yield per plant (0.5668). It showed maximum negative correlation with incidence of leaf curl disease (-0.3147), number of mites per plant (-0.2294), number of white flies per plant (-0.2158) and number of secondary branches (-0.1297).

Fruit width had strong positive correlation with individual fruit weight (0.7614), fruit yield per plant (0.7222), plant height (0.6813), fruit length (0.6280) and number of days to first flowering (0.4781). The correlation was strong and negative with incidence of leaf curl disease (-0.5298) and number of mites per leaf (-0.4192).

Strong positive correlation of individual fruit weight was obtained with fruit yield per plant (0.9599), fruit width (0.7614), plant height (0.7606), fruit length (0.7100), number of fruits per plant (0.6213), number of secondary branches (0.4971), number of primary branches (0.4690) and number of days to first flowering (0.3651). It was strong and negative with incidence of leaf curl disease (-0.6023) and number of mites per leaf (-0.5558).

The interrelationship of number of seeds per fruit had no significant values; but it was positive with plant height (0.3230) and fruit length (0.2839). It was negative with number of secondary branches (-0.2151) and number of fruits per plant (-0.1668).

Plant height had positive correlation with all the characters except incidence of leaf curl disease (-0.6262), number of mites per leaf (-0.5667), number of white flies per plant (-0.4664) and number of thrips per leaf (-0.1127). High positive correlation was observed for fruit yield per plant (0.7775), individual fruit weight (0.7606), number of primary branches (0.7002), fruit width (0.6813), fruit length (0.6025), number of fruits per plant (0.5416), number of days to first flowering (0.5061) and number of secondary branches (0.4365).

Incidence of leaf curl disease had negative phenotypic correlation with most of the characters. The phenotypic correlation was significantly positive with number of white flies per plant (0.6655) and number of mites per leaf (0.4411).

Number of white flies per plant had negative phenotypic correlation with most of the characters while it was significantly positive with incidence of leaf curl disease (0.6655).

Table 11. Environment correlation coefficients

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	1.0000	0.2361	-0.0164	-0.1018	0.0760	-0.1023	-0.0030	-0.0755	0.1404	-0.2749	0.1231	-0.1297	0.0448	0.0541
X2		1.0000	-0.1193	-0.0501	0.1993	-0.3259	0.4203*	0.3274	-0.1369	-0.3330	-0.2424	0.2077	-0.1287	-0.1445
X3			1.0000	-0.0709	-0.032	0.4499*	-0.1773	-0.2546	0.1564	0.1845	0.1719	0.2767	0.4076*	0.0020
X4				1.0000	0.2505	0.0002	-0.2915	-0.1702	-0.0044	-0.1872	-0.1002	0.1609	-0.2411	-0.1426
X5					1.0000	-0.4578*	0.2727	0.1824	0.2696	-0.0646	0.1927	0.4043*	-0.3837*	-0.5132**
X6						1.0000	-0.4397*	-0.3425	-0.1644	-0.0972	-0.1075	-0.3904*	0.7255**	-0.1091
X7							1.0000	0.9142**	0.0355	-0.0402	-0.1096	0.0700	-0.1054	-0.2858
X8								1.0000	-0.1546	-0.2622	-0.1192	-0.1066	-0.0685	-0.2790
X10									1.0000	0.2693	0.0977	0.0389	0.0863	-0.1571
X11										1.0000	-0.0364	0.5206**	-0.0132	-0.0776
X12											1.0000	0.1151	-0.1412	0.1423
X13												1.0000	-0.3821*	-0.2243
X14													1.0000	-0.2245
X15														1.0000

X_1 Number of days to first flowering
X2 Number of primary branches
X3 Number of secondary branches
X4 Number of fruits per plant
X5 Average fruit length (cm)
X6 Average fruit width (cm)
X7 Individual fruit weight (g)
X8 Fruit yield per plant (g)
X9 Number of seeds per fruit
X10 Plant height (cm)
X11 Incidence of leaf curl disease
X12 Number of white flies per plant
X13 Number of thrips per leaf
X14 Number of mites per leaf

* significant at 5% level   ** significant at 1% level

The phenotypic correlation for number of thrips per leaf was significant and negative with days to first flowering (-0.6291), while it was non significant and positive with other characters.

Number of mites per leaf had negatively significant correlation with fruit yield per plant (-0.6419), plant height (-0.5667), number of fruits per plant (-0.5666), individual fruit weight (-0.5558), number of days to first flowering (-0.5107), number of secondary branches (-0.4543) and fruit width (-0.4192). It was significant and positive with incidence of leaf curl disease (0.4411).

4.2.1.6.3 Environmental correlation coefficient

The environmental correlation coefficients are presented in Table 11. Most of the characters showed a low value for environmental correlation. However, high positive correlation was observed for fruit yield per plant with individual fruit weight (0.9142). Number of thrips per leaf had high positive correlation with fruit width (0.7255) and number of secondary branches (0.4076). High positive correlation was observed for number of white flies per plant with plant height (0.5206) and fruit length (0.4043). Average fruit width had high positive correlation with number of secondary branches (0.4499) finally individual fruit weight had high positive correlation with number of primary branches (0.4203).

4.2.1.7 Path coefficient analysis

The direct and indirect effects of the component characters on yield were estimated using path coefficient analysis (Table 12). The characters having high genotypic correlation with yield viz., number of days to first flowering, number of primary branches, number of secondary branches, number of fruits per plant, average fruit length, average fruit width, individual fruit weight, plant height and incidence of leaf curl disease were selected.

Number of primary branches and incidence of leaf curl disease had negative direct effect on yield, while the other characters such as number of days to first flowering, number of secondary branches, number of fruits per plant, average fruit length, average fruit width, individual fruit weight and plant height had positive direct effect. Direct effect of individual fruit weight (0.5241) and number of fruits per plant (0.3924) on fruit yield were high and positive.

Number of days to first flowering had low positive direct effect (0.0526) on yield and it had indirect effect on yield via individual fruit weight which was positive and high (0.1968). Its genotypic correlation with yield was high and positive (0.4160).

Number of primary branches had low negative direct effect (-0.0730) on yield. It had high positive indirect effect on yield via number of fruits per plant (0.2631) and individual fruit weight (0.2565). It had a high positive genotypic correlation with yield (0.5864).

The direct effect of number of secondary branches on yield was positive (0.0707). It had high positive indirect effect on yield via number of fruits per plant (0.3515) and individual fruit weight (0.2858). It had a high positive genotypic correlation with yield (0.7183).

Number of fruits per plant showed high positive direct effect on yield (0.3924). Its indirect effects on yield via other characters were positive except for number of primary branches. It had a high positive genotypic correlation with yield (0.8064).

Fruit length had positive direct effect on yield (0.1264). It had high positive indirect effect on yield via individual fruit weight (0.3766) and it showed high positive genotypic correlation with yield (0.5733).

Fruit width had positive direct effect on yield (0.0238). Its indirect effects on yield was positive and high via individual fruit weight (0.4074). It had high positive genotypic correlation with yield (0.7324).

Table 12. Path coefficient analysis (direct diagonal / indirect off diagonal)

Characters	Number of days to first flowering	Number of primary branches	Number of secondary branches	Number of fruits per plant	Average fruit length (cm)	Average fruit width (cm)	Individual fruit weight (g)	Plant height (cm)	Incidence of leaf curl disease (V.I)	Genotypic correlation co-efficiencies
Number of days to first flowering	**0.0526**	-0.0179	0.0324	0.0677	0.0254	0.0118	0.1968	0.0244	0.0226	0.4160
Number of primary branches	0.0129	**-0.0730**	0.0453	0.2631	0.0178	0.0070	0.2565	0.0360	0.0207	0.5864
Number of secondary branches	0.0241	-0.0469	**0.0707**	0.3515	-0.0185	0.0086	0.2858	0.0218	0.0211	0.7183
Number of fruits per plant	0.0091	-0.0490	0.0633	**0.3924**	0.0079	0.0084	0.3311	0.0256	0.0177	0.8064
Average fruit length (cm)	0.0106	-0.0103	-0.0103	0.0244	**0.1264**	0.0155	0.3766	0.0287	0.0119	0.5733
Average fruit width (cm)	0.0260	-0.0214	0.0256	0.1383	0.0820	**0.0238**	0.4074	0.0322	0.0186	0.7324
Individual fruit weight (g)	0.0197	-0.0357	0.0385	0.2479	0.0908	0.0185	**0.5241**	0.0359	0.0211	0.9610
Plant height (cm)	0.0275	-0.0563	0.0330	0.2152	0.0776	0.0165	0.4034	**0.0467**	0.0221	0.7856
Incidence of leaf curl disease (V.I)	-0.0417	0.0529	-0.0522	-0.2425	-0.0526	-0.0155	-0.3879	-0.0362	**-0.0286**	-0.8042
Residual effect (R)	0.0237									

The direct effect of individual fruit weight on yield was very high and positive (0.5241). It had high positive indirect effect on yield via number of fruits per plant (0.2479). Its genotypic correlation with yield was positive and very high (0.9610).

The direct effect of plant height on fruit yield was positive (0.0467). Its genotypic correlation with yield was positive and high (0.7856). Its indirect effect via other characters was low except for number of fruits per plant (0.2152).

The direct effect of incidence of leaf curl disease on yield was negative but very low (-0.0286) and its genotypic correlation with yield was also negative (-0.8042). Its indirect effects on yield were negative except for number of primary branches (0.0529).

The residual effect obtained was 0.0237.

Plate 5. Selected superior bird chilli genotypes

VANDITHADAM-I

KAKKAMOOLA-IX

KOTTAKKAL-IV

KOZHENCHERI

KUMARAPURAM-I

KUMARAPURAM-II

THAMALLAKKAL

KALITTHATU

CHAPPANANGADI-III

NARIKKUNI-II

Discussion

5. DISCUSSION

Chilli is an important vegetable or spice crop of India and it is consumed both in unripe (green) and ripe (red) forms. Bird chilli (*Capsicum frutescens* L.) is a stimulating herb renowned for aroma, taste, flavour and pungency which is due to an alkaloid "capsaicin" present in the pericarp and placenta of fruits. Bird chilli is Kerala's "kanthari mulaku" and it possesses many medicinal values. Leaf curl is considered to be one of the major limiting factors in production of chilli and causes considerable yield loss up to 50 percentage. Bird chilli has been reported to possess multiple disease resistance and this property can be utilised to develop leaf curl disease resistant or tolerant genotypes.

The present investigation was conducted at Department of Plant Breeding and Genetics, College of Agriculture, Vellayani to identify the genotypes for yield and resistance to leaf curl in bird chilli (*Capsicum frutescens* L.) through evaluation by growing along with susceptible varieties and also to study the genetic divergence, variability and character association among the genotypes under field evaluation.

The experimental results are discussed under different headings

5.1 EXPERIMENT I

5.1.1 Evaluation of genotypes for yield and leaf curl resistance

5.1.1.1 Mean performance of accessions

There was remarkable difference among the accessions for number of days to first flowering with a range of 95.6 to 133.2. The number of primary branches showed a considerable amount of variation among the genotypes ranging between 5.5 and 15.8 and number of secondary branches also showed a considerable variation. It ranged between 12.5 and 45.2. Average fruit length and average fruit width also showed considerable variation among the genotypes. Individual fruit weight, fruit yield per plant, number of seeds per fruit and plant height showed an impressive variation among the genotypes. Such variation for these characters were in accordance with the earlier reports of Mathew (2006) and Anandhi (2010).

Vulnerability index calculated on the basis of disease scoring showed a range of 0 to 98.2. Among the seventy eight accessions one accession was found to be resistant, thirteen accessions were found to be tolerant, nine accessions were found to be susceptible and fifty five accessions were found to be highly susceptible. The resistant accession can be utilized to develop resistant variety through crop improvement programme. These findings were supported by Mathew (2006). There was a range of difference among the accessions for number of white flies per plant (0.11 to 2.31), number of thrips per leaf (0.12 to 4.62), number of mites per leaf (0.93 to 5.88) as reported by Mathew (2006) and Jayaramegouda (2009).

5.1.1.2 Genetic divergence analysis

A clear cut understanding of the extent of variability prevalent for each of the characters indicates the scope for improving the character studied, through selection. But in a hybridization programme, where in, selection of diverse parents to get better heterosis is done, not only the estimates of variability will suffice, but also the knowledge of genetic diversity among the genotypes is necessary. For population improvement also, diverse parents which can be selected based on the genetic diversity among the genotypes are needed. Therefore, in the present study information on genetic diversity present in the seventy eight genotypes of bird chilli was analysed.

Seventy eight genotypes were grouped into nine clusters. Out of the nine clusters, cluster II was the largest one comprising of twenty four genotypes followed by cluster IV with 13 genotypes, cluster I with 11 genotypes, cluster V with 9 genotypes, cluster IX with 8 genotypes, cluster VI with 7 genotypes, cluster VII with 3 genotypes, cluster VIII with 2 genotypes and cluster III with 1 genotype, indicating high degree of heterogeneity among the genotypes. This was supported by Yatung *et al*. (2014) in a study of genetic diversity in 30 chilli genotypes which were grouped into 6 clusters. Hasan *et al*. (2014) also reported that 54 chilli genotypes studied were fallen into seven clusters. Since there is a high variability in *Capsicum spp*, the selection of genotypes for hybridization should be based on genetic divergence rather than geographical diversity.

Cluster VIII had the maximum cluster means for fruit yield per plant, followed by number of fruits per plant, plant height, number of days to first flowering, number of secondary branches, number of primary branches, average fruit length , average fruit width and individual fruit weight. The genotypes in cluster V exhibited the lowest number of days to first flowering while those in cluster VIII exhibited the highest. Similar results were also reported by Thul *et al.* (2009), Farhad *et al*. (2010) and Kumari *et al*. (2010). The maximum number of primary branches per plant was observed in cluster VIII and the minimum number was in cluster VI. The highest number of secondary branches per plant was recorded for cluster VIII and the lowest for cluster IV. The maximum number of fruit per plant was recorded in cluster VIII and the minimum was in clusters IV. Fruit length varied from 7.50 in cluster VIII to 3.00 in cluster III. The maximum fruit width was observed in cluster VIII and the minimum was in cluster IV. The highest individual fruit weight was observed for cluster VIII and the lowest was in cluster V. The maximum fruit yield per plant was reported in cluster VIII while cluster II reported the minimum. This was supported by the findings of Datta and Jana (2011), Hasanuzzaman and Golam (2011) and Yatung *et al*. (2014). The maximum number of seeds per fruit was shown by cluster I and the minimum by cluster III. Cluster VIII reported the maximum plant height while cluster VI exhibited the minimum. The highest and lowest incidence of leaf curl disease was recorded for cluster IV and VIII respectively. Cluster VII recorded highest number of white flies per plant while cluster VIII recorded the lowest. Similar results were reported by Senapati *et al*. (2003) and Mathew (2006). Cluster VII had highest number of thrips per leaf while those in cluster VIII exhibited the lowest. The highest number of mites per leaf was observed for cluster VI and the lowest for cluster VIII. The results suggested that selection of genotypes having high values for a particular trait can be made and used in the hybridization programme for improvement of that character (Lahbib *et al*., 2013, Yatung *et al.*, 2014, and Hasan *et al*., 2014).

Maximum contribution towards genetic divergence was noticed for fruit yield per plant. These finding were reinforced by earlier reports of Hasanuzzaman and Golam (2011) and Hasan *et al*. (2014).

5.2 EXPERIMENT II

5.2.1 Confirmation study

5.2.1.1 Variability

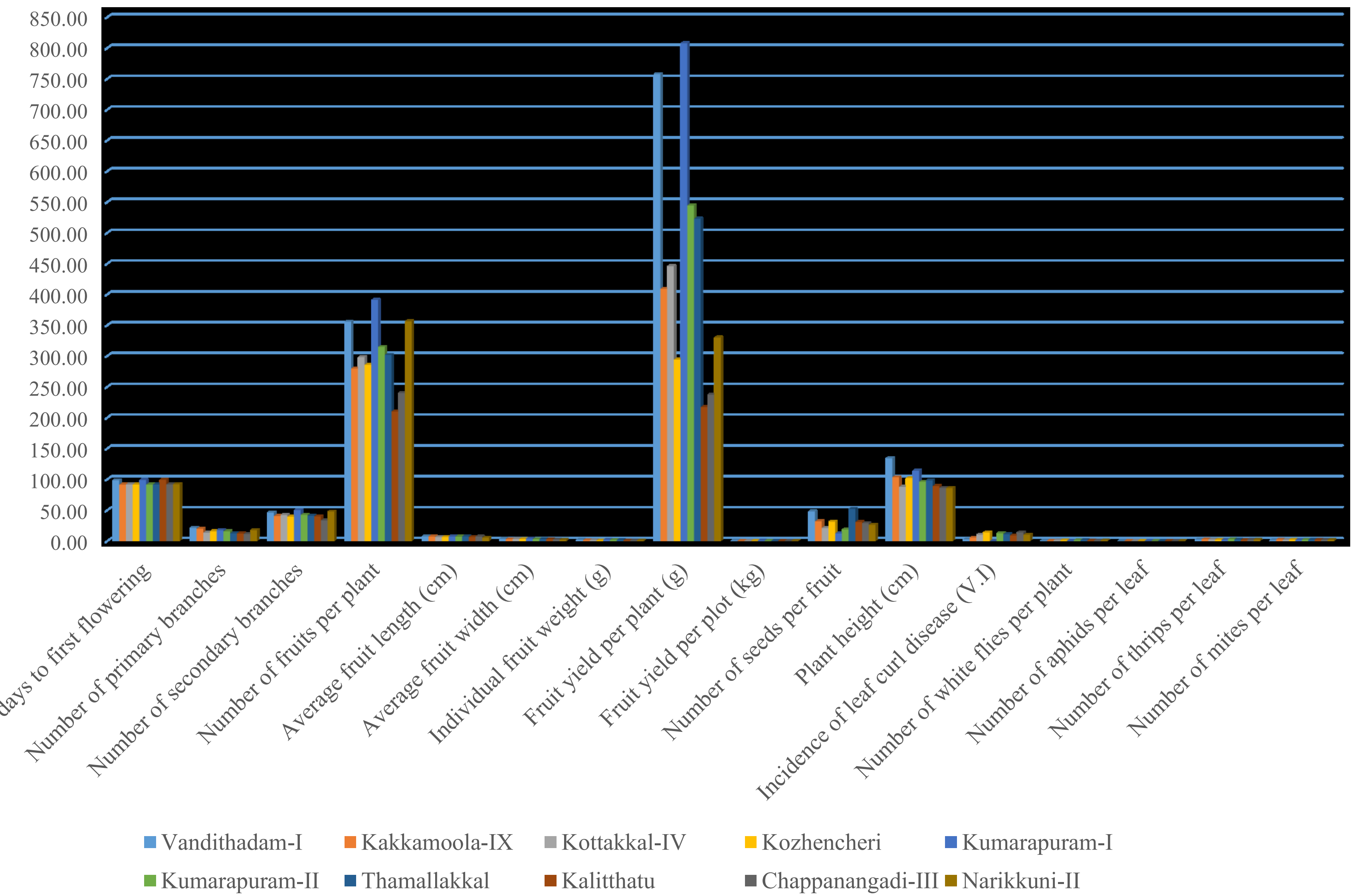
The phenotypic variation present in a population with respect to yield and morphological characters gives the basic idea of the extent of variability.

In the present investigation, all the 17 characters under study showed a wide range of variation. This was supported by the findings of Gogi and Goutam (2002), Rathod *et al*. (2002), Acharya *et al.* (2002), Nandadevi and Hosamani (2003a), Prabhudeva (2003), Sreelathakumary and Rajamony (2003b), Reddy *et al.* (2006), Ukkund *et al*. (2007), Pandit and Adhikary (2014) and Amit *et al*. (2014).

Incidence of leaf curl disease and fruit yield per plant showed the greatest range of variation followed by number of fruits per plant, plant height and number of seeds per fruit (Fig 2). This was in accordance with Munishi and Behara (2000), Mishra *et al*. (2001), Khurana *et al.* (2003), Gupta *et al*. (2009), Singh and Singh (2011) and Idowu *et al*. (2012).

The genotype T5 (Kumarapuram-I) produced the highest yield per plant followed by T1 (Vandithadam-I), T6 (Kumarapuram-II), T7 (Thamallakkal), T3 (Kottakkal-IV), T2 (Kakkamoola-IX) and T10 (Narikkuni-II). T8 (Kalitthatu) produced the least yield per plant followed by T9 (Chappanangadi-III) and T4 (Kozhencheri).

Fig. 2. Mean performence of 10 selected genotypes



5.2.1.2. Coefficient of variation

Genetic improvement through conventional breeding approaches depends mainly on the availability of diverse germplasm and the amount of genetic variability present in the population for the desired characters. The genotypic coefficient of variation measures the range of variability available in the crop and also enables a breeder to compare the amount of variability present among different characters. The phenotypic expression of the character is the result of interaction between genotype and environment. Hence, the total variance should be partitioned into heritable and non heritable components to assess the true breeding nature of the particular trait under study.

In the present study there was close association between the estimates of PCV and GCV. High phenotypic and genotypic coefficients of variation were observed for incidence of leaf curl disease, fruit yield per plant and number of seeds per fruit. Similar results of high GCV and PCV values were reported by Manju and Sreelathakumary (2002), Nandadevi and Hosamani (2003a), Sreelathakumary and Rajamony (2003b), Mathew (2006), Reddy (2006), Gupta *et al.* (2009), Sharama *et al.* (2010), Anandhi (2010), Ullah *et al.* (2011) and Krishnamurthy (2013). The character, number of days to first flowering showed extremely low variance which is in conformity with the findings of Mathew (2006), Sandeep (2007) and Krishnamurthy (2013). Moderate phenotypic coefficient of variation was observed for number of fruits per plant, average fruit width, number of thrips per leaf, plant height, number of mites per leaf and number of secondary branches.

A major portion of PCV was contributed by GCV for most of the characters suggesting that the observed variation was mainly due to genetic factors. Genetic coefficient of variation and phenotypic coefficient of variations were closely in corresponding with each other for most of the characters. However comparatively low values of environmental coefficient of variation for all the characters indicated environment has less influence on these traits.

5.2.1.3 Heritability and genetic advance

Heritability indicates the relative degree at which a character is transmitted from parents to off-spring. High heritability values indicate that the characters under study are less influenced by environment in their expression. The traits exhibiting high heritability could be improved by adopting simple selection methods. Further, the information on genetic variation, heritability and genetic advance helps to predict the genetic gain that could be obtained in later generations.

High heritability (in broad sense) estimate was recorded for all the characters under study viz., number of seeds per fruit, fruit yield per plant, plant height, number of fruits per plant, average fruit width, individual fruit weight, fruit length, number of white flies per plant, number of days to first flowering, number of thrips per leaf, number of primary branches, number of mites per leaf, number of secondary branches and incidence of leaf curl disease. Genetic advance as per cent of mean were high for all the characters except number of days to first flowering and average fruit length for which it was low and moderate respectively.

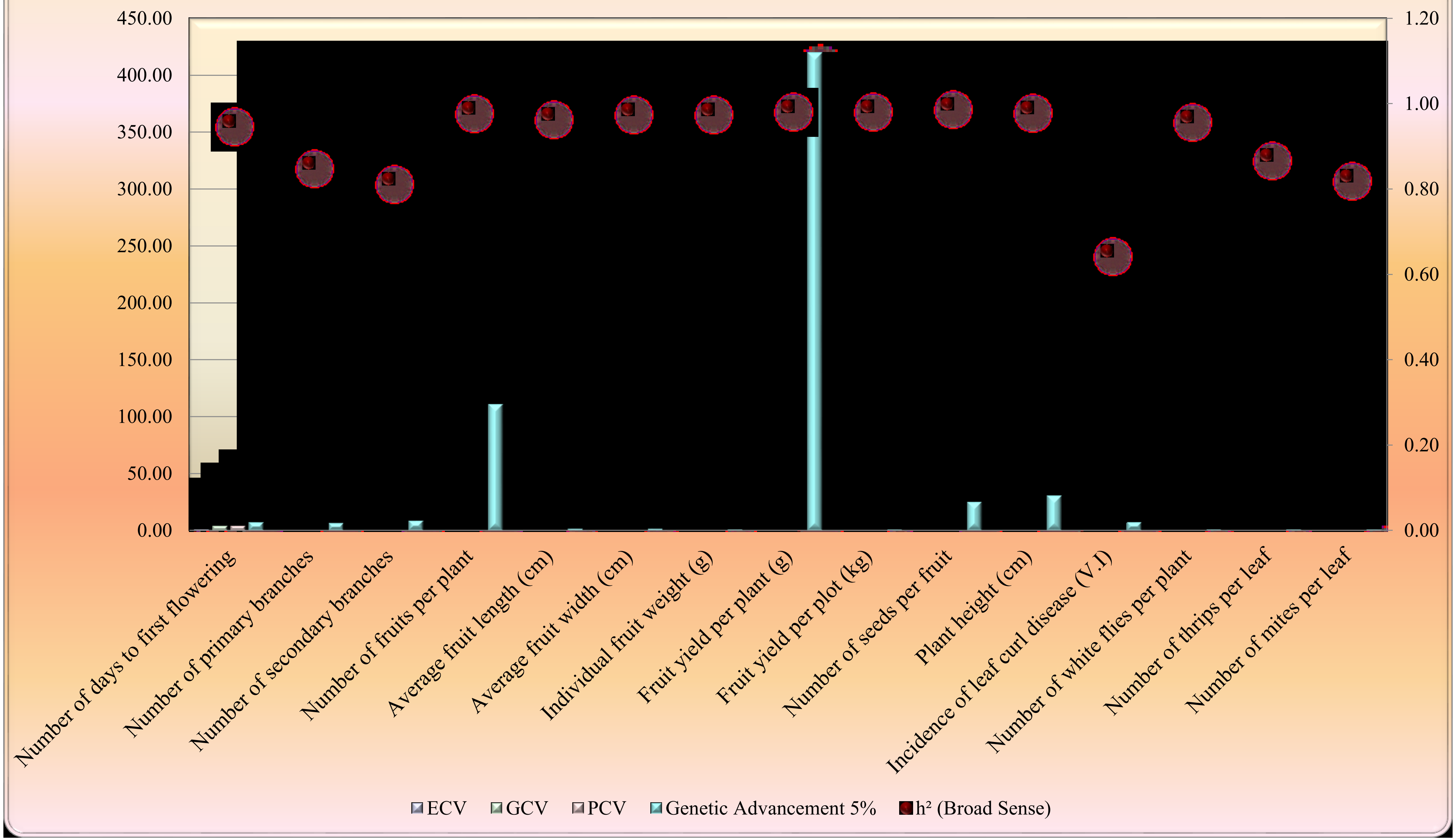
Many workers have reported high heritability coupled with high genetic advance for different characters in chilli. Mathew (2006) reported high heritability coupled with high genetic advance for all the 14 characters except days to first flowering, for which the genetic advance was moderate. Reddy (2006) noticed high heritability coupled with high genetic advance for number of fruits per plant, yield per plant and secondary branches per plant. Similar results were obtained by Bharadwaj *et al.* (2007) for number of fruits per plant, Sood *et al.* (2007) for capsaicin content and yield, Sarkar *et al*. (2009) for fruit weight, Gupta *et al*. (2009) for number of fruits per plant, fruit yield per plant, fruit length, fruit weight and capsaicin content and Sharma *et al*. (2009) for average fruit weight, fruit yield per plant, fruit diameter, number of lobes per fruit, number of days to first harvest, leaf area and ascorbic acid content.

High heritability along with high genetic advance in chilli was also noticed by Sharma *et al.* (2010) for average fruit weight, fruit yield per plant and fruit diameter, Kumari *et al.* (2010) for number of fruits plant, fresh fruit yield plant, seed weight, number of seeds per fruit, Anandhi (2010) for number of days to first flowering, duration of flowering, number of fruits per plant, green fruit yield per plant, number of seeds per fruit, duration of crop and vulnerability index, Sood *et al*. (2011) for number of fruits per plant and fruit yield per plant, Ullah *et al.* (2011) for fruit yield per plant, number of fruits per plant, plant height and days to 50% flowering, Krishnamurthy *et al.* (2013) for green fruit yield per plant and red fruit yield per plant, Amit *et al*. (2014) for plant height, number of fruits per plant, number of seeds per fruit, dry fruit yield and green fruit yield and Pandit and Adhikary (2014) for days to 50 per cent flowering, number of fruits per plant, number of seeds per plant and green fruit yield per plant.

Moderate genetic advance was expressed by average fruit length and low genetic advance was shown by number of days to first flowering in this study. These results were supported by Pandit and Adhikary (2014), as moderate genetic advance was observed for days to 50% flowering, placenta length, fruit length, number of fruits per plant and number of seeds per plant. Krishnamurthy *et al.* (2013) reported that fruit width, 100 seed weight, days to 50 per cent flowering, days to first fruit maturity, plant height and fruit length had high heritability coupled with low genetic advance and for number of fruits per plant high heritability was associated with moderate genetic advance.

In the present study high heritability values obtained for all the traits (Fig 3) indicated negligible influence of environment. High heritability coupled with high genetic advance indicates that the traits are controlled by additive gene action which makes selection very effective (Sharma *et al.,* 2010).

Fig. 3. Genetic parameters



5.2.1.4 Association of characters

5.2.1.4.1 Correlation coefficient analysis

A thorough understanding of the association of plant characters with yield and among themselves is essential for a successful crop improvement programme. It enables the breeders to manipulate the expression of these traits in crop improvement. The efficiency of selection for yield mainly depends on the direction and magnitude of association between yield and its components and among themselves. Estimation of correlations provides information on the nature and magnitude of the association of different component characters with fruit yield, which is regarded as a highly complex trait. It also helps us to understand the nature of inter relationships among the component traits themselves. Ultimately this kind of analysis helps to design selection strategies to improve fruit yield, which the breeder is ultimately interested in.

In the present investigation, a number of yield components were studied and their relationship with yield as well as among themselves was examined using correlation analysis.

Genotypic correlations in general are high as compared to their phenotypic correlations indicating strong inherent association between the characters which might be masked by modifying effects of environment.

High positive correlation was recorded for fruit yield per plant with individual fruit weight, number of fruits per plant, plant height, number of secondary branches, average fruit width, number of primary branches, fruit length and number of days to first flowering while it was significantly negative with incidence of leaf curl disease and number of mites per leaf.

Fruit yield per plant was negatively correlated with plant height in chilli (Aliyu *et al*., 2000). Munshi *et al*. (2000) reported positive association of yield with fruit weight and fruit number. Wyrzykowska *et al*. (2000) found that fruit yield depended significantly on mean fruit weight and number of fruits per plant in chilli. Fresh red chilli yield had significant positive association with number of fruits per plant, hundred seed weight and harvest index (Rathod *et al*., 2002). According to Acharya *et al*. (2002) total fresh yield per plant had positive effect and significant correlation with total dry yield per plant. Jose and Khader (2002) reported positive correlation of yield with fruit weight, number of fruits, primary branches per plant, secondary branches per plant, plant height, 100 seed weight, fruit length, fruit girth and crop duration and negative correlation with days to flowering. Sreelathakumary and Rajamony (2003a) reported that yield per plant showed highly significant positive correlation with number of fruits per plant, fruit length, fruit girth and fruit weight. Fruit yield was positively correlated with number of fruits, fruit length, fruit diameter, plant height, capsaicin content and colouring matter, but negatively correlated with number of days to flowering (Khurana *et al*., 2003).

Similar studies were reported by many scientists in chilli, as discussed here. Mathew (2006) reported that fruit yield per plant was positively correlated with number of fruit per plant, number of secondary branches, plant spread, 100-seed weight, number of primary branches, number of seeds per fruit, individual fruit weight, fruit length, fruit width and plant height and it was negatively correlated with vulnerability index. Reddy (2006) revealed that fruit yield per plant showed high positive genotypic correlation with number of fruits per plant, duration, length of fruit bearing period, plant canopy width and number of secondary branches. Ukkund *et al.* (2007) reported that early fruit yield and late fruit yield per plant had highly significant and positive correlation with total fruit yield. Yield per plant exhibited highly significant correlation with fruits per plant, branches per plant and height in chilli (Jabeen *et al*., 2009). According to Gupta *et al*. (2009) fruit yield per plant had positive and highly significant correlation with number of fruits per plant and fruit length. Jogi *et al*. (2013) revealed significant and positive phenotypic and genotypic association of fruit yield with all the characters except days to first flowering and fruit weight. Amit *et al*. (2014) reported fruit yield (green and red) per plant was positively and significantly correlated with number of fruits per plant and fruit length. All these findings are in agreement with the present results.

A highly positive significant correlation of days to first flowering suggested that early flowering genotypes would be an appropriate selection criterion to get early marketable fruit yield.

Number of days to first flowering showed significant positive correlation with plant height, fruit width, number of secondary branches, fruit yield per plant, and individual fruit weight. It had negative correlation with incidence of leaf curl disease, number of thrips per leaf, number of white flies per plant and number of mites per leaf. Contrary to this, Sreelathakumary and Rajamony (2003a) reported that number of days to first flowering was negatively correlated with number of fruits per plant. Negative association of number of days to first flowering with the characters studied and positive association with fruit length was reported by Muthuswamy (2004).

The number of branches showed significant positive correlation with yield and this can be justified by the fact that more number of branches provided more number of fruits.

Number of primary branches had negative correction with incidence of leaf curl disease, number of white flies per plant and number of mites per leaf while it was positive for rest of the characters. It showed high positive genotypic correlation with plant height, number of fruits per plant, number of secondary branches, fruit yield per plant and individual fruit weight. This was supported by the finding of Ibrahim *et al.* (2001). Number of secondary branches had the highest positive correlation with number of fruits per plant, followed by fruit yield per plant, number of primary branches, individual fruit weight and number of days to first flowering. The association was negative with incidence of leaf curl disease and number of mites per leaf. These characters were found to have significant positive correlation with yield and hence selection for these characters would indirectly increase the yield.

Number of fruits per plant had the highest positive correlation with number of secondary branches followed by fruit yield per plant, number of primary branches, individual fruit weight and plant height. It had negative correlation with number of mites per leaf and incidence of leaf curl disease. This was in accordance with the findings of Ibrahim *et al*. (2001) in which number of fruits per plant showed highly significant positive correlation with number of branches and plant height. Krishnamurthy *et al*. (2013) also observed that number of fruits per plant had positive correlation with green fruit and red fruit yield per plant. Selection on the basis of these traits may lead to higher yield.

Fruit length had the maximum positive phenotypic correlation with individual fruit weight, average fruit width, plant height and fruit yield per plant. It had significant negative correlation with incidence of leaf curl disease. Fruit width had strong positive correlation with individual fruit weight, fruit yield per plant, plant height, fruit length and number of days to first flowering. In agreement to this, Sreelathakumary and Rajamony (2003a) also reported that fruit length and fruit girth had significant positive correlation with fruit weight. The correlation was strong and negative with incidence of leaf curl disease and number of mites per leaf.

Individual fruit weight had strong and positive correlation with fruit yield per plant, fruit width, plant height, fruit length, number of fruits per plant, number of secondary branches, number of primary branches and number of days to first flowering. The value was strong and negative with incidence of leaf curl disease and number of mites per leaf. This was supported by the results of Munshi *et al*. (2000) and Chatterjee *et al*. (2001).

Number of seeds per fruit had no significant values, but positive was correlated with plant height and fruit length. It was negative with number of secondary branches and number of fruits per plant. However, according to

Chatterjee *et al*. (2001) number of seeds per fruit and 1000 seed weight showed positively significant association with fruit yield.

Plant height had positive correlation with all the characters except incidence of leaf curl disease, number of mites per leaf, number of white flies per plant and number of thrips per leaf. High positive correlation was obtained for fruit yield per plant, number of primary branches, individual fruit weight, fruit width, fruit length, number of fruits per plant, number of days to first flowering and number of secondary branches. Significant association of plant height with yield could be justified by the fact that there was more number of branches per plant which led to increased number of fruits.

Number of white flies per plant had negative phenotypic correlation with most of the characters while it was significantly positive with incidence of leaf curl disease. Number of thrips per leaf had significant negative correlation with days to first flowering while it was not significantly positive with other characters. Number of mites per leaf had negatively significant correlation with fruit yield per plant, plant height, number of fruits per plant, individual fruit weight, days to first flowering, number of secondary branches and fruit width. The correlation was significantly positive with incidence of leaf curl disease. Incidence of leaf curl disease had negative phenotypic correlation with most of the characters. The genotypic correlation was significantly positive with number of white flies per plant and number of mites per leaf. This was in accordance with the results of Mathew (2006). This clearly indicates that increased incidence of these pests and disease parameters leads to significant reduction in yield.

5.2.1.5 Path coefficient analysis

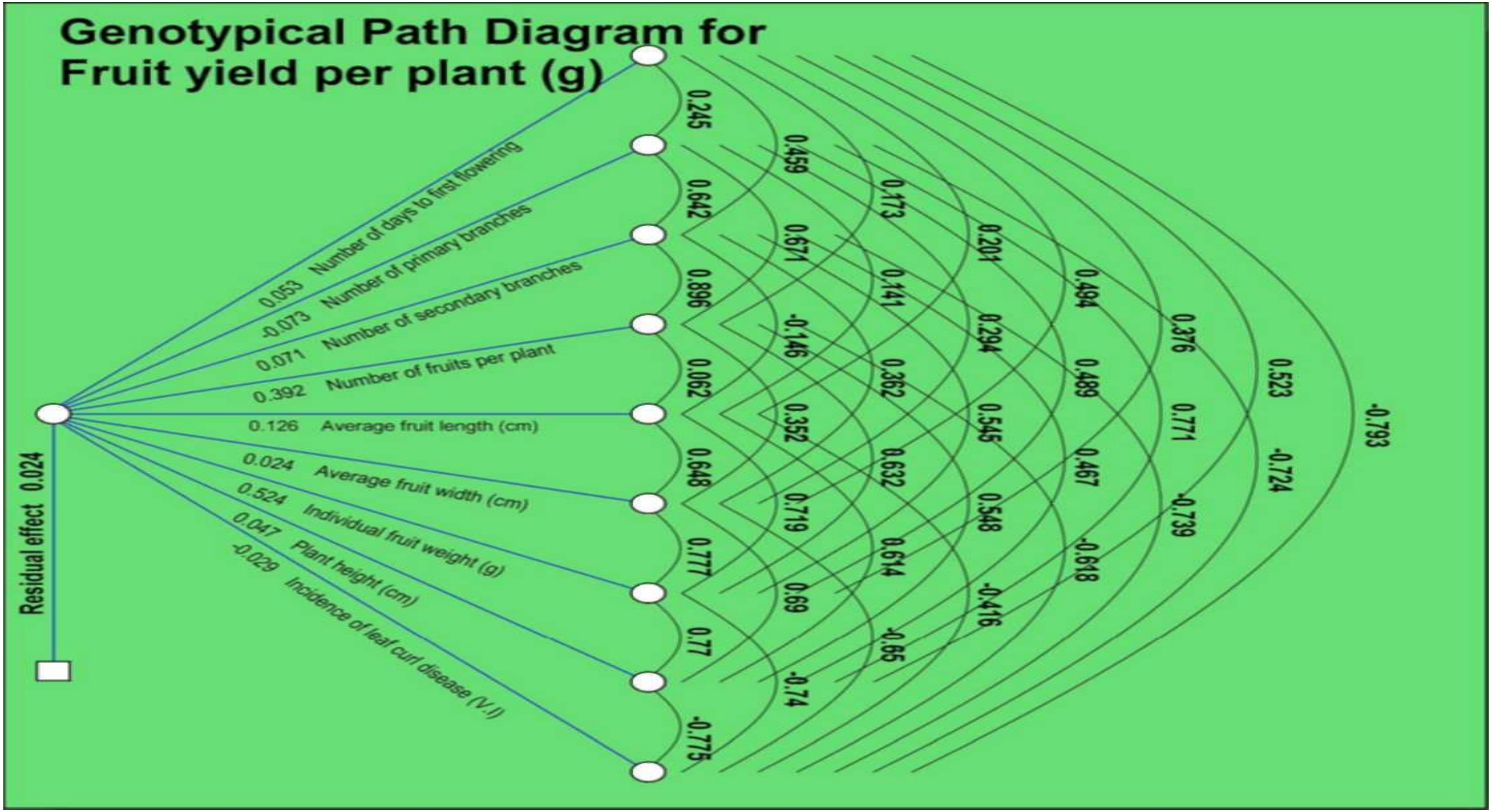
The association of different component characters among themselves and with yield is quite important for making an efficient selection criterion for yield. The total correlation between yield and its component characters may sometimes be misleading, as it might be an over-estimate or under-estimate because of its association with other characters which are also associated with economic yield. Hence, indirect selection by correlated response may sometimes not be fruitful. When many characters are effecting a given character, splitting the total correlation into direct and indirect effects based on association between the dependent variable like yield and independent variables like yield components could be beneficial. This kind of information will help in making the basis of selection more meaningful for breeding programme.

In the present study, number of primary branches and incidence of leaf curl disease had negative direct effect on yield, while the other characters viz., number of days to first flowering, number of secondary branches, number of fruits per plant, average fruit length, average fruit width, individual fruit weight and plant height had positive direct effect (Fig 4), emphasizing the importance of these characters in bird chilli improvement.

Individual fruit weight and number of fruits per plant had high positive genotypic correlation with yield and it showed high positive direct effect on yield. Hence direct selection for individual fruit weight and number of fruits per plant would effectively improve the fruit yield per plant. This was supported by Munshi *et al*. (2000), Jose and Khader (2002), Sreelathakumary and Rajamony (2003a), Mini (2003), Ajith (2004), Mathew (2006), Reddy (2006), Sharma *et al*. (2010), Ullah *et al*. (2011), Chattopadhyay *et al*. (2011), Krishnamurthy *et al*. (2013) and Pandit and Adhikary (2014).

Number of days to first flowering had a positive direct effect on yield and its indirect effect on yield via individual fruit weight was positive and high. Its genotypic correlation with yield was high and positive which was supported by Ullah *et al.* (2011). Sreelathakumary and Rajamony (2003a) revealed that number of days to first flowering had negative direct effect on yield and Ajjapplavara *et al*. (2005) reported that number of days to 50 per cent flowering showed a negative direct effect on yield in chilli.

Fig. 4. Path diagram showing direct and indirect effects of various characters



Fruit length exhibited positive direct effect on yield and it also had positive genotypic correlation with yield. This was in accordance with the report of Sreelathakumary and Rajamony (2003a), Ajjapplavara *et al*. (2005), Chattopadhyay *et al*. (2011), Ullah *et al.* (2001) and Krishnamurthy *et al*. (2013) in chilli.

The direct effect of individual fruit weight on yield was high and positive. Its genotypic correlation with yield was also high. Its indirect effects on yield via other characters were positive in chilli. This was supported by the finding of Munshi *et al*. (2000), Mini (2003) and Mathew (2006) in chilli.

The direct effect of plant height on fruit yield was positive. Its genotypic correlation with yield was positive and high. Its indirect effect via other characters was low and included both positive and negative values. Sreelathakumary and Rajamony (2003a) also observed positive direct effect on yield; Aliyu *et al*. (2000) reported that plant height had a negative direct contribution to final yield and Mini (2003) found high negative direct effect on yield in chilli.

Fruit width had positive direct effect on yield and its genotypic correlation with yield was also positive. This was supported by the findings of Aliyu *et al*. (2000), Munshi *et al*. (2000) and Krishnamurthy *et al*. (2013) in chilli.

Incidence of leaf curl disease had negative correlation with yield. So selection should be done against susceptibility of the plant to disease.

Low magnitude of residual effect of genotypic level indicated that traits included in the present investigation accounted for most of the variation present in the dependent variable. Jose and Khader (2002) and Chattopadhyay *et al*. (2011) also observed low residual value in their studies in chilli.

Based on correlation and path analysis studies, it could be concluded that selection for high individual fruit weight, number of fruits per plant and high fruit length might lead to increase in yield. Similarly, selection for lesser incidence of leaf curl disease also could be useful in the improvement of *Capsicum frutescens*.

Summary

6. SUMMARY

The present project entitled “Evaluation of genotypes for yield and resistance to leaf curl in bird chilli (*Capsicum frutescens* L.)" was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, Thiruvananthapuram during 2013-2015 with an objective of to identify high yielding genotypes of bird chilli resistant to leaf curl. The study was carried out and data collected from the two field experiments.

In the first experiment, 78 accessions of bird chilli collected from different parts of Kerala were evaluated in the field for yield and resistance to leaf curl. Observations were recorded on 17 characters viz., number of days to first flowering, number of primary branches per plant, number of secondary branches per plant, number of fruits per plant, average fruit length, average fruit width, individual fruit weight, fruit yield per plant, number of seeds per fruit, plant height, leaf pubescence, incidence of leaf curl disease (vulnerability index calculated on the basis of leaf curl disease scoring), number of white flies per plant, number of aphids per plant, number of thrips per leaf, number of mites per leaf.

The important findings from the experiment I are summarized below.

The accession 04 (Vandithadam-I) showed highest mean values with respect to number of primary branches, number of secondary branches, fruit length, plant height and lowest number of white flies per plant and categorised as tolerant to leaf curl. The accession 24 (Kakkamoola-IX) has taken lowest number of days to first flowering. The number of thrips per leaf and number of mites per leaf had lowest mean values for accession 28 (Kottakkal-IV) and accession 38 (Palakkad I) respectively. The accession 50 (Kumarapuram-I) showed highest mean values for number of fruits per plant, average fruit length, average fruit width and fruit yield per plant and it had zero vulnerability index *i.e.* resistance to leaf curl. The accession 43 (Sreekurumbakkavu-IV) and accession 51 (Kanjikuzhi) had highest mean values for individual fruit weight and accession 55 (Thamallakkal) showed highest mean

value for number of seeds per fruit.

Genetic divergence analysis was carried out and the 78 accessions were grouped into nine clusters. Out of the nine clusters, cluster II was the largest one comprising of twenty four genotypes. Maximum contribution towards genetic divergence was noticed for fruit yield per plant. Cluster VIII had the maximum cluster means for fruit yield per plant, followed by number of fruits per plant, plant height and number of days to first flowering. Hence genetic divergence existing in the population helps in the selection of suitable parents for utilization in crop breeding programme.

In experiment II, leaf curl of 10 bird chilli genotypes (*Capsicum frutescens* L.) were ensured artificially by growing susceptible varieties of *C. annuum* in a field experiment in Randomised Block Design with three replications.

Significant differences among the genotypes for all the 17 characters studied indicated high variability among genotypes. Kumarapuram-I was the highest yielder followed by Vandithadam-I, Kumarapuram-II, Thamallakkal, Kottakkal-IV and Kakkamoola-IX while the lowest yielder was Kalitthatu.

The genotypic variance values were close to the phenotypic variances for almost all the characters, suggesting the predominance of genetic component over environmental effect.

Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) also showed a similar trend. A major portion of PCV was contributed by GCV for characters. Highest estimate of phenotypic and genotypic coefficient of variation were recorded for incidence of leaf curl disease and fruit yield per plant. Except number of days to first flowering and average fruit length all the other characters studied exhibited moderate to high PCV and GCV.

High heritability coupled with high genetic advance exhibited for all the traits except days to first flowering and average fruit length suggested additive gene action for these traits.

Correlation analysis indicated that most of the character combinations had higher genotypic correlation coefficient than phenotypic correlation coefficient while environmental correlation coefficients were the lowest. High positive correlation was recorded for fruit yield per plant with individual fruit weight, number of fruits per plant, plant height, number of secondary branches, average fruit width, number of primary branches, fruit length and number of days to first flowering while significant negative correlation was observed with incidence of leaf curl disease and number of mites per leaf.

Path coefficient analysis explained that individual fruit weight and number of fruits per plant had high positive direct effect on fruit yield per plant while having low negative direct effects with number of primary branches and incidence of leaf curl disease. The low residual value (0.0237) indicated that the traits included in the present investigation accounted for most of the variation present in the dependent variable. The genotype T5 (Kumarapuram-I) was ranked first with respect to yield and resistance to leaf curl and this can be developed as a superior bird chilli variety.

References

7. REFERENCES

Acharya, P., Joshi, A. K. and Rajput, C. B. S. 2002. Studies on variability and character association for different traits in six generations of the cross 'LCA 301 x Punjab Lal' (*Capsicum annuum* L.) under two environments with respect to leaf curl complex. *Capsicum Eggplant Newsl.* 21: 60-63.

Ahmed, N., Bhat, M. A., Tanki, M. I. and Singh, A. K. 2006. Correlation and path analysis in paprika (*Capsicum annuum* L.). *Indian J. Hortic.* 63 (1): 92-95.

Ajith, P. M. 2004. Genetic analysis of yield and resistance to anthracnose in chilli (*Capsicum annuum* L.) Ph.D. Thesis, Kerala Agricultural University, Thrissur, 157p.

Ajjapplavara, P. S., Patil, S. S., Hosamani, R. M., Patil, A. A. and Gangaprasad, S. 2005. Correlation and path coefficient analysis in chilli. *Karnataka J. Agric. Sci.* 18 (3): 748-751.

Aliyu, L., Ahmed, M. K. and Magaji, M. D. 2000. Correlation and multiple regression analysis between morphological characters and components of yield in pepper (*Capsicum annuum* L.). *Crop Res*. 19: 318-323.

Allard, R. W. 1960. *Principles of Plant Breeding*. John Wiley & Sons, New York, 485p.

Amit, K., Ahad, I., Kumar, V. and Thakur, S. 2014. Genetic variability and correlation studies for growth and yield characters in chilli (*Capsicum annuum* L.). *J. Spices and Aromat. Crops* 23 (2): 170-177.

Anandhi, K. 2010. Genetic analysis of yield and leaf curl virus resistance in chilli (*Capsicum spp.*). Ph.D. Thesis, Kerala Agricultural University, Thrissur, 148p.

Ashfaq, M., Iqbal, S., Mukhtar, T. and Shah, H. 2014. Screening for resistance to cucumber mosaic Cucumovirus in chilli pepper. *The J. Anim. and Plant Sci.* 24 (3): 791-795.

Babu, B. S., Pandravada, S. R., Reddy, K. J., Varaprasad, K. S. and Sreekanth, M. 2002. Field screening of pepper germplasm for source of resistance against leaf curl caused by thrips (*Scirtothrips dorsalis* Hood) and mites (*Polyphagotarsonemus latus* Banks). *Indian J. Plant Prot.* 30 (1): 7-12.

Baruah, S. J. N. and Baruah, M. 2004. Bird's eye chilli-a forex earner for North East. *Spice India* 17 (4): 40-43.

Bendale, V. W., Palsuledesai, M. R., Bhave, S. G., Sawant, S. S. and Desai, S. S. 2006. Genetic evaluation of some economic traits in chilli (*Capsicum annuum* L.) in Konkan region of Maharashtra. *Crop Res.* 31: 401-403.

Bharadwaj, D. N., Singh, S. K. and Singh, H. L. 2007. Genetic variability and association of component characters for yield in chilli. *Int. J. Plant Sci.* 2: 93-96.

Bos, L. 1982. Crop losses caused by viruses. *Adv. Virus Res*. 2: 31-57.

Bosland, P. W. 1994. Chiles: history, cultivation, and uses. In*:* G. Charalambous, ed., Spices, Herbs and Edible Fungi. *Developments in Food Science*. pp. 347-366.

Bosland, P. W., and E. J. Votava. 2000. Peppers: Vegetable and spice capsicums. Crop production science in horticulture 12. CAB International Publishing, Wallingford, England, U. K. 204 p.

Burton, G. W. 1952 .Quantitative inheritance in grasses. *Proc. Int. Grassl. Cong.* 6: 227-283.

Chaim, A. B. and Paran, I. 2000. Genetic analysis of quantitative traits in pepper (*Capsicum annuum* L.). *J. Am. Soc. Hortic. Sci*. 125: 66-70.

Chatterjee, R., Kohli, U. K. and Chatterjee, R. 2001. Correlation and path coefficient analysis in bell pepper (*Capsicum annuum* L.). *Hortic. J.* 14: 51-55.

Chattopadhyay, A., Sharangi, A. B., Dai, N. and Dutta, S. 2011. Diversity of genetic resources and genetic association analyses of green and dry chillies of Eastern India*. Chilean. J. Agric. Res.* 71 (3): 350-356.

Darwin, C. 1859. *The origin of species*. Wolfe and Company, London.

Datta, S. and. Jana, J. C. 2011. Studies on genetic divergence in chilli *(Capsicum spp*.) under sub Himalayan tracts of West Bengal. *J. Crop and Weed* 7 (1): 44-48.

Desai, H. R., Bhandania, K. A., Patel, A. J., Patel, M. B. and Rai, A. B. 2006. Screening of chilli varieties for resistance to yellow mite, *Polyphagotarsonemus latus* (Banks) in south Gujarat. *Pest Manag. Hortic. Ecosyst.*12: 55-62.

Dewey, D. R. and Lu, K. H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J*. 51: 515-518.

Echer, M. M., Fernandes, M. C. N., Ribeiro, R. I. D. and Peracchi, A. L. 2002. Evaluation of Capsicum genotypes for resistance to the broad mite. *Horticultura Brasileira* 20 (2): 217-221.

Falconer, D. S. 1964. Introduction to quantitative genetics. Longmann, London and New York pp. 294-300.

Farhad, M., Hasanuzzaman, M., Biswas, B. K., Arifuzzaman, M. and Islam, M. M. 2010. Genetic divergence in chilli (*Capsicum annuum* L.). *Bangladesh Res. Publ. J.* 3 (3): 1045-1051.

Gogoi, D. and Gautam, B. P. 2002. Variability, heritability and genetic advance in chilli. *Agric. Sci. Digest* 22: 102-104.

Green, S. K. and Kim, J. S. 1991. Characteristics and control of viruses infecting peppers: a literature review. *Asian Veg. Res. and Dev. Cent., Tech. Bull.* No. 18.

Grube, R. C., Yiping, Z., Murphy, J. F., Loaiza-Figueoa, F., Lackney, V. K., Provvidenti, R. and Jain, M. K. 2000. New source of resistance to cucumber mosaic virus in *Capsicum frutescens*. *Plant Dis*. 84: 885-891.

Gupta, A. M., Singh, D. and Kumar, A. 2009. Genetic variability, genetic advance and correlation in chilli (*Capsicum annuum*). *Indian J. of Agric. Sci.* 79 (3): 221-223.

Hasan, M. J., Kulsum, M. U., Ullah, M. Z., Hossain, M. M. and Mahmud, M. E. 2014. Genetic diversity of some chili (*Capsicum annuum* L.) genotypes. *Int. J. Agric. Res. Innovation and Technol*. 4 (1): 32-35.

Hasanuzzaman, M. and Golam, F. 2011. Selection of parents in chilli (*Capsicum annuum* L.) *Int. J. Sustain. Crop Prod.* 6 (1): 63-75.

Hidayat, S. H., Opriana, E., Manzila, I. and Sujiprihati, S. 2012. Occurrence of chilli veinal mottle virus (ChiVMV) in Indonesia and response of chilli germplasms to chivmv infection. *J. ISSAAS.* 18: 55-61.

Huxley, J. 1955 Morphism and evolution. *Heredity* 9: 1-62.

Ibrahim, M., Ganiger, V. M., and Yenjerappa, S. T. 2001. Genetic variability, heritability, genetic advance and correlation studies in chilli. *Karnataka J. Agric. Sci.* 14: 784-787.

Idowu, A., Ogunniyan, D. J. and. Ajayi, E. O. 2012. Flowering and fruiting behaviour of long cayenne pepper (*Capsicum frutescens* L.) *Int. J. Plant Breed. and Genet.* 6 (4): 228-237.

Jabeen, N., Sofi, P. V. and Wani, S. A. 2009. Characteer association in chilli (*Capsicum annuum* L.). *Revista UDO Agricola* 9 (3): 487-490.

Jadhav, M. G., Dhumal, S. A., Burli, A. V. and Moro, S. M. 2000. Phule sai (GCH-8) a new rainfed chilli variety. *J. Maharashtra Agric. Univ.* 25: 110-112.

Jain, J. P. 1982. *Statistical Techniques in Quantitative Genetics*. Tata Mc Graw Hill Publishing Company, New Delhi, p.103.

Jayaramegowda, R. 2009. Breeding for yield and resistance to chilli thrips (*Scirtothrips dorsalis* Hood) and yellow mite (*Polyphagotarsonemus latus* Banks) in chilli (*Capsicum annuum* L.). M. Sc. (Ag.) Thesis, Kerala Agricultural University, Thrissur, 121p.

Jogi, Y. M., Madalageri, M. B., Ganiger, V. M., Bhuvaneswari, G., Patil, H. B. and Kotikal, Y. K. 2013. Character association and path analysis studies in green chilli (*Capsicum annuum* L.*) Int. J. Agric. Sci.* 9 (2): 547-550.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. 1955. Estimation of genetic and environmental variability in soybean. *Agric. J.* 47: 314-318.

Jose, Khader, K. M. A. and Jose, L. 2003. Screening for leaf curl virus (*Capsicum annuum*). *Plant Dis. Res*., 18 (1): 48-51.

Jose, L. and Khader, K. M. A. 2002. Correlation and path coefficient analysis in chilli (*Capsicum annuum* L.). *Capsicum and Eggplant Newsl.* 21: 56-59.

Julia, Y. S., Tyagi, W., Pandey, A., Meetei, N. T. and Rai, M. 2012. Evaluation of genetic diversity of chilli landraces from North Eastern India based on morphology, SSR markers and the pun1 locus. *Plant Mol. Biol. Rep.* 30 (6): 1470-479.

Kalaiyarasan, S., Sathiyananthan, V. K. R., Geetha, C. and Muthusamy, M. 2002. Screening of different chilli accessions against thrips, *Scirtothrips dorsalis* (Hood.). *South Indian Hortic.* 50 (4/6): 613-615.

Kallu, P. J. A. and Ravindran, P. N. 2004. Chilli varieties for higher yield. *Spice India.* 17: 2-8.

Kang, J. Y. 1992. The effect of chile ingestion of gastrointestinal mucosal proliferation and azoxymethane-induced cancer in the rat. *J. Gastroenterology-Hepatol*. 7 (2): 194-198.

Karad, S. R., Raikar, G. R. and Navale, P. A. 2002. Genetic divergence in chilli. *J. Maharashtra Agric. Univ.* 27: 143-145.

KAU [Kerala Agricultural University]. 2011. *Package of Practices Recommendations: Crops* (14th Ed.) Directorate of Extension, Kerala Agricultural University, Thrissur, pp. 180-181.

Khader, K. M. A., Anandhi, K., Umamaheshwaran, K. and Kumar, V. 2007. Response of bird pepper (*Capsicum frutescens* L.) genotypes to leaf curl virus. *Proc. XXI Int. Plant Prot. Cong.* 15-18 Oct. 2007. Glasgow. U. K. 714 -716.

Khalid, A., Rao, V. H., Rao, P. P. and Ahmed, K. 2001. Resistance in chilli cultivars to yellow mite, *Polyphagotarsonemus latus*. *Indian J. Agric. Res.,* 35 (2): 95-99.

Khurana, D. S., Singh, P. and Hundal, J. S. 2003. Studies on genetic diversity for growth yield and quality traits in chilli (*Capsicum annuum* L). *Indian J. Hortic*. 60: 277-282.

Konai, M. and Nariani, T. K. 1980. Reaction of different chilli varieties and *Capsicum spp*. to mosaic and leaf curl viruses. *Indian Phytopathol*. 33:155.

Krishnamurthy, S. L., Reddy, M. K. and Rao, M. A. 2013. Genetic variation, path and correlation analysis in crosses among Indian and Taiwan parents in chilli. *Veg. Sci.* 40 (2): 210-213.

Kumar, B. 2013. Indian Horticulture Database-2013, (eds). Mistry, N. C., Singh, B. and Gandhi, P. C. p. 6.

Kumar, S., Kumar, S., Singh, M., Singh, A. K. and Rai, M. 2006. Identification of host plant resistance to pepper leaf curl virus in chilli (*Capsicum* species). *Scientia Horticulturae*. 110: 359-361.

Kumari, S. S., Jyothi, K. U., Reddy, V. C., Srihari, D., Sankar, A. S. and Sankar, C. R. 2011. Character association in paprika (*Capsicum annuum* L.). *J. Spices and Aromat. Crops* 20 (1): 43-47.

Kumari, S. S., Uma, J. K., Srihari, D., Sankar, S. A. and Sankar, C. R. 2010. Variability and genetic divergence in paprika (*Capsicum annuum* L.). *J. Spices and Aromat. Crops.* 19 (1 and 2): 71-75.

Lahbib, K., Bnejdi, F. and Gazzah, M. E. 2013. Selection of pepper parent from a collection of *Capsicum annuum* landraces based on genetic diversity. *J. Plant Breed. and Crop Sci.* 5 (5): 68-72.

Mallapur, C. P. 2000. Screening of chilli genotypes against thrips and mites. *Insect Environ*. 5: 154-155.

Manju, P. R., and Sreelathakumary, I. 2002. Genetic Variability, Heritability and Genetic Advance in hot chilli *(Capsicum Chinense* Jacq.). *J. Trop. Agric.* 40: 4-6.

Mathew, N. 2006. Screening for leaf curl virus disease complex resistance, genetic evaluation and molecular characterization of bird chilli (*Capsicum frutescens* L.). M.Sc. (Ag.) Thesis, Kerala Agricultural University, Thrissur, 100p.

Meena, R., Patni, V. and Arora, D. K. 2006. An epidemic of chilli leaf curl disease in Rajasthan. *J. Phytopathol. Res.* 19: 335-336.

Mini, S. 2003. Genetic variability and characteristics in wax type chilli (*Capsicum annuum* L.). M.Sc. (Ag.) Thesis, Kerala Agricultural University, Thrissur, 65p.

Mishra, A., Sahu, S. S. and Mishra, P. K. 2001. Variability in fruit characters of chilli. *Orissa J. Hortic.* 29: 107-109

Moscone, E. A., Scaldaferro, M. A., Grabiele, M. and Cecchini, N. M. 2007. The evolution of chili peppers (*Capsicum*-Solanaceae): A cytogenetic perspective. VI International Solanaceae Conference: Genomics Meets Biodiversity. *Acta Hortic.* 745: 137-170.

Munshi, A. D. and Behera, T. K. 2000. Genetic variability, heritability and genetic advance for some traits in chilli (*Capsicum annuum* L.). *Veg. Sci*. 27: 39-41.

Munshi, A. D., Behra, T. K. and Singh, G. 2000. Correlation and path coefficient analysis in chilli. *Indian J. Hortic.* 57: 157-159.

Muthuswamy, A. 2004. Genetic analysis of yield and leaf curl virus resistance in chilli (*Capsicum annuum* L.). Ph.D. Thesis, Kerala Agricultural University, Thrissur, p.139.

Nandadevi, and Hosamani, R. M. 2003a. Variability, correlation and path analysis in Kharif grown chilli (*Capsicum annuum* L.) genotypes for different characters. *Capsicum Eggplant Newsl*. 22: 43-46.

Nandadevi, and Hosamani, R. M. 2003b. Estimation of heterosis, combining ability and *per se* performance in summer grown chilli (*Capsicum annuum L.)* for yield and resistance to leaf curl complex. *Capsicum Eggplant Newsl*. 22: 59-62.

Ortiza, R., Flor, D. F., Alvarado, G. and Crossa, J. 2010. Classifying vegetable genetic resources - A case study with domesticated *Capsicum spp*. *Scientia Horticulturae.* 126 (2) 186-191.

Pandit, M. K. and Adhikary, S. 2014. Variability and heritability estimates in some reproductive characters and yield in chilli (*Capsicum annuum* L.). *Int. J. Plant and Soil Sci.* 3 (7): 845-853.

Panse, V. G. and Sukhatme, P. V. 1967. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi, 359 p.

Peter, K. V. and Mc Cullum, G. D. 1984. Pollen stigma compatability in direct and reciprocal crosses of *Capsicum* sp. *J. Heredity.* 75: 70.

Pozzobon, M. T., Schifino-Wittmann, M. T. and Bianchetti, L. B. 2006. Chromosome numbers in wild and semi domesticated Brazilian *Capsicum* sp. *Biol. J. Linniaean. Soc.* 151: 259-269.

Prabhakaran, T. S., Natarajan, S. and Veeraragavatham, D. 2004. Studies on genetic variability, heritability and genetic advance in chilli (*Capsicum annuum* L.). *South Indian Hortic.* 52: (1/6) 70-72.

Prabhudeva, S. A. 2003. Variability, genetic diversity and heterosis study in chilli (*Capsicum annuum* L.). M. Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, 98p.

Prasad, B., Gulab Khan, R., Radha, T., Ravi, C. H., Venkataiah, P., Subhash, K. and Reuben, C. T. 2013. DNA profiling of commercial chilli pepper (*Capsicum annuum* L.) varieties using random amplified polymorphic DNA (RAPD) markers. *Afr. J. Biotechnol.* 12 (30): 4730-4735.

Rajamony, L., More, T. A., Seshadri, V. S. and Varuna, A. 1990. Reaction of muskmelon collections to cucumber green mottle mosaic virus. *Phytopathol.* 29: 239-224.

Rathod, R. P., Deshmukh, D. T., Sable, N. H. and Rathod, N. G. 2002. Genetic variability studies in chilli (*Capsicum annuum* L.). *J. Soils Crops* 12: 210-212.

Reddy, B. S., Thammaiah, N., Nandihalli, B. S., Dharmatti, P. R. and Patil, R. V. 2000. Performance of chilli genotypes under Ghataprabha command area of Northern part of Karnataka. *J. Maharashtra Agric. Univ.* 25: 73-74.

Reddy, G. M., Mohankumar, H. P. and Salimath, P. M. 2006. Variability, Correlation and path coefficient analysis in chilli (*Capsicum annuum L). Karnataka J. Agric. Sci.* 2 (12): 225-261.

Rishi, N. and Dhawan, P. 1988. Field reaction of chilli germplasm to different viral diseases. *Plant Dis. Res.* 3: 69-70.

Sandeep, 2007. Genetic variability, correlation, morphological and molecular diversity in byadgi kaddi and byadgi dabbi chillies (*Capsicum Annuum* L.) accessions. M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, 153p.

Sarkar, S., Murmu, D., Chattopadhyay, A. and Hazra, P. 2009. Genetic variability, correlation and path analysis of some morphological characters in chilli. *J. Crop and Weed* 5 (1): 162-166.

Senapati, B. K., Sahu, P. K. and Sarkar, G. 2003. Genetic divergence in chilli. *Crop Res.* 26: 314-317.

Sharma, V. K., Semwal, C. S. and Uniyal, S. P. 2009. Genetic variability and character association analysis in bell pepper (*Capsicum annuum* L.). *J. Hortic. and For.* 2 (3): 58-65.

Sharma, V. K., Semwal, C. S. and Uniyal, S. P. 2010. Variability and character association analysis in chilli (*Capsicum annuum* L.) *J. Hortic. and For.* 3 (4) 58-65.

Silbernagel, M. J. and Jafri, A. M. 1974. Temperature effects on curly top resistance in *Phaseolus vulgaris*. *Phytopathol.* 64: 825-827.

Singh, R. and Chowdhury, A. K. 2005. Screening of different varieties of chilli (*Capsicum annuum* L.) against chilli leaf curl virus (CLCV) disease in the plains of West Bengal. *Environ. Ecol.* 23: 395-397.

Singh, D. K. and Singh, A. 2011. Assessment of variability parameters and character association for quantitative traits in chilli (*Capsicum annuum L.*). *Progressive Agric.* 11 (1): 113-116.

Singh, P., Singh, A. K., Sharma, M. and Salgotra, S. K. 2014. Genetic divergence study in improved bread wheat varieties (*Triticum aestivum*). *Afr. J. Agric. Res.* 9 (4): 507-512.

Singh, S. P. 2007. Production and management of spices. Agrihortica Publications, Junagadh, pp. 171-190.

Sivasubramanian, S. and Menon, M. 1973. Genotypic and phenotypic variability in rice. *Madras Agric. J.* 60: 1093-1096.

Smitha, R. P. and Basavaraja, N. 2006. Genetic divergence studies in chilli (*Capsicum annuum* L.). Department of Horticulture, University of Agricultural Sciences, Dharwad, India. *Karnataka J. Agric. Sci.* 19 (4): 975-977.

Sood, S., Bindal, A. and Sharma, A. 2007. Genetical study for quality traits in bell pepper (*Capsicum annuum* L.). *Indian. J. Genet.* 67: 95-98.

Sreelathakumary, I. and Rajamony, L. 2002. Variability, heritability and correlation studies in chilli (*Capsicum* spp.) under shade. *Indian J. Hortic.* 59: 77-83.

Sreelathakumary, I. and Rajamony, L. 2003a. Correlation and path coefficient analysis in bird pepper (*Capsicum frutescens* L.). *Capsicum Eggplant Newsl*. 22: 71-74.

Sreelathakumary, I. and Rajamony, L. 2003b. Variability, heritability and genetic advance in bird pepper (*capsicum frutescens* L). *Capsicum and eggplant newsl*. 22: 51-54.

Sreelathakumary, I. and Rajamony, L. 2004. Genetic divergence in chilli (*Capsicum annuum* L.). *Indian J. Hortic.* 61: 137-139.

Sreelathakumary, I. and Rajamony, L. 2004. Variability, heritability and genetic advance in chilli (*Capsicum annuum* L.). *J. Trop. Agric.* 42 (1-2): 35-37.

Tatagar, M. H., Prabhau, S. T. and Jagadesha, R. C. 2001. Screening of chilli genotypes for resistance to thrips, *Scirtothripsdorsalis* (Hood) and mite, *Polyphagotarsonemus latus* (Banks). *Pest Manag. Hort. Ecosyst*. 7 (2): 133-116.

Thul, S. T., Lal, R. K., Shasany, A. K., Darokar, M. P., Gupta, A. K., Gupta, M. M., Verma, R. K. and Khanuja, S. P. S. 2009. Estimation of phenotypic divergence in a collection of Capsicum species for yield-related traits. *Euphytica* 168: 189-196. DOI 10.1007/s10681-009-9882-y.

Ukkund, K. C., Madalageri, M. B., Patil, M. P. and Kotikal, Y. K. 2007. Variability studies in green chilli (*Capsicum annuum* L.). *Karnataka J. Agric. Sci.* 20 (1): 102-104.

Ukkund, K. C., Patil, M. P., Madalageri, M. B., Mulage, R. and Jagadeesh, C. 2007. Character association and path analysis studies in green chilli for yield and yield attributes (*Capsicum annuum* L.). *Karnataka J. Agric. Sci.* 20 (1): 99-101.

Ullah, M. Z., Hasan, M. J., Saki, A. I., Rahman, A. H. M. A. and Biswas, P. L. 2011. Association of correlation and cause-effect analysis among morphological traits in chili (*Capsicum frutescens* L.). *Int. J. Biol. Res.* 10 (6): 19-24.

Varkey, J., Saiyed, M. P., Patel, J. S. and Patel, D. B. 2005. Genetic variability and heritability in chilli. *J. Maharashtra Agric. Univ.* 30: 346-347.

Wright, S. 1921. Correlation and causation. *J. Agric. Res*. 20: 557-585.

Wyrzykowska, M., Pazytula, M., Zieminska, J. and Pala, J. 2000. Quantitative traits and their correlation in sweet paprika (*Capsicum frutescens*) kambi introduced into the pod larie region of Poland. *Bull. Inst. Hodowli Aklim. Roslin* 216 (2): 463-468.

Yatung, T., Dubey, K. R., Singh, V. and Upadhyay, G. 2014. Genetic diversity of chilli (*Capsicum annuum* L.) genotypes of India based on morpho-chemical traits. *Aust. J. Crop Sci.* 8 (1): 97-102.

EVALUATION OF GENOTYPES FOR YIELD AND RESISTANCE TO LEAF CURL IN BIRD CHILLI (*Capsicum frutescens* L.)

BANDLA SRINIVAS

(2013 - 11 - 197)

ABSTRACT

of the thesis submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF PLANT BREEDING AND GENETICS

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM – 695 522

KERALA, INDIA

2015

ABSTRACT

The project entitled “Evaluation of genotypes for yield and resistance to leaf curl in bird chilli (*Capsicum frutescens* L.)" was under taken with an objective to identify high yielding genotypes of bird chilli with resistance to leaf curl. The data for the investigation were collected from two field experiments.

In experiment I, 78 accessions of bird chilli collected from different parts of Kerala were evaluated in the field for yield and resistance to leaf curl. The accession A4 (Vandithadam-I) showed highest mean values with respect to number of primary branches, number of secondary branches, fruit length, plant height and lowest number of white flies per plant and categorised as tolerant to leaf curl. The accession A50 (Kumarapuram-I) showed highest mean values for number of fruits per plant, average fruit length, average fruit width and fruit yield per plant and it had zero vulnerability index *i.e.* resistance to leaf curl. The number of thrips per leaf and number of mites per leaf were lowest for accessions A28 (Kottakkal-IV) and A38 (Palakkad-I) respectively.

The genetic divergence among 78 genotypes, in experiment I was studied and the genotypes were grouped into nine clusters. Cluster II accommodated maximum number of genotypes (24) followed by cluster IV with 13 genotypes, cluster I with 11 genotypes, cluster V with 9 genotypes, cluster IX with 8 genotypes, cluster VI with 7 genotypes, cluster VII with 3 genotypes, cluster VIII with 2 genotypes and cluster III with 1 genotype. Cluster VIII and cluster IX were found to be superior to the other clusters with respect to the desirable characters. It was observed that there was no close correspondence between geographical distribution and genetic divergence.

In experiment II, 10 accessions of bird chilli (*Capsicum frutescens* L.) selected from experiment I, were studied. These genotypes showed significant difference for all the biometric characters. They all showed high heritability coupled with high genetic advance except for number of days to first flowering and

average fruit length for which the genetic advance was low and moderate respectively. The maximum values for phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were recorded for incidence of leaf curl disease and fruit yield per plant and the minimum values were for number of days to first flowering.

High positive correlation was recorded for fruit yield per plant with individual fruit weight, number of fruits per plant, plant height, number of secondary branches, average fruit width, number of primary branches, average fruit length and number of days to first flowering. Path coefficient analysis revealed that individual fruit weight and number of fruits per plant had high positive direct effect on fruit yield per plant. Hence, through selection for these characters yield can be improved. The genotype T5 (Kumarapuram-I) was ranked first with respect to yield and resistance to leaf curl and this can be developed as a superior bird chilli variety.