

**EVALUATION OF CHILLI (*Capsicum annuum* L.) GENOTYPES
AND HYBRIDS AGAINST *Fusarium* WILT**

MARUTI T. BANDIWADDAR

**DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE, RAICHUR – 584 102
UNIVERSITY OF AGRICULTURAL SCIENCES
RAICHUR – 584 102**

JUNE, 2013

**EVALUATION OF CHILLI (*Capsicum annuum* L.) GENOTYPES
AND HYBRIDS AGAINST *Fusarium* WILT**

Thesis submitted to the
University of Agricultural Sciences, Raichur
in partial fulfillment of the requirement for the
Degree of

Master of Science (Agriculture)

in

GENETICS AND PLANT BREEDING

By

MARUTI T. BANDIWADDAR

**DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE, RAICHUR – 584 104
UNIVERSITY OF AGRICULTURAL SCIENCES
RAICHUR – 584 104**

JUNE, 2013

DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE, RAICHUR – 584 104
UNIVERSITY OF AGRICULTURAL SCIENCES,
RAICHUR – 584 104

CERTIFICATE

This is to certify that the thesis entitled “**EVALUATION OF CHILLI (*Capsicum annuum* L.) GENOTYPES AND HYBRIDS AGAINST *Fusarium* WILT**” submitted by **Mr. MARUTI T. BANDIWADDAR** for the award of Degree of **MASTER OF SCIENCE (AGRICULTURE)** in **GENETICS AND PLANT BREEDING** to the University of Agricultural Sciences, Raichur, is a record of research work done by him during the period of his study in this university under my guidance and supervision, and the thesis has not previously been formed the basis of award of any degree, diploma, associateship, fellowship or other similar titles.

RAICHUR
JUNE, 2013

(B.V. TEMBHURNE)
CHAIRMAN

Approved by:

Chairman: _____
(B.V. TEMBHURNE)

Members: 1. _____
(P.H. KUCHANUR)

2. _____
(RAJU L. CHAVAN)

3. _____
(Y.S. AMARESH)

Affectionately dedicated to
My beloved

Grandfather, Grandmother
& My parents

ACKNOWLEDGEMENT

*Diction is not enough to express my deep and profound sense of gratitude and indebtedness, reverence and heartfelt thanks to my major advisor and chairman of advisory committee, **Dr. B. V. TEMBHURNE**, Assistant Professor, Department of Genetics and Plant Breeding, College of Agriculture, Raichur for his meticulous guidance, transcendent suggestions, constructive criticism and constant encouragement right from the conceptualization of the research work to preparation of the thesis.*

*It gives me immense pleasure to express my heartfelt thanks to the members of my advisory committee **Dr. P. H. KUCHANUR**, Associate Professor and Head, Department of Genetics and Plant Breeding, College of Agriculture,, Bheemarayanagudi **Dr. RAJU. L. CHAVAN**, Assistant Professor, Department of Genetics and Plant Breeding, College of Agriculture, Raichur and **Dr. Y. S. AMARESH**, Assistant Professor, Department of Plant Pathology, College of Agriculture, Raichur, for their constant encouragement, suggestions and valuable guidance during the course of my investigation.*

*I take this rare opportunity and proud privilege to extent my heartfelt and deep sense of gratitude towards **Dr. R. Lokesh**, Professor and Head, Department of Genetics and Plant Breeding, College of Agriculture, Raichur and **Dr. J. R. Diwan**, Assistant Professor, Department of Genetics and Plant Breeding, College of Agriculture, Raichur for their valuable expert teaching and guidance.*

I am extremely grateful to my beloved seniors Vinodkumar, S. Naik, Shreenivas, B.V., Dr. Muniswamy, Scientist, ARS, Gulbarga, Yamanura, Boranaik, Vinay Patted, Mallikarjuna, B. P., Mehaboobsa, Chethana C. K. Skilled labours and all workers of AC, Raichur for their help and co-operation during my research.

*I owe my respectful gratitude to my parents, **Sri. Timmanna** and **Smt. Renukavva**, Sister **Rekha**, brothers **Shivaraj**, **Chandru** and **Raju** all my sisters and all my friends for their constant support, love and encouragement, which enabled me to complete my studies successfully.*

I also have been highly fortunate in having many affectionate buddies whose hands were evident at every moment of tension, anxiety and

achievements. I am ever grateful to my classmates Kishore, Sheshaiah, Siddesh, Muttappa, Babafakruddin, Niranjana, Santhosh, Shilpa and Savitha, I also thankful to my junior friends Chandru, Deekshith, Mahanthesh, Kiran, Shivakumar and Shrishail etc. Special thanks to my friend Ramanjineya who has helped me lot during my research work.

I am also taking this opportunity to say special thanks to my sweet friends like Raghavendra S, Chandrashekar Malur, Mohan, Jainu, Praveen Yaddu, Shashikumar, N., Prasanna, Sahebgouda and others Who are all supported me to complete my master's degree either directly or indirectly.

*I take this opportunity and proud privilege to extend my heartfelt and deep sense of gratitude towards my sportive teacher's **Dr. M. K. Naik** and **Dr. A. G. Shreenivas** for their constant support, love and encouragement for my studies and research successfully.*

Raichur

June, 2013

(MARUTI T. BANDIWADDAR)

CONTENTS

Sl. No.	Chapter particulars	Page
	CERTIFICATE	iii
	ACKNOWLEDGEMENT	iv
	LIST OF ABBREVIATIONS	vi
	LIST OF TABLES	ix
	LIST OF FIGURES	xi
	LIST OF PLATES	xii
	LIST OF APPENDICES	xiii
I.	INTRODUCTION	1-3
II.	REVIEW OF LITERATURE	4-32
	2.1 Symptomatology	4
	2.2 <i>Fusarium</i> wilt Screening	6
	2.3 Mechanism of resistance	6
	2.4 Inheritance of F ₁ hybrids to <i>Fusarium</i> wilt	12
	2.5 Genetic variability, heritability and genetic advance	16
	2.6 Correlation coefficient analysis	22
	2.7 Path coefficient analysis	26
	2.8 Screening of genotypes against powdery mildew (<i>Leveillula taurica</i>) of Chilli	28
	2.9 Screening of chilli genotypes for fruit borer (<i>Helicoverpa armigera</i>)	31
III	MATERIAL AND METHODS	33-43
	3.1 General Laboratory Procedure	33
	3.2 Collection and maintenance of the <i>Fusarium</i> culture	33
	3.3 Pathogenicity test	34
	3.4 Screening of chilli genotypes/hybrids against <i>F. solani</i> (F25)	35
	3.5 Methodology	36
	3.6 Yield performance of genotypes and hybrids	39
	3.7 Statistical analysis	41
	3.8 Screening for powdery mildew disease resistance	43
	3.9 Screening for chilli fruit borer resistance	44

Contd.....

Sl. No.	Chapter particulars	Page
IV.	EXPERIMENTAL RESULTS	45-79
	4.1 Symptomatology	45
	4.2 Screening of chilli genotypes and hybrids against <i>F. Solani</i>	45
	4.3 Analysis of variance for yield and its components	59
	4.4 Heritability and genotypic advance	63
	4.5 Correlation coefficient	67
	4.6 Path co-efficient analysis	72
	4.7 Screening for powdery mildew (<i>Leveillula taurica</i>) disease resistance.	74
	4.8 Screening for chilli fruit borer (<i>Helicoverpa armigera</i>) resistance.	74
V.	DISCUSSION	80-91
	5.1 Screening of chilli genotypes and hybrids	80
	5.2 Analysis of variance for yield and its component	81
	5.3 Heritability and genotypic advance	84
	5.4 Correlation coefficient	86
	5.5 Path coefficient analysis	88
	5.6 Screening for powdery mildew (<i>Leveillula taurica</i>) disease resistance.	91
	5.7 Screening for chilli fruit borer (<i>Helicoverpa armigera</i>) resistance	91
VI.	SUMMARY AND CONCLUSIONS	92-94
VII.	REFERENCES	95-109
	APPENDIX	110

LIST OF ABBREVIATIONS

Abbreviations		Expansions
g	:	Gram
mm	:	Milligram
cm	:	Centimetre
CD	:	Critical Difference
Fig.	:	Figure
%	:	Per cent
Kg ha ⁻¹	:	Kilogram per hectare
tonnes ha ⁻¹	:	Tonnes per hectare
Spp	:	Species
ml	:	Millilitre
⁰ C	:	Centigrade
F ₁	:	First filial
F ₂	:	Second filial
BC ₁	:	Back cross one
BC ₂	:	Back cross two
>	:	Greater than
<	:	Less than
RAPD	:	Random Amplified Polymorphic
DNA	:	De-oxy-ribo Nucleic Acid
UV	:	Ultra violet
cm ²	:	Centimetre square
CMS	:	Cytoplasmic male sterile
DAS	:	Days after sowing
DAT	:	Days after treatment
Min	:	Minimum
Max	:	Maximum
GCV	:	Genotypic co-efficient of variation
PCV	:	Phenotypic co-efficient of variation
GA	:	Genetic advance
df	:	Degrees of freedom

LIST OF TABLES

Table No.	Title	Page No.
1.	Genetic variability for yield and yield attributing characters in chilli (<i>Capsicum annuum</i> L.)	17-19
2.	Heritability and genetic advance for yield and yield attributing characters in chilli (<i>Capsicum annuum</i> L.)	20-21
3.	Three available cytoplasmic male sterile lines and two maintainers	36
4.	List of selected restorer lines for identification of <i>Fusarium</i> wilt resistance	37-38
5.	Screening of chilli genotypes against <i>Fusarium solani</i> by using seed inoculation technique	47-48
5.1	Reaction of chilli genotypes against <i>Fusarium solani</i> under seed inoculation technique	49
6.	Screening of chilli genotypes against <i>Fusarium solani</i> by using rapid root dip transplanting technique	50
6.1	Reaction of chilli genotypes against <i>Fusarium solani</i> under rapid root dip transplanting technique	50
7.	Screening of chilli hybrids against <i>Fusarium solani</i> by using rapid root dip transplanting technique	52
7.1	Reaction of different chilli hybrids against <i>Fusarium solani</i> under rapid root dip transplanting technique	53
8.	Screening of chilli hybrids against <i>Fusarium solani</i> by using sick pot method	55
8.1	Reaction of different chilli hybrids against <i>Fusarium solani</i> by under sick pot method	56
9.	Screening of six important parents/genotypes for <i>Fusarium solani</i> in sick pot method	58
10.	Analysis of variance for yield and its components	60
10.1	Mean <i>per se</i> performance of the genotypes for various traits	62
10.2	Genetic parameters for different traits in chilli (<i>Capsicum annuum</i> L.)	65

Contd.....

Table No.	Title	Page No.
11.	Estimate of genotypic correlation coefficient between fruit yield and its components in chilli	17-19
12.	Estimate of phenotypic correlation coefficient between fruit yield and its components in chilli	20-21
13.	Genotypic and phenotypic path coefficients of the characters affecting dry fruit yield per plant	36
14.	Screening of chilli genotypes for powdery mildew	37-38
14.1	Reaction of chilli genotypes for powdery mildew (<i>Leveillula taurica</i>) under natural epiphytotic condition	47-48
15.	Screening of chilly genotypes for fruit borer	49
15.1	Reaction of chilli genotypes for fruit borer (<i>Helicoverpa armigera</i>) under natural condition	50

LIST OF FIGURES

Figure No.	Title	Page No.
1.	Genotypic coefficient of variation and phenotypic coefficient of variation in chilli	83
2.	Heritability and genetic advance as per mean for sixteen characters in chilli	85
3.	Genotypical path diagram for DFWP (Dry Fruit Weight per Plant)	89
4.	Phenotypical path diagram for DFWP (Dry Fruit Weight per Plant)	90

LIST OF PLATES

Plate No.	Title	Page No.
1.	a) Wilting symptoms on chilli seedlings b) Resistant seedlings	44
2.	Screening of chilli genotypes against <i>Fusarium solani</i> . a) <i>Fusarium</i> culture on solid medium b) Wilted and healthy seedlings c) Control d) Rapid root dip transplanting technique.	54
3.	Sick pot method (Sorghum giant culture technique)	56

LIST OF APPENDIX

Appendix No.	Title	Page No.
I.	Monthly meteorological data for the year 2012-13 and mean of the last 81 years (1931-2012) at Main Agricultural Research Station, Raichur	110

I. INTRODUCTION

Chilli (*Capsicum annum* L.) is an important tropical and sub tropical condiment and vegetable crop. The primary center of origin of chilli is considered to be Mexico (Eshbaugh *et al.*, 1983). It is an indispensable spice essentially used in every Indian cuisine due to its pungency, taste, appealing odour and flavour. Chilli fruits are rich sources of vitamin A, C and E. Pungency of chilli is due to a crystalline acrid volatile alkaloid called capsaicin, present in the placenta of fruit. It is also a good source of chilli oleoresin, which is the total flavour extract of dried and ground chillies and concentrated in homogenous free flowing product, which has varied uses in processed food and beverage industries.

The natural colour extracts of chilli are also finding their increased value in place of artificial colours in the food items, especially in the developed nations. In the diet of poor people in India, chilli plays a major role in providing ascorbic acid in sufficient quantity. Carotene, the yellow pigment is a provider of vitamin A. Chillies can act as a heart stimulant, which regulates blood flow and strengthens the arteries, possibly reducing heart attacks. Medicinally, capsaicin is being used to alleviate pain. It is the most recommended tropical medication for arthritis. Chilli pungency is desirable attribute in many foods. Medicinal use of *Capsicum* is to treat asthma, coughs, sore throats and to relieve toothaches. Besides new medicinal applications it has been tried as a barnacle repellent to repel mice from gnawing on underground electrical cables. Thus, chilli has diverse uses as spice, condiment, culinary supplement, medicine, vegetable and ornamental plant.

Chilli is part of the large night shade family Solanaceae and is closely related to tomato, potato, tobacco and eggplant. The genus *Capsicum* includes all the peppers, from mildest bell to the hottest infinity and represents a diverse plant group including twenty seven species (five domesticated and twenty two undomesticated). The five major cultivated species are derived from different ancestral stocks found in three distinct centers of origin. Mexico is the primary center for *Capsicum annum*, with Guatemala a secondary center, Amazonia for *Capsicum chinense* and *Capsicum frutescens*, Peru and Bolivia for *Capsicum pendulum* and *Capsicum pubescens*. The species, *Capsicum annum* and *Capsicum frutescens* are widely distributed from Mexico through Central America and throughout the India.

Today peppers are widely grown in many parts of the world including Africa, Europe, and Asia. During the 16th century, Portuguese have introduced the chilli to India. India ranks first in the world in terms of production, consumption and exports occupying third place among the vegetable crops in area and production. Chilli is the most widely used universal spice, named as wonder spice. Indian chilli is considered to be world famous for two important commercial qualities, *i.e.*, colour and pungency levels. There are about 70 varieties of chillies grown in India and major varieties are Guntur, Sannam, Tejaswini, Roshini, LC 334, Byadgi, Wonder Hot and Jwala *etc.*

India is the largest producer of chilli and contributes 25 per cent to total world production and produced about 13.2 million tonnes of chilli during 2009-10. After India, China is the major producer of chilli in the world. During 2010, chilli production declined sharply in China because of unfavourable weather condition which became an advantage for chilli exporters in India. As per trade sources, chilli production for year 2010-11, is estimated down by 20-25 per cent to around 9.95-10.5 lakh tonnes as 30-40 per cent crop has been damaged due to unseasonal rains (Anon., 2011).

India is the major and highly erratic producer, consumer and exporter of chilli covering an area of 0.792 million hectares with a production of 1.223 million tonnes averaging a productivity of 1544 kg per ha (Anon., 2011). Indian chilli and its products are imported by Sri Lanka, Bangladesh, South Korea and USA for dry chilli and USA, Germany, Japan, UK and France for oleoresin. India can supply chilli in whole, crushed, powder or oleoresin forms in consistent colour and required pungency.

In India, chilli is grown in almost all the states. Andhra Pradesh, Karnataka, Maharashtra, Orissa, Rajasthan, Tamil Nadu and West Bengal account for 85.8 per cent of the total area and 89.3 per cent of the total production (Anon., 2002).

Karnataka (2008-09) has an area of 0.070 million hectares and a production of 0.094 million tonnes. In Raichur district (2008-09), green chilli occupies an area of 0.002 million hectares with a production of 0.016 tonnes accounting for a productivity of 8 tonnes per ha (Anon., 2012).

The crop suffers from many diseases like damping off, anthracnose or fruit rot or die back, wilt, murda complex, leaf spot, powdery mildew and wilt. Wilt caused by [*Fusarium solani* (Mart.) Sacc.], is becoming more serious in chilli growing tracts of India (Singh *et al.* 1998) and also in Karnataka particularly in black cotton soil leading up

to 25 per cent yield loss (Madhukar and Naik, 2004). The incidence of wilt varied from 0 to 75 per cent in different states of India (Anon., 2005).

The wilt appears both in seedling and adult stage but highest mortality occurs at flowering and fruiting stage, as a result whole plant wilts leading to a complete loss. Although the disease first appears in patches in a field, it can extend to the entire field if chilli is cultivated repeatedly in the same field.

Host plant resistance has been a choice in all crop improvement programme and is perhaps the best method available to tackle the soil borne diseases in particular. *Fusarium* wilt is a typical soil borne disease which can be mitigated appropriately by use of disease resistant cultivars. Most of the commercial cultivars grown in India are susceptible to wilt including the very popular, Byadagi type of chilli. Further, the use of resistant variety will go a long way not only in reducing losses due to disease but also in avoiding fungicidal toxicity likely to occur due to their application to soil. Hence, evaluation of chilli (*Capsicum annum* L.) genotypes and hybrids against *Fusarium* wilt was initiated with the following objectives.

1. To identify *Fusarium* wilt disease resistant genotypes.
2. To develop chilli hybrids resistant to *Fusarium* wilt.

II. REVIEW OF LITERATURE

Fusarium wilt of chilli (*Capsicum* spp.) is one of the most destructive soil borne diseases, which is widely distributed throughout the country and responsible for huge losses (Singh *et al.*, 1998). However, not much work had been carried out on this particular disease and hence a very few literatures are available. The literature pertaining to present investigations are reviewed and presented here under.

2.1 Symptomatology

In general, the types of symptoms caused by *Fusarium* infections are many and varied. Diversity is one of the most interesting features of this disease. Different types of manifestation of symptoms have been reported in *Fusarium* spp. at any stage of plant growth and on any part of the plant.

Frederick (1940) described symptoms of *Fusarium* wilt of tomato. The organism is a vascular pathogen, invading the plants through root system. Epinasty of tomato is one of the earliest symptoms of *Fusarium* wilt that is of special interest. The earliest observable symptom appeared within 48 hours after entry of the pathogen, where in the ultimate veinlets become translucent followed by yellowing, epinasty of leaves and stimulation of root initials were connected with liberation of chemicals (Ethylene and Auxins).

Foster (1946) and Davis (1953) independently reported vascular discolouration which was brought about by oxidation of conjugated phenols into melanins, which in turn caused browning in *Fusarium* wilt of tomato. Further, Dimond (1955) observed that the obvious symptom of yellowing of leaves and discolouration of vascular tissue which appeared seven to ten days later. The older leaves turned yellow succeeded by younger petioles, and stem and the whole plant slowly wilted. Leaves become necrotic and desiccated and the plants withered and dried slowly.

Mathur and Mathur (1965) described the metabolites produced by *Fusarium oxysporum* f. sp. *lycopersici* in tomato which produced characteristic drooping of leaves, flagging of petiole along with vascular browning and finally wilting. Similarly, Chube (1968) described the symptoms of *Fusarium* wilt of tomato. The wilt appeared in early stages of plant growth *i.e.*, when the plants are about 4-6 weeks old. The typical symptoms of the disease appeared as withering and drying of green parts exactly as if they were suffering from drought even though there might be plenty of water in the soil.

Dimond (1970) reported that wilting is prominent and unique symptom was caused by the failure of transport system to conduct adequate water. Withering was associated with polysaccharides and glycopeptides. These compounds resulting from infection were transported to the margin of leaves and they damaged membrane in parenchyma cells of tomato.

Smith and Synder (1971) reported that discolouration of vascular bundles, which had been used as an index of susceptibility or resistance to *Fusarium oxysporum*. Trapero and Jimenez (1981) observed two types of wilt symptoms in chickpea that were discernable in early stages, but later became difficult. First there was yellowing of leaves followed by necrosis and drooping of leaflets, which was usually but not always associated with external black and internal dark brown discolouration of the collar tissues. The other symptom was a typical wilting.

Lodha and Singh (1983) reported that 5-6 month old jojoba plants were found drying in the field. The leaves turned yellow and drooped off prematurely. Necrosis and discolouration were observed in the collar region of the dead plants. Roots of such plants were found to be partially decayed. Vandrew and Peterson (1988) described that *Fusarium solani* produced lesion on the tap root or main roots with young foliage distorted, lightly mottled with necrotic spotting in tomato.

Upadhaya and Rai (1989) observed the symptom of *Fusarium* wilt of tomato. In the beginning, yellowing of leaves, blackening of portion of the stem starting from collar to the fine branches appeared which gradually resulted in drying of leaves, stem, fine branches and finally the death of whole plant.

Pandey *et al.* (1997) observed transverse section from roots and stem segments for changes in tissue of pigeonpea infected with *Fusarium udum*. A number of xylem vessels in root and stem were clogged and turned brown in colour. Rakholiya *et al.* (2003) reported yellowing, wilting of roots and brownish vascular discolouration in *Fusarium* wilt of bitter melon. On the young seedlings initially, water soaked areas developed at the collar region and a brown sunken lesion which soon appeared as girdled resulting in seedling collapse. An adult plant initially, slight drooping of leaves which led to drying of leaves starting from lower ones extended from root to stem region and plants exhibited wilting symptom (Anon., 2012).

2.2 *Fusarium* wilt screening

It would be an ideal situation to look forward to have eventually disease resistant varieties especially for soil borne diseases, particularly *Fusarium* wilt though it may be too much to expect in view of the variability in pathogens. Various techniques were employed by different investigators for inducing wilt symptoms in plants. The techniques included mixing of three weeks old wheat kernal cultures at the rate of 50 g to sterilized soil for each four pot (White, 1927); pouring a heavy spore suspension and mycelial fragment suspension to the plants grown in pots containing sterilized soil (Haymaker, 1929); dipping of injured roots of transplants in the mycelial suspension (Wellman, 1939); inoculating the soil with fungal culture and transplanting the seedlings (Schroeder *et al.*, 1953); wilt sick plot (ICRISAT) pouring suspension around the root zone (Henderson and Winstead, 1961). Incubating the seven days old seedlings in adjusted spore suspension (1×10^4 conidia/ml) on a Brunswick gyrotory incubator shaker (Roberts and Kraft, 1971), rapid root dip transplanting technique (Naik *et al.*, 1996). Similarly root inoculation in Hoagland's solution (Shanthalakshmi *et al.*, 1999) standardized root dip inoculation technique (Desai and Dange, 2003) were tried from time to time.

Wang and Wang (1991) concluded that the root dip inoculation method is the best technique for identifying and screening the *Fusarium* wilt resistance of pepper germplasm. They found the optimum inoculation concentration of 106 spores per ml, with suitable pathogenesis temperature 25-28 °C. They identified 30 pepper germplasm/ accessions resistance to *Fusarium* wilt by using artificial inoculation method at the seedling stage.

Seki *et al.* (2007) followed simple inoculation method using pathogen infected soil useful for investigation of carnation wilt disease resistance. The wilt disease resistant line was selected from nine cultivated lines. They identified the wilt disease resistant lines derived from the cross between resistant and susceptible lines. Some lines showed higher resistance level than resistant parent. Shahriyari *et al.* (2009) developed wilt sick plot for chickpea in dryland area through Iran-ICARDA collaboration to screen the *Fusarium* wilt disease.

2.3 Mechanism of resistance

Bohn and Tucker (1939) reported a high level of resistance against *Fusarium* wilt of tomato (*Lycopersicon pimpinellifolium*). The resistance was dependent on single

dominant genetic character. High amount of total phenol, total reducing sugars and orthodihydric phenols were reported in resistant muskmelon against *F. oxysporum* f. sp. *melonis* by Bhaskaran and Prasad (1971). However, total phenols increased after inoculation, whereas orthodihydroxy phenols and sugar levels decreased after inoculation. In addition, cucurbitacin a substance which existed prior to infection and which has fungistatic properties has been found to play a role in resistance. The increase in polyphenol oxidase and peroxidase activity after infection has been reported by Mariate (1973).

Gopalakrishnan and Peter (1991) identified bacterial wilt resistance chilli genotypes, from the accessions belonging to *Capsicum annuum*, *C. frutescens* and *C. chinense*, in wilt sick pot after artificial inoculation. Out of 146 accessions, two cluster-fruited types from *C. annuum*, CA219 and CA33 were resistant, two selections from CA219 and 2 from CA33 which were completely resistant to wilt also gave good dry chilli yields of 31.2 g per plant and 42.0 g per plant and 61 and 13 g per plant, respectively. Cluster-fruited plants gave significantly better wilt resistance than solitary fruited types.

Ahmed *et al.* (1994) identified advance breeding lines of chilli, sweet and hot pepper cultivars against wilt. Among the 142 advance lines of chilli (*Capsicum annum*) tested under natural infection of *Fusarium pallidoroseum* in the Kashmir Valley, where the disease is severe, 16 and 48 were moderately resistant respectively. Out of 28 hot pepper cultivars, 12 were resistant and six moderately resistant. However only two out of 26 sweet pepper cultivars tested were resistant and 10 showed moderately resistance.

Muhyi and Bosland (1995) detected *Rhizoctonia solani* resistance in chilli (*Capsicum annuum* L.) using infested corn (*Zea mays*) kernels at inoculum. The most aggressive New Mexican isolate of *R. solani* (PWB-25) was used to screen 74 *Capsicum* accessions for resistance to root rot caused by the fungus. The accessions differed in resistance, with disease ratings ranging from 2.9 to 8.6 on a 0 (no disease) to 9 (seedling dead) scale. The percentage of resistant plants, those in the interaction phenotype index class 0, 1, 2 and 3 ranged from 2.4 per cent to 77.1 per cent. Nineteen accessions representing four species had greater than or equal to 50 per cent resistant individuals and would be useful in breeding programs

Nayeema *et al.* (1995) screened hot pepper germplasm for resistance to *Fusarium* wilt caused by *F. pallidoroseum* under controlled (artificial inoculation of soil and sick

soil) and natural epiphytotic conditions at Srinagar. Germplasm Masalwadi was immune under all conditions. Similarly, Singh *et al.* (1996) obtained multiple disease resistance in chickpea at Hissar, when they screened over 1000 chickpea genotypes for resistance to wilt (*F. oxysporum* f. sp. *ciceri*), root rot (*Macrophomina phaseolina*) and blight (*Ascochyta blight*). The genotypes H83-125, G-186012, GL-186143, H90-93, H91-35 and H91-37 were identified as resistant to wilt, root rot and Ascochyta blight.

Infantino *et al.* (1996) reported that the wilt, caused by *Fusarium oxysporum* f. sp. *cicer*, is the most widespread soilborne disease of chickpea (*Cicer arietinum* L.). In an attempt to identify new sources of resistance to wilt, 102 accessions of six wild annual *Cicer* species were evaluated in the greenhouse. The isolate from central Italy used in this experiment was characterized by using a set of chickpea differential lines. Highly resistant reaction to wilt was shown by all accessions of *C. bijugum* and some of *C. echinospermum*, *C. judaicum*, *C. pinnatifidum* and *C. reticulatum*. This evaluation has helped to identify new and diverse sources of resistance to wilt for use in chickpea breeding. Six accessions of *C. bijugum* (ILWC-64, -71, -73, -76, -80, and -83), one accession (ILWC-186) of *C. judaicum*, and two accessions (ILWC-126, and -130) of *C. reticulatum* were free from wilt damage.

Sakata (1996) evaluated sixty accessions of eggplants collected in Malaysia for their resistance to bacterial wilt, *Verticillium* wilt and *Fusarium* wilt, caused by *Pseudomonas solanacearum*, *Verticillium dahliae* and *Fusarium oxysporum*, respectively. In the evaluation of the field infected with *P. solanacearum*, more than 60 per cent of the accessions were resistant. Based on the evaluation at the seedling stage of the resistant accessions, LS1934 was the most resistant accession to bacterial wilt. But most of the same accessions were not resistant to *Verticillium* wilt. LS2436 was the only accession with a relatively high resistance to *Verticillium* wilt. LS1934 and LS2436 were also resistant to *Fusarium* wilt.

Pandey *et al.* (1997) observed the interaction between the wilt susceptible (TT6) and resistant (ICP8863) pigeonpea genotypes. Rapid spread of fungus was observed in TT6 compared to ICP8863, resulting in clogging of the xylem vessels due to formation of gel and infusion of phenolic compounds in a greater amount, but they concluded that browning and occlusion of the xylem vessels play no significant role in resistance to wilt. The alternative mechanism *i.e.* production of phytoalexins may be involved in the resistance mechanism.

Markose *et al.* (1998) conducted the experiments for A near isogenic line Pusa Jwala showed moderately resistant to bacterial wilt, was developed by hybridizing Ujwala (92% resistance) with Pusa Jwala (88% susceptibility) and advancing the F₁s to the BC₂F₄. Bacterial wilt resistant plants having characteristics of Pusa Jwala were selected from the BC₂F₂ onwards. Resistance in F₁ (23.2%) was enhanced to 61 per cent in the BC₂F₄. In BC₂F₂, 21.43 per cent of resistant plants had characteristics of Pusa Jwala which was increased to 54.01 per cent in BC₂F₄.

Singh *et al.* (1998) evaluated 30 genotypes resistant to *Fusarium* wilt, caused by *Fusarium oxysporum* in the Paonta valley, Himachal Pradesh. Among them 9 germplasms viz., Punjab Lal, Solan Red, Pachhad Yellow, Solan Yellow, Pant C-1, Sweet Banana, IC-4, IC-8 and IC-21 showed moderately resistant and the remaining 21 were either susceptible or highly susceptible. None of the germplasm lines tested was highly resistance.

Rao and Krishnappa (1999) screened thirteen popular cultivars of chickpea for their reaction to *F. oxysporum* f. sp. *Ciceri* and *Meloidogyne incognita*, they noticed differential reaction to fungus, nematode and nematode fungal pathogen complex. Annigeri-1, H-208, Chaffa and JG-62 were found susceptible to fungus as well as nematode fungal complex. While, BEG-482, Jyothi, ICC-37 and ICCV-2 were tolerant to fungus, reacted as moderately susceptible in the presence of nematode, the *Fusarium* resistant cultivars viz., BDN-9-3 and ICC-4 became susceptible to wilt disease in the presence of nematode; the nematode failed to break resistance in other two wilt resistant cultivars viz., Radhey and Avrodhi. On an average the percentage of wilt incidence caused by fungus alone was 28.7 per cent while its accentuated to 45 per cent in the nematode fungal complex.

Saleem *et al.* (1999) screened 66 varieties/lines of chillies, 16 lines belongs to *C. annuum* showed immune reaction both in pots and in the sick field. The varieties showing resistant reaction in pots also exhibited the same reaction in the sick field. Twenty four varieties/lines belonging to *C. annuum*, *C. chinense* and *C. frutescens* were highly susceptible and gave 90-100 per cent mortality of plants in pots while 58.33 to 100 per cent in field. However, the mortality percentage in the field was comparatively less than that in pots. The varieties/lines of *Capsicum annuum* showed comparatively resistant reaction than *C. chinense*, *C. frutescens* and *C. pendulum* varieties/lines tested.

Kelaiya and Parakhia (2000) conducted experiment in greenhouse condition to determine the resistance against *Fusarium solani*. In this screening technique none of the cultivars were immune to the pathogen, cultivars GC-1 and GC-2 were resistant; Jwala, HC-9, HC-1, PBS-86-1 and PBS-86-2 were moderately resistant; HC-4, HC-10, HC-12, HC-5, HC-7, HC-13, HC-15, HC-11, HC-2, HC-3 and HC-6 were susceptible. However, Reshampatto and Gholar recorded as highly susceptible to *Fusarium solani*.

Fatima and Joseph (2001) screened 15 resistant (<20% infection), 16 moderately resistant (20-40%), 13 moderately susceptible (40-60%) and 9 highly susceptible (>60%) for bacterial wilt caused by *Ralstonia solanacearum* in Kerala.

Kaur *et al.* (2004) screened 150 chilli genotypes comprising hybrids, commercial cultivars and breeding lines against wilt disease caused by *Fusarium* spp, under field conditions in Ludhiana. None of the hybrid cultivar was found to be immune or highly resistant under field conditions. Two cultivars, namely PBC-408 and PBC-199, recorded as resistant which were also confirmed under artificial inoculations. These cultivars can be used as donors for resistance breeding programme. However, cultivars such as Punjab Lal, Punjab Surkh, Punjab Guchhedar and MF-41-1-1-1 possessed good degree of field resistance in addition to acceptable horticultural characters.

Andres *et al.* (2005) identified one pathotype among eight tested isolates of *Phytophthora capsici* collected in Northwest Spain, after inoculation tests using pepper cultivars of different origin, including the well known reference resistant cultivar Serrano Criollo de Morelos 334. Complete resistance to *P. capsici* was not found after the inoculation of 23 local genotypes of *C. annuum* with three different isolates of this oomycete, collected in northwest Spain. However significant differences in virulence were found for the three *P. capsici* isolates inoculated into the local pepper germplasm, using disease data based on results of genotype-isolate interactions.

Fassihiani and Shirvani (2005) screened 98 tomato germplasm in gene bank including pure line and accessions (*Lycopersicon esculentum* and *Lycopersicon* spp.) were inoculated with *Fusarium oxysporum* f. sp. *lycopersici* (Fol) race 1 collected from Hormozghan province of Iran. Results indicated that 21 lines and accessions were resistant, 33 were tolerant and 44 were susceptible. Among the resistant lines Kc315060, Kc315064, Kc315070 Kc315079, Kc315081, Kc315082 and Kc315090 were promising.

Watcharachaiyakup *et al.* (2005) studied the mechanism of resistance to bacterial wilt disease of chilli pepper caused by *Ralstonia solanacearum*. Comparison

of resistance levels among eight pepper cultivars infected with *Ralstonia solanacearum* was performed. Bacterial sizes from infected plant exudates were smaller among the resistant cultivars PBC 495 and CA 364 (0.475 x 0.895 and 0.560 x 1.049 micro m) than in the moderately susceptible cultivar CA 363 (0.632 x 1.146 micro m). Hexosamine content of resistant cultivars increased following bacterium compared with uninoculated paper.

Chaudhry *et al.* (2006) evaluated 414 varieties/germplasm accessions for *Fusarium* wilt resistance. Thirty five lines were found resistant, 208 intermediate, 77 susceptible and 94 were highly susceptible.

Mahdiyeh *et al.* (2006) recorded four resistant lines, five lines semi-resistant and three lines susceptible to *Fusarium oxysporium* f. sp. *ciceri*. However the local check and two other lines were susceptible.

Devika *et al.* (2008) screened 68 chilli genotypes against *Fusarium* wilt caused by *Fusarium solani*. Among them genotypes, F-112-5-83, SKAU-C 101 and PC-6 found resistant and Ajeet 6, KCS-2013, Pant C-1, ACS 201, PPHT 0516, PPHT 0520, PPHT 0524 and PPHT 0527 moderately resistant. The genotypes P-14, PPHT 0510, PPHT 0502, Jawahar-218, Punjab Lal, PC-6, LCA-206, ACS-97-2, KCS-2013, PPHT 0513, PPHT 0521, BSS-267, F-112-5-83 and LCA-353 showed resistance reaction in sick pot technique. However, F-112-5-83 and PC-6 showed resistant in both rapid root dip transplanting and sick pot technique.

Naik *et al.* (2008) identified resistance sources against wilt of chilli (*Capsicum annum* L.) caused by *Fusarium solani*. They were screened 30 chilli genotypes against *Fusarium* wilt under laboratory condition by using three different inoculation technique viz., seed inoculation technique, rapid root dip transplanting method and sick pot method. Among 30 genotypes IHR-3018 showed consistently resistant reaction in both seed inoculation and rapid root-dip transplanting method. DS-1 and LCA-206 were moderately resistant and remaining genotypes found susceptible to highly susceptible. However in sick pot method high percentage of mortality was noticed due to consideration of both pre and post emergence infection, as a result even IHR-3018 and LCA-312 were categorized under moderately resistant genotypes.

Srivastava *et al.* (2009) evaluated 25 germplasms of tomato against pathogenic and the most virulent isolate of *F. oxysporum* f. sp. *lycopersici*. Among the germplasm

CL-11-31-0-38-4-0 was found to be most resistant while as Pant tomato 3 showed most susceptible reaction.

Ahmad *et al.* (2012) evaluated 321 genotypes from different sources under controlled condition to identify genetic sources of resistance against *Fusarium oxysporum* f. sp. *ciceri* disease at seedling and reproductive stage. Disease reaction at two stages revealed considerable variation among the genotypes. At seedling stage disease incidence varied from 0 to 29.3 per cent whereas at reproductive stage ranged from 0 to 57 per cent. 173 genotypes were resistant, 54 were tolerant and 94 were susceptible at seedling stage, whereas 102 genotypes were resistant, 36 were tolerant and 183 were susceptible at reproductive stage. However, 82 genotypes showed steady resistance at both stages.

Joshi *et al.* (2012) registered two varieties resistant against the *Fusarium* wilt among the 30 chilli varieties.

2.4 Inheritance of F₁ hybrids to *Fusarium* wilt.

Sindhu *et al.* (1983) observed the inheritance of resistance to *Fusarium* wilt, caused by *F. oxysporum* f. sp. *Ciceri* in crosses between three wilt resistant lines (1231, 32/35-8/7 and 32/35-32/2) and two susceptible commercial varieties of chickpeas (*Cicer arietinum* L.). Evaluation of the parents, F₁, F₂ and backcrosses indicated that *Fusarium* wilt resistance parents were conditioned by a single recessive gene.

Opena *et al.* (1990) recorded the regulations of both additive and non-additive gene actions genetic system for wilt resistance. In a test of F₁ hybrids, the proportion of wilt-resistant F₁'s was generally higher when both parents were resistant compared to resistant x susceptible crosses. However, in some processing hybrids with one susceptible parent, the resistance was comparable to the highly resistant stocks, L285 and CLN 65-349, indicating non-additive action.

Park *et al.* (1990) observed the inheritance of resistance to anthracnose caused by *Colletotrichum dematium* f. sp. *Capsicum* and *C. gloeosporioides* in pepper. Mean squares for both general combining ability (GCA) and specific combining ability (SCA) were significant for inoculations of both green and red fruits with *C. dematium*, indicating the involvement of both additive and dominance effects in the lesion development. In inoculation with *C. gloeosporioides* strain G, mean squares for both GCA and SCA were significant for inoculations of green fruits, with mean square for GCA accounting for

most of the genetic variability. However, neither GCA nor SCA effect was significant on red fruits.

Ahmed (1991) screened 6 generations of a cross between susceptible *Capsicum* cultivar Kolascai E-14 and resistant genotype Perennial for their reaction to *Colletotrichum capsici*. The mean reaction of the F₁ generation was intermediate indicating additive gene action governing resistance. The reactions of the backcross progenies were intermediate between the F₁'s and the respective recurrent parents. The continuous variation for resistance in F₁, B₁ and B₂ suggested polygenic control of resistance. It was concluded that resistance to anthracnose in *Capsicum* is controlled by polygenes with a predominantly additive type of gene action and that the level of disease resistance can be improved through simple selection methods.

Sathyanarayana and Anand (1993) studied the combined performance of two lines for resistance to both bacteria and nematodes and 3 lines with resistance to bacterial wilt tomato alone. All 30 F₁ hybrids had a high degree of resistance to wilt. Among these 7 were suitable for processing, based on fruit size, firmness and colour. However, 11 hybrids were classed as dual-purpose (fresh and processing markets).

Pawliczuk and Orlikowski (1994) evaluated the resistance of carnation clones obtained as the results of crossing of four cultivars, used both as mother plants and pollinators, toward *Fusarium oxysporum* f. sp. *dianthi*. The hybrids obtained from each crossing showed various degree of resistance toward the pathogen. Resistant cultivars used as mother plants gave more resistant clones than used as pollinators.

Zhang *et al.* (1995) planted four resistant, four susceptible *Gossypium hirsutum* lines and their 28 F₁ hybrids in disease nurseries infected with *Fusarium oxysporum* f. sp. *vasinfectum* strain. Resistance in the F₁ hybrids was significantly and positively correlated with resistance level in the parents. The rank order of decreasing resistance for the resistant parents was Zhongmian 12, Sumian 3, E62-1 and Ekangmian 1. The F₁ of resistant × susceptible showed partially dominant resistance in nature. However, resistant × susceptible and highly resistant × susceptible hybrids exhibited moderately resistance, while moderately resistant × susceptible and low resistance × susceptible were susceptible.

Fery and Dukes (1996) revealed inheritance of the high level of southern root-knot nematode (*Meloidogyne incognita*) resistance exhibited by Carolina Hot cayenne pepper

(*Capsicum annuum* L.) and compared the genetic nature of this resistance to that exhibited by Mississippi Nemaheart. Evaluation of parental F_1 , F_2 and backcross generations or the cross Mississippi Nemaheart x California Wonder confirmed that the Mississippi Nemaheart resistance is conditioned by a single dominant gene. Evaluation of parental, F_1 , F_2 , and backcross generations of a cross between highly resistant and highly susceptible lines selected from a heterogeneous Carolina Hot population indicated that the resistance exhibited by Carolina Hot is conditioned by two genes, one dominant and one recessive.

Mulge and Anand (1997) tested powdery mildew resistant sweet pepper lines in line x tester analysis using commercial varieties as testers. Powdery mildew disease observed in parents and hybrids confirmed the dominant nature of disease resistance. Non additive gene action was predominant for plant growth and yield parameters except for number of secondary and tertiary branches.

Hemon (1998) conducted to develop and evaluate resistance of F_1 hybrids of tomatoes to pathogen causing *Fusarium* wilt, bacterial wilt and root-knot nematode. The progenies of the crosses Florida MH-1 x 508, Florida MH-1 x Yellow Plum, Florida x CIRT 106 and their respective reciprocals were found resistant to *Fusarium oxysporum* f. sp. *lycopersici*. Florida MH-1 x 508 and its reciprocal crosses produced hybrids resistant to *Ralstonia solanacearum*. The progenies of CIRT 106 x Florida MH-1, CIRT 106 x Bonny Best and their respective reciprocals were found resistant to combined *F. oxysporum* f. sp. *lycopersici*.

Hemon and Rosario (1999) evaluated the resistance of tomato parents and F_1 hybrids to *Fusarium* wilt and bacterial wilt causing pathogens. The progenies of the crosses Florida MH-1 x 508, Florida MH-1 x Yellow Plum and their respective reciprocals were found resistant to *Fusarium oxysporum* f. sp. *lycopersici*. Florida MH-1 x 508 and the reciprocal cross produced hybrids resistant to *Ralstonia solanacearum* and to combined *F. oxysporum* f. sp. *lycopersici* and *R. solanacearum*.

Okiror (2002) noticed the mode of inheritance to *Fusarium* wilt in lines which are to be utilized as sources of resistance in the pigeonpea. Two resistant lines, NPP 725 and NPP 726 were crossed with a susceptible line NPP 718. A cross was also made between the resistant lines. The parents, F_1 and F_2 generations were tested alongside the backcross

generations in wilt-sick soil boxes in the glasshouse. Qualitative genetic analysis indicated resistance in both lines to be dominant over susceptibility and controlled by two genes.

Mohamed and Badr (2004) evaluated the tomato parents, F₁, F₂, BC₁ and BC₂ generations of the three interspecific crosses Super–Marmande x LA1375, Edkawi x LA1375 and UC.97-3 x LA1375 in field and greenhouse to study the inheritance and nature of resistance to *Fusarium* wilt disease. Resistance to *Fusarium* wilt disease was found to be controlled by one dominant gene. The ratio of resistance to susceptibility in the F₂ hybrid and the BC₁ hybrid (from a backcross to the susceptible parent) populations was 3: 1 and 1: 1, respectively. The nature of dominance for some of resistance to *Fusarium* wilt disease of tomato ranged from partial dominance to over dominance in the different interspecific crosses.

Gregory *et al.* (2007) observed a new virulent strain of *Fusarium* wilt appeared in Australia in the early 1990's and new cultivars. They found good sources of resistance in Indian and Chinese parents as well as from within existing Australian cultivars. A new cultivar Sicot F-1 was released in 2004 with double the resistance of Sicot 189 and suggested that better resistance was required for situations with very high incidence of *Fusarium* wilt.

Jabeen *et al.* (2007) reported inheritance of resistance to *Fusarium* wilt [*Fusarium pallidoseum* (Cooke) Sacc.] in chilli (*Capsicum annuum* L.) governed by single dominant gene. They crossed the genotype Arkalohit under both field and artificial epiphytotic conditions and crossed to susceptible but agronomically superior genotypes Kashmir Long-1, SH-C-101 and Local Pampori. All 120 plants in BC₁ cross were resistant when F₁ back crossed to Arka Lohit, while in BC₂ a segregation ratio of 1 resistant 1 susceptible was registered. Incorporation of gene for resistance into high yielding locally adopted commercial cultivars (Kashmir Long1, SH-C-101 and Pampori) would expand cultivation of this commercial crop which otherwise is threatened by the disease occurrence.

Mahmood *et al.* (2011) investigated the inheritance of wilt resistance of chickpea genotypes under field conditions. Inheritance of resistance to *Fusarium oxysporum* was studied in a set of crosses among six resistant CM-98, Aug-786, Bittal-98, Balksar-2000, Wanhar-2000, Punjab-2000 and one disease susceptible parent viz., AUG-424. F₁, F₂ and F₃ generations indicated that resistance was conferred by a single recessive allele at

the same locus in the six resistant parents. The resistance was successfully transferred from resistant parents to susceptible parent by hybridization and pedigree and bulk selection.

2.5 Genetic variability, heritability and genetic advance

Successful breeding programme for the crop improvement is largely related to availability to comprehensive information of the genetic architecture of plant characters to be improved. It would be worthy to quote that variability is the appraisal guiding a breeder to look forward for improving a crop species. For starting any improvement work, information about the genetic variability in the population is a prerequisite. Presence of high variability in this crop offers much scope for its improvement. Fisher (1918) was the first Scientist to partition variability into genotypic and environmental components.

A quantitative measure which provides information about correspondence between genotypic variance and phenotypic variance is heritability. This term was originally proposed by Lush (1943) to describe the ratio of variance due to hereditary differences (σ^2_g) to the total phenotypic variance (σ^2_p). This is expressed in per cent. If percentage is large, character is regarded as highly heritable. On the other hand, if it is smaller, environmental agency is considered as mainly responsible for phenotypic manifestation of the character.

Genetic advance is the improvement in genetic value of new population as compared with base population, depends among other things upon the magnitude of differences among genotypic value of individuals in the base population. If all or the most of the variability among the individual in the base population is attributable to non-heritable agencies, selection of phenotypically superior individuals from the population will not lead to improvement.

Makari *et al.* (2009) investigated the genetic diversity of ten different varieties of chilli using random amplified polymorphic DNA analysis (RAPD) analysis. Around 500 different bands were observed under UV light. Seven were polymorphic for a specific primer and can be used as differential marker.

A brief summary of review of literature pertaining to genetic variability heritability and genetic advance for yield and yield attributing characters is given in Table 1 and 2.

Table 1. Genetic variability for yield and yield attributing characters in chilli (*Capsicum annuum* L)

Sl. No.	Name of Scientist (s)	Year	Population	Genetic variability		
				High	Moderate	Low
1.	Adamu and Ado	1988	-	Fresh fruit weight 100-seed weight, fresh fruit yield per plant, fruit numbers per plant and dry fruit yield per plant	-	-
2.	Joshi	1988	-	Day to 75 per cent flowering, number of primary branches, days to first picking, early yield per plant, length of fruit, circumference of fruit, number of fruits per plant, average fruit weight and fruit yield per plant.		-
3.	Sahoo <i>et al.</i>	1990	-	Number of seeds per fruit, Dry fruit yield per plant and number of fruits per plant		-
4.	Manju and Sreelathakumary	2002	32 Accessions	Number of fruits per plant, fruit yield per plant, number of seeds per fruit and fruit weight		Days to first flower initiation
5.	Nandadevi and Hosmani	2003	26 Genotypes	Number of primary branches, fruit length, petiole length, number of fruits per plant and green fruit yield per plant.		-
6.	Neharu <i>et al.</i>	2003	-	-	Yield per plant	-
7.	Shreelathakumari and Rajmony	2003	20 Accessions	Fruit yield per plant, fruit weight, number of fruit per plant, fruit length and fruit girth.	-	Days to first flower initiation
8.	Shreelathakumary and Rajmony	2004	35 Accessions	Fruit yield per plant, leaf area, number of fruits per plant, fruit weight, fruit length and fruit girth.	-	-

Table 1. Contd....

Sl. No.	Name of Scientist (s)	Year	Population	Genetic variability		
				High	Moderate	Low
9.	Mini and Khedar	2004	25 Genotypes	Green fruit yield per plant, number of fruit per plant and fruit weight.	-	Days to first flower initiation
10.	Mishra, <i>et al.</i>	2004	22 Genotypes	Number of fruits per plant, 1000 seed yield and fruit length.	Fruit length, number of harvest, 1000 seed weight, plant height, petiole length, fruit weight, fruit diameter and number of branches.	50 per cent flowering
11.	Abu and Uguru	2006	10 Genotypes	Fruit length, single fruit weight and number of fruits per plant		-
12.	Johari and Kumar	2007	25 Genotypes	Yield per plant		Days to 50 per cent flowering and first harvest, number of primary branches, plant height, fruit length and width, number of fruits per plant, fruit weight, number of pickings.
13.	Farhad <i>et al.</i>	2008	45 Genotypes	Number of secondary and primary branches per plant and yield per plant.		Days to 50 per cent flowering, maturity, plant height, fruit length, girth and weight, number of fruits per plant, seeds per fruit, 100 seed weight, pedicel length.
14.	Patil <i>et al.</i>	2008	37 Genotypes		Matured ripe chilli yield	Plant height, primary branches, days to 50 per cent flowering, number of fruits per plant and dry chilli yield

Table 1. Contd....

Sl. No.	Name of Scientist (s)	Year	Population	Genetic variability		
				High	Moderate	Low
15.	Gupta <i>et al.</i>	2009	40 Hybrids	Number of fruits and fruit yield per plant and fruit weight and length		-
16.	Wilson and Philip	2009	44 Genotypes	Number of fruits and fruit yield per plant	-	Days to 50 per cent flowering
17.	Surya Kumari <i>et al.</i>	2010	94 Accessions	Number of fruits per plant, fresh fruit yield per plant, dry fruit yield per plant, 100 seed weight, number of seeds per fruit and capsanthin, capsaicin and oleoresin	Plant height, plant spread and fruit diameter	-
18.	Yedeta <i>et al.</i>	2011	20 Genotypes	Fruit yield and single fruit weight	-	Days to flower and days to maturity
19.	Sonia <i>et al.</i>	2011	19 Genotypes	Fruit yield and fruits per plant	-	-
20.	Lakshmi and Vijayapadma	2012	7 varieties	100 pod weight, number of pods per plant and plant height	-	-

Table 2. Heritability and genetic advance for yield and yield attributing characters in chilli (*Capsicum annuum* L.)

Sl. No.	Name of Scientist (s)	Year	Population	Genetic variability		Genetic Advance	
				High	Low	High	Low
1.	Thakur	1988	-	Days to first harvesting, fruit weight, plant height, number of branches per plant, number of fruits per plant, days to flowering.	-	-	-
2.	Sahoo <i>et al.</i>	1990	-	Number of seeds per fruit, dry fruit yield per plant and number of fruits per plant	-	Number of seeds per fruit, Dry fruit yield plant ⁻¹ and number of fruits per plant	Seed weight.
3.	Munju and Sreelathakumary	2002	32 Accession	Pollen viability, days to maturity, number of fruits per plant, fruit and pedicel length, fruit diameter, fruit weight, number of seeds per fruit, 1000 seed weight, fruit length, yield harvest per and number of harvest	Number of primary branches per plant.	Fruit yield per plant, Number of fruits per plant, Fruit weight, girth and length.	Days to first flower initiation.
4.	Nandadevi and Hosmani	2003	26 Genotypes	Fruit length and green fruit yield per plant.	-	-	-
5.	Neharu <i>et al.</i>	2003	-	Yield per plant.	-	-	-
6.	Shreelathakumari and Rajmony	2003	20 Accessions	Number of fruits per plant, fruit length, girth weight and yield per plant	-	Number of fruits per plant, fruit weight, length, girth, and yield per plant.	-
7.	Mini and Khedar	2004	25 Genotypes	Seed weight, fruit length and weight, number of fruits per plant and green fruit yield per plant.	-	Seed weight, fruit length, fruit weight, number of fruits per plant, and green fruit yield.	-
8.	Mishra, <i>et al.</i>	2004	22 Genotypes	Plant height, 50 per cent flowering, number of branches, fruit length, fruit diameter, fruit length, seed yield per plant, 1000 seed weight, number of fruits per plant, number of harvest, fruit weight and yield per plant.	-	Number of fruits per plant, fruit yield per plant, fruit length, 50 per cent flowering, 1000 seed weight and fruit weight.	-

Table 2. Contd....

Sl. No.	Name of Scientist (s)	Year	Population	Genetic variability		Genetic Advance	
				High	Low	High	Low
9.	Shreelathakumari and Rajmony	2004	35 Accessions	Fruit yield per plant, fruit length, fruit girth, fruit weight and number of fruits per plant.	-	Number of fruits per plant, fruit weight, length and girth and fruit yield per plant.	-
10.	Ukkund <i>et al.</i>	2007	8 Accessions	Plant height, days to first flowering, percent fruit set, number of fruits per plant, fruit length, ten fruit weight and total green fruits per plant.	-	Plant height, days to first flowering, percent fruit set, number of fruits per plant, fruit length, ten fruit weight and total green fruits per plant.	-
11.	Tembhurne <i>et al.</i>	2008	11 Genotypes	Number of fruits per plant and fruit girth		Number of fruits per plant	-
12.	Gupta <i>et al.</i>	2009	40 Hybrids	number of fruits per plant, fruit yield per plant, fruit length, fruit weight and capsaicin content	-	Number of fruits and fruit yield per plant and fruit weight and length	Days to 50% flowering
13.	Surya Kumari <i>et al.</i>	2010	94 accessions	Number of fruits per plant, fresh fruit yield per plant, dry fruit yield per plant, 100 seed weight, number of seeds per fruit and capsanthin, capsaicin and oleoresin	-	Number of fruits per plant, fresh fruit yield per plant, dry fruit yield per plant, 100 seed weight, number of seeds per fruit and capsanthin, capsaicin and oleoresin	-
14.	Sonia <i>et al.</i>	2011	19 Genotypes	Fruit yield per plant, fruits per plant, fruit length, fruit girth, pericarp thickness and average fruit weight	-	Fruit yield per plant, fruits per plant, fruit length, fruit girth, pericarp thickness and average fruit weight	-
15.	Yedeta <i>et al.</i>	2011	20 Genotypes	Pungency index	Stem diameter	Fruit weight	Days to 50 % maturity
16.	Lakshmi and Vijayapadma	2012	7 varieties	Plant height, number of branches per plant, number of pods per plant, pod length, 100 pod weight and green pod yield.	-	Plant height, number of branches per plant, number of pods per plant, pod length, 100 pod weight and green pod yield.	-

2.6 Correlation coefficient analysis

Depestre *et al.* (1985) observed positive correlation between total yield and number of fruits per plant, which suggest that this is the component with the highest effect on yield. As expected there was a negative correlation between number of fruits per plant and average fruit weight. There is a positive correlation among average fruit weight, fruit diameter and pericarp thickness on yield, which is a favorable effect as any of them increases.

Hex and Wang (1989) established positive correlation between fruit weight and fruit diameter, between pericarp weight and pericarp thickness while negative correlation between weight and length of the fruit.

Aliyu *et al.* (1991) reported significant positive relationship between fruit yield and fruit number, plant height, leaf number, and branch number. The correlation between fruit number and plant height, leaf number and branch number was also highly significant positive. Fruit diameter was positively correlated with plant height, leaf and branch number. Days to 50 per cent flowering was negatively correlated with other characters. Similarly, correlation between fruit length and fruit diameter was negative. The correlation between days to 50 per cent flowering and fruit yield, fruit number and leaf number was significant.

Thakur (1988) revealed genotypic correlation coefficients were higher than phenotypic ones. Environmental correlation coefficient was significant only between number of fruits per plant and total yield per plant. Plant height was having positive correlations with number of branches per plant, number of fruits per plant and yield per plant. While, number of branches per plant showed similar correlations with number of fruit per plant as well as yield per plant. Numbers of fruits per plant were significantly correlated with per yield. A significant correlation was found between days to first harvesting and early yield. Plant height, number of branches per plant, numbers of fruits per plant being closely associated with yield per plant are the major components contributing towards total yield,

Ahmed *et al.* (1997) reported that genotypic correlation coefficients were higher in magnitude than corresponding phenotypic correlation coefficients, indicating inherent association between various characters. Fruit yield exhibited highly significant positive correlation with number of fruits per plant, average fruit weight, plant height, plant spread and fruit length. Significant positive correlation were observed between fruit number and branch number per plant,

plant height and plant spread, plant height and fruit size (length and thickness), plant spread and fruit length, plant spread and average fruit weight, branch number and maturity, fruit length and fruit thickness, fruit length and average fruit weight, fruit thickness and pericarp thickness and fruit thickness and average fruit weight. On the contrary, days to maturity showed significant negative correlation with yield and yield components indicating its undesirable association.

Mamedov and Pyshnaja (2001) reported highly positive correlation of fruit weight with germination-flowering and germination-technical ripening negatively correlated with early yield. Early yield was positively correlated with fruit number and total yield. High positive correlation were also recorded by fruit weight with fruit length, fruit girth and pericarp thickness.

Sreelathakumary and Rajmony (2003) obtained higher genotypic correlation coefficient in magnitude than phenotypic correlation coefficient indicating a strong inherent association among various characters. The positive association of leaf area with days to first flower, fruit length, fruit girth, fruit weight and yield per plant suggested that the selection of genotypes with high leaf area would help in isolating lines with early flowering and high yield. Days to first flower were found to be negatively correlated with fruits per plant. Yield per plant showed highly significant positive correlation with fruits per plant, fruit length, fruit girth and fruit weight. Fruit length and fruit girth showed significant positive correlation with fruit weight.

Kumar *et al.* (2003) found that genotypic correlation coefficients were higher in magnitude than the corresponding phenotypic correlations coefficients indicating a strong inherent relationship between various characters. Yield per plant expressed significant positive correlation with number of primary branches, number of secondary branches and number of fruits per plant indicating that selection for bushy plants with more number of fruits per plant could lead to higher yield. Fruit length and fruit width showed significant positive correlation with fruit weight but all these three characters expressed significant negative correlation with number of fruits per plant. Capsaicin content exhibited significant positive association with number of fruits per plant and negative association with fruit width, fruit length and fruit weight whereas ascorbic acid content exhibited significant negative association with number fruits per plant and positive association with fruit width, fruit length and fruit weight. Moreover, capsaicin content and ascorbic acid content showed strong negative association with one another.

Nandadevi and Hosmani (2003) showed positive correlation with number of fruits per plant and pedicel length. High correlations of fruits per plant with fruit yield during all the three years were reported by Neharu *et al.* (2003). Todorava *et al.* (2003) reported correlation between the average fruit weight and the weight of the usable part in all cultivars and all years of cultivation was strong. The link between length and diameter of the fruit was inversely proportional.

Mathew *et al.* (2004) reported higher values of genotypic correlation coefficients compared to phenotypic coefficients. Yield was significantly positively correlated with fruit width, fruit length, single fruit weight, seed number, 1000 seed weight, and flower weight and highly positive significant correlation was observed with fruit number and fruit wall thickness. Days to first flower was found to be negatively correlated with fruits per plant, fruit length, and fruit yield where as yield per plant showed highly significant positive correlation with fruits per plant, fruit length, fruit girth and fruit weight. However, fruit length and fruit girth showed significant positive correlation with fruit weight (Sreelathakumary and Rajmony, 2004).

Kumar *et al.* (2005) showed that single fruit weight, number of fruits per plant and 100 seed weight are the most important traits governing fruit yield. Capsaicin contents of fruit were improved by applying selection pressure on number of seeds per fruit in the positive side whereas, single fruit weight in negative side. However, fruit yield per plant showed significant positive correlation with average fruit weight and fruit width (Ahmed *et al.*, 2006).

Sharma *et al.* (2007) reported higher magnitude of genotypic correlation coefficients than in their phenotypic counterparts for most of the traits reflecting the inherent relationship among the traits. Fruit yield per plant exhibited significant positive correlation with average fruit weight and seeds per fruit both at genotypic and phenotypic levels. Days to fifty per cent flowering showed significant positive association with days to first picking. On the other hand, days to fifty per cent flowering and days to first picking showed negative correlation with average fruit weight. The number of fruits per plant showed positive correlation with plant height. Average fruit weight had negatively associated with fruit length at genotypic levels only.

Farad *et al.* (2008) showed significant positive correlation of dry fruit yield per plant with number of secondary branches per plant, fruit girth, fruit weight, fruits per plant, seeds per fruit and 1000 seed weight.

Tembhurne *et al.* (2008) reported that the yield per plant was positively correlated with number of primary branches, number of secondary branches, days to 50 per cent flowering, fruit diameter, fruit weight and number of fruits per plant.

Pandit, *et al.* (2009) showed significant positive correlation of fruit yield per plant with fruit length, fruit pedicel length, number of fruits per plant, fruit weight and 1000 seed weight. Fruit weight was significantly positively correlated with number of seeds per plant and 1000 seed weight. Fruit yield per plant was positively correlated with number of fruits per plant and fruit length (Gupta *et al.*, 2009). Yield was positively correlated with fruit diameter, fresh fruit weight, and dry fruit weight (Tembhurne *et al.*, 2009). Strong correlation was recorded for trait number of fruits per plant with fresh fruit yield per plant (Naidu *et al.*, 2009).

Wilson and Philip (2009) recorded higher genotypic correlation coefficient than phenotypic correlation coefficient. Yield per plant exhibited significant positive association with fruits per plant, fruit length, fruit weight, 100 seed weight, plant height, and negatively correlated with 50 per cent flowering.

Surya Kumari *et al.* (2011) showed dry fruit yield per plant was significant and positive association with plant height, plant spread, number of fruits per plant, fruit girth, seeds per fruit and capsanthin content.

Karima *et al.* (2012) revealed that correlation analysis for both yield plant⁻¹ and placenta weight was positively correlated with the number of fruits plant⁻¹. While, fruit diameter and fruit wall thickness were negatively correlated with fruit length. No significant correlation was observed between plant height and the other characters assessed.

Ahmed *et al.* (2013) studied thirty five genotypically diverse indigenous genotypes of brinjal for eight important characters for character association. The phenotypic and genotypic association of fruit yield was significantly positive with number of fruits per plant, fruit weight and fruit width, whereas plant height, plant spread, number of primary branches and fruit length was non-significantly negatively associated.

2.7 Path coefficient analysis

A path coefficient analysis is simply a standardized partial regression coefficient and as such measures the direct influence of one variable upon another and permits the separation of the correlation coefficient into component of direct and indirect effects. The use of the methods requires a cause and effect situation among the variables, and the experimenter must assign direction in the casual system based up on a priory grounds or experimental evidence. The method of “path coefficients” proved useful in analyzing correlation coefficients in this system of interrelated variables. Description of the technique was first published by Wright (1921)

Olimpia and Gomez (1988) reported that there were high direct effects of mean fruit weight, number of fruits per plant and fruit width on yield pointing out the importance of these characters in pepper breeding. Yield in chilli pepper was directly contributed by number of fruits per plant and the mean fruit weight (Depestre and Gomez, 1992).

Ahmed *et al.* (1997) revealed that fruit thickness and days to maturity has negative direct effect on the yield. Among different yield components, the fruit number per plant, plant height, average fruit weight, fruit length, plant spread, pericarp thickness and branch number had a positive direct effect towards fruit yield. The number of branches per plant showed highly indirect positive effect via fruit number per plant towards fruit yield. The residual effect indicated that the components under study accounted for about 93 per cent variability in the yield.

Kumar *et al.* (2003) exhibited that fruit length and number of fruits per plant had higher degree of direct effects, followed by fruit width and days to first fruit harvest on fruit yield. The direct effect of number of fruits per plant was high in magnitude that counteracted its negative indirect effects through fruit length and fruit width. The two biochemical characters, capsaicin content and ascorbic acid were inversely related to each other and any improvement in one of the trait would always affect the other. The number of fruits per plant had maximum direct positive effect on fruit yield per plant, followed by fruit weight at edible maturity and fruit diameter at phenotypic level and at genotypic level, maximum direct positive contribution was made by the number of fruits per plant followed by fruit diameter, pedicel length and fruit weight at edible maturity (Mishra *et al.*, 2003).

Nandadevi and Hosmani (2003) revealed the importance of number of fruits per plant in determining selection criteria for improvement of chilli yield as it had maximum direct effect on yield followed by pedicel length and pericarp thickness. Low negative direct effect of fruit weight was observed with yield per plant due to indirect negative association with number of fruits per plant.

Sreelathakumary and Rajmony (2003) revealed that fruits per plant, fruit length, plant height and stem girth had shown positive direct effect on yield while leaf area, days to first flower, fruit girth and fruit weight had exerted negative direct effect on yield. The direct effect of fruits per plant was positive and much higher than its genotypic correlation with yield. Though the direct effect of fruit girth and fruit weight was negative, its indirect effect through fruits per plant and fruit length was highly positive indicating that indirect selection for fruit length and fruits per plant can increase yield.

Mathew *et al.* (2004) revealed the high direct positive effect of recovery ratio on dry fruit yield. Recovery ratio also a positive indirect effect through flower weight, fruit width, fruit length and their indirect effect through fresh fruit yield and fruit numbers for dry fruit yield. Fruit number had a direct positive effect on dry fruit yield and its indirect positive effect through fresh fruit yield, recovery ratio, fruit wall thickness, single fruit weight and seed number. Number of fruits per plant, fruit weight, fruit girth, and plant height, had shown positive direct effect while stem girth, leaf area, days to first flower and fruit length, had exerted negative direct effect on yield (Sreelathakumary and Rajmony, 2004).

Higher direct positive effects were shown by average fruit weight followed by fruits per plant, fruit width, days to first picking, and seeds per fruit with fruit yield Nazeer *et al.* (2005). Higher direct positive effects were also shown by average fruit weight followed by fruits per plant, fruit width with fruit yield (Sharma *et al.*, 2007). Fruits per plant and fruit weight exerted the highest positive direct effect both at genotypic and phenotypic levels (Farad *et al.*, 2008).

Pandit *et al.* (2009) recorded the highest direct positive effects of fruits plant⁻¹ and 1000 seed weight on yield.

Shrilekha *et al.* (2010) revealed that the number of primary branches per plant was found to be the premium direct contributor to the capsaicin content followed by fruit length. Fruit diameter exhibited the third highest direct effects. The fruit surface area

added to the capsaicin content indirectly *via* fruit length and fruit weight. Primary branches per plant and days to first flowering emerged as a reliable component in selection criterion for breeding high capsaicin content in chilli (*Capsicum annuum* L.).

Surya Kumari *et al.* (2011) revealed that number of fruits per plant had the highest positive direct effect on dry fruit yield per plant. Number of fruits per plant, plant height, plant spread, number of seeds per fruit, days to maturity and capsanthin content (in the given order) were important yield and quality components having direct bearing on dry fruit yield and hence can be considered while breeding for improved yield in paprika.

Hasanuzzaman and Faruq (2011) recorded the direct effect of number of fruits per plant very close to correlation value and five different characters were involved to indirect positive effect. At genotypic level, the direct effect was closer to correlation value and indirect positive effect was acting through seven different characters. Selection should be done through number of fruits per plant. The residual effect of path analysis was 0.21 at genotypic level indicated all the important traits had been considered.

Ahmed *et al.* (2013) revealed that the highest positive direct effect (0.700) on fruit yield followed by number of fruits per plant (0.653), plant spread (0.053), fruit width (0.052), fruit length (0.030), whereas plant height (−0.153) showed negative direct effects on fruit yield per plant for genotypic path coefficient. Overall the path analysis confined that direct effect of fruit weight, number of fruits per plant, plant spread, fruit width, fruit length and number of primary branches, whereas indirect effect of plant height should be considered simultaneously for amenability in fruit yield of brinjal.

2.8 Screening of genotypes against powdery mildew (*Leveillula taurica*) of chilli

Blazquez (1976) reported that, out of ten diverse (Pungent and Non pungent) chilli genotypes screened, most of the non pungent genotypes were resistant to powdery mildew. Ullasa *et al.* (1981) classified that, out of 298 genotypes of *Capsicum* spp. evaluated, six were resistant and thirteen were moderately resistant to *Leveillula taurica*. *Capsicum microcarpum* was resistant to *L. taurica* and *Cercospora capsici*, While, *C. annuum* (PI 288982) was resistant to *L. taurica* and *Colletotrichum capsici*.

Deshpande *et al.* (1985) screened 33 accessions of six *Capsicum* spp. (other than *C. annuum*) and found that *C. baccatum* var *pendulum* had good resistance for powdery mildew. Kunouski and Todorova (1985) reported that, of 27 forms of *Capsicum annuum*,

other *Capsicum* spp. and various related species studied under artificial infection, high to moderate resistance was shown by forms of *C. chinense*, *C. eximium*, *C. frutescens*, *C. minimum*, *C. pendulum*, *C. praetense* and *C. pubescens*. Some mutant lines of *C. annuum* had good resistance.

Muneem *et al.* (1995) evaluated 150 collections of chilli for powdery mildew and observed that IC 99910, IC 99912, IC 92150, P-1718, P-1939, N-1015, EC –362901, EC 362910, EC 362913, EC 362925, EC 362934, EC 362935 and EEC 3637 were free from powdery mildew. Evaluation of 13 *Capsicum* cultivars against *L. taurica* by Allagui *et al.* (1995) at Tunisia revealed that, the evaluation was more relevant at the end than during the growing period. Most of the local Tunisian cultivars were susceptible and only two haplodiploid lines showed high resistance to powdery mildew.

Murthy and Deshpande (1997) studied genetics of powdery mildew resistance by using two powdery mildew resistant parents (PMR – 10/95 K and IIHR –1238), and came to conclusion that, powdery mildew resistance is dominant and polygenically controlled.

Iqbal *et al.* (1998) tested fifteen cultivars of pea for resistance against powdery mildew under rainfed conditions of natural infection. None of the lines were highly resistant to the disease. However, one cultivar "Rondo" reacted resistant response and four other lines showed moderately resistant reaction while all the rest were susceptible.

Lee–Okhee *et al.* (2001) evaluated a total of 238 accessions of chilli for resistance to powdery mildew. The germplasms viz., KC –604, 605, 606 and 608 of *C. baccatum*, KC 616 of *C. chinense*, and KC 638,640, 641, 642, 643 and 644 of *C. pubescens* were highly resistant and remained disease free.

Ali *et al.* (2002) screened various pea genotypes viz., Rondo, Novana, Dasan, Kohat local, Climax, Hungry Red Peas, Meteor and Green Feast against powdery mildew. Infestation of powdery mildew was found maximum on cultivar climax (90%); while minimum on cultivar Meteor (0.1%). The literature pertaining to resistant sources are presented in tabular form.

De Souza *et al.* (2003) studied resistance to *L. taurica* in *Capsicum* by evaluating 162 genotypes and reported that, *C. baccatum*, *C. chinense* and *C. frutescens* were most often resistant, indicating that resistance to *L. taurica* among *Capsicum* species is found mainly outside the *C. annuum* taxon.

Resistant sources against powdery mildew of chilli.

Sl. No.	Resistant varieties	References
1.	S-32, local, kalyanpuri red, Dondaicha	Pawar <i>et al.</i> (1985)
2.	Puri orange-2, EC-21660, puri red, EC-31308, EC34242 puriorange-1	Bidari <i>et al.</i> (1985)
3.	B15, R7, Padasali, Tinwari	Singh and Lodha (1985)
4.	IHR-703	Anand <i>et al.</i> (1987)
5.	PMR-45, PMR-70, PMR-68, PMR-59	Mulge (1992)
6.	HV-12	Shifris <i>et al.</i> (1992)
7.	CV IHR 517 A	Chander (1994)

Pandravada *et al.* (2007) screened 174 accessions of chilli originated from 12 countries against powdery mildew under the natural field conditions to identify sources of resistance. NIC-23906 was found to be the most field promising accession against powdery mildew under the resistant category. This field promising accession would most certainly be useful in developing disease resistant cultivars having good agronomic traits and highly productive

Khiavi *et al.* (2010) evaluated fourteen grape varieties for testing powdery mildew (*Uncinula necator*) resistance under natural infection conditions and artificial inoculation methods. Cultivars such as Shahani, Yagothi and Tabrizkishmishi were immune, Sahibi cultivar was highly resistant, Agshilig and Tokoulgan were resistant, Kishmishi, Khalili and Tabarzeh cultivars were tolerant, Aldarag and Koupakbogan were susceptible and Garashilig, Seyrakpousteh and Rasmi cultivars were highly susceptible to disease.

Belete *et al.* (2012) evaluated total of 17 pepper genotypes against powdery mildew (*Leveillula taurica*) in field experiments. Starting seven days after transplanting, plants in each plot were monitored for diseases symptoms and infection. Data were collected on incidence and severity of powdery mildew. Besides the area under disease progress curve (AUDPC) were calculated. Powdery mildew disease and yield parameters differed significantly among the tested genotypes. The majority of the genotypes were moderately resistance to susceptible to *L. taurica*, none of the genotypes was found to be immune.

2.9 Screening of chilli genotypes for fruit borer (*Helicoverpa armigera*)

Mishra *et al.* (1987) screened 46 eggplant varieties for resistance to egg plant shoot and fruit borer, *Leucinodes orbonalis* Guen., variety Katrain-4 (long-fruited) was graded as highly resistant, recording lowest fruit damage (1.74%). However, it was found significantly on par with other eight long-fruited varieties namely, Madrak, Junagarth Long, PPC, Arka Sheel, Mukta Keshi, Annamalai, White Long and ARU-1 with respect to percent fruit damage. Variety T-3 (round-fruited) recorded maximum fruit damage (53.24%) and graded as highly susceptible. However, it was found significantly at par with other three varieties namely, Kalyanpur-202-9, ARU-2 C, Punjab Sel-1 in respect to percent fruit damage.

Kakar *et al.* (1990) evaluated seventy genotypes and cultivars of tomato, one stamenless variety, one variety of *Lycopersicon esculentum* and 31 crossed between promising and commercial cultivars against the noctuid *Heliothis armigera* [*Helicoverpa armigera*]. However, the genotype 122775 and the cross Rick x Solan Gola not attacked by fruit borer were considered as resistant.

Lal (1991) screened 21 cultivars of eggplant (*Solanum melongena* L) under field conditions against the shoot and fruit borer *Leucinodes orbonalis*. The damage ranged from 9-66.33 per cent on fruit number basis and 9.5-87.41 per cent on fruit weight basis. According to the infestation on fruit number basis, Sm.-202 was found highly resistant while Pusa Purple Custer, Sm. 17-4, P.Br. 129-5 and Sm.-202 x PPI showed fairly resistant. However, cultivars viz., Ramy round purple, Arka navneet, Ram nagar giant and Pusa purple round showed susceptible to fruit borer incidence.

Parvez *et al.* (1996) evaluated twenty test lines of chickpea against gram pod borer, *Helicoverpa armigera* (Hb.). However, cultivars i.e. 549 and 600 were showed resistant to *H. armigera* (Hb.). Four cultivars viz., 620, 662, C-727 and 905 considered as moderately resistant to the pest while rest of the cultivars were moderately susceptible. Though, a cultivar, 801 was found to be moderately susceptible but it gave highest yield.

Hossain *et al.* (2002) screened twenty varieties and lines of brinjal for resistance to shoot and fruit borer *Leucinodes orbonalis* (Pyralidae: Lepidoptera) infestation in the field conditions. The lines viz., Nayankajal, BLO95, BL085, BLO98, BLO114, Khotkhotia-2, Borka, Laffa, Islampuri, BLO45, Dhohazari-2, BLO101, Dhohazari-I,

Khotkhotia-1, BLO96, Sada ball, Singnath, Uttara, Baromashi and Jhumki were registered as resistant to moderately resistant to fruit borer attack.

Khanam *et al.* (2003) screened thirty tomato varieties/lines to tomato fruit borer, *Helicoverpa armigera*. The varieties/lines, V-29 and V-282 were found moderately resistant and susceptible reaction, respectively.

Shankarnag and Madalageri (2005) screened the 30 F₁ hybrids (developed using six cytoplasmic genic male sterile lines viz., MSY-1A, MSY-2A, MSY-3A, MSP-4A, MSP-5A and MSC-6A and five testers, such as Arka Lohith, PMR-5-34, Hisar Shakthi, Anagi and Pant CI) and their parents for resistance against fruit borer *H. armigera* incidence under natural epiphytotic condition. Among the parents, the percentage fruit borer incidence ranged from 2.60 (PMR-5-34) to 16.40 (Arka Lohith) with six parents exhibiting resistant reaction. The percentage borer infestation among the crosses varied from 0.00 (MSY-3A × Anagi) to 33.32 (MSP-5A × Arka Lohith) with 50 per cent of the crosses registering resistant reaction.

Shivaramu and Kulkarni (2008) screened thirty three genotypes for resistance to fruit borer *Helicoverpa armigera* (Hubner) under field conditions. The seven selected genotypes of chilli and *capsicum* were SL-37, Arka Lohith, Purired, Devarhippargi, TC-1, Button and H.C.-28 were grouped as resistant. However, the six genotypes viz., Agni, CA-960, LCA-312, California Wonder, North-Hira and PAU-101 recorded more than 48.7 percent fruit borer damage were grouped as highly susceptible. The remaining 20 genotypes were rated as susceptible.

Sajjad *et al.* (2011) evaluated tomato genotypes to identify resistant/susceptible genotypes against the fruit borer. Roma VF, NARC-1 and FS-8002 were categorized as susceptible, whereas, the genotypes viz., Sahil, Pakit and Nova Mecb were declared as resistant genotypes to tomato fruit borer.

Suresh *et al.* (2013) evaluated 13 tomato hybrid varieties against the fruit borer (*Helicoverpa armigera*) infestation. None of the varieties were found to be highly resistant. Two varieties, viz., NS-538 and Shaktiman were least infested and classified as resistant varieties. Nine varieties viz., NS-501, Lakshmi, Shahenshah and NS-815, All rounder, Manithoibi, Manileima, Ms (Marglobe supreme) and American apple were graded as moderately resistant. Two varieties viz., Dev and Manikhumnu were graded as moderately susceptible.

III. MATERIAL AND METHODS

The present investigation on *Fusarium* wilt of chilli was carried out during 2012-2013 at the Department of Plant Pathology, Department of Genetics and Plant Breeding and Agriculture college farm, Raichur. Raichur is situated in North Eastern dry zone (Zone 2) of Karnataka state at 16° 11' N latitude, 77° 20' East longitude with an altitude of 389 meter above the mean sea level. The details of the materials used and methodology followed during the course of investigation are described in this chapter.

3.1 General Laboratory Procedure

3.1.1 Glassware cleaning

For all laboratory experimental studies, Corning and Borosil glassware's were used. The glass wares were kept in cleaning solution for 24 hours, containing 60 g of Potassium dichromate ($K_2Cr_2O_7$), 60.0 ml of concentrated Sulphuric acid (H_2SO_4) in 1000 ml of water. They were washed with vim powder followed by washing in running tap water and then rinsed in distilled water before use.

3.1.2 Sterilization

All glasswares, solid and liquid media were subjected to sterilization by autoclaving at 1.1 kg/cm² (121.6 °C) for 20 minutes. The plant tissues were surface sterilized in 1:1000 mercuric chloride solution followed by three changes in sterile water. All cultural studies were conducted in aseptic condition under laminar flow. The tips of inoculation needle, forceps and cork borers were sterilized under flame.

3.2 Collection and maintenance of the *Fusarium* culture

The fungus *Fusarium solani* was collected from Department of Plant Pathology Agriculture College Raichur and sub cultured on PDA slants and allowed to grow at $28 \pm 1^\circ$ C for fifteen days. Such slants were preserved in refrigerator at 5° C and maintained by sub culturing once in a month. Such culture was used throughout the study.

3.2.1 Mass multiplication of *Fusarium* on PDA

Test fungus was multiplied on potato dextrose agar (PDA) in petri plates. Conidia and mycelium were harvested after ten days growth by flooding the petri plates with

sterile water and dislodged the conidia and mycelium bits into water by using camel hair brush. The spore suspension thus obtained was used for experiments.

3.2.2 Multiplication of *Fusarium* on PDB

The fungus was mass multiplied on potato dextrose broth (PDB). 100 ml of PDB was taken into 250 ml Borosil conical flask and autoclaved at 1.1 kg/cm² for 20 minutes. The mycelial disc cut from the margin of a week old culture grown on Petri dish was inoculated into PDB under aseptic conditions. The flasks were incubated at 28±1⁰ C for 15 days. The mycelium mats were collected after 15 days by filtering with Whatman No 42 filter paper disc of 12.5 cm diameter and washed with sterile water and used for further experiments. The spore suspension was prepared using waring blender to disturb the spores in sterile water and filtered through cheese-cloth before use and spore load ml⁻¹ was computed by using a Haemocytometer.

3.3 Pathogenicity test

The pathogenicity test was conducted using three methods viz., seed inoculation technique, sick pot and rapid root dip transplanting technique, using F25 isolate obtained from Department of Plant Pathology, University of Agricultural Sciences, Raichur.

3.3.1 Seed inoculation technique

Apparently healthy seeds were collected and surface sterilized with mercuric chloride (0.1%). The seeds were dipped in *Fusarium solani* spore suspension (Concentration of 1x10⁷ conidia ml⁻¹) for 12 hours, there after they were sown in pots containing sterilized soil. Twenty seeds in each replication and one control were maintained. Data on per cent wilt incidence was recorded.

3.3.2 Rapid root dip transplanting technique

Rapid root dip transplanting technique method developed by Naik *et al.* (1996) was followed. Chilli seedlings were raised in a plastic trays containing sterilized sand in a nylon net house and protected with two insecticidal sprays of Melathion (0.1%) and Monocrotophos (0.05%) to prevent the viral disease. Three weeks old seedlings were removed, roots thoroughly washed in running tap water and three mm tip of roots were cut and immersed in spore suspension of *F. solani* and planted in a plastic tray containing sterilized soil. Then plants were planted in each row with three replications and one

uninoculated control (without dipping in spore suspension) was maintained. In cases where isolates produced typical wilting symptoms, the fungus was successfully re-isolated and Koch's postulates proved.

3.3.3 Sick pot technique

Chilli seeds were surface sterilized with HgCl₂ (0.1%) for one minute and washed repeatedly thrice in sterile water to remove the traces of HgCl₂ and planted in sick pot containing *F.solani*. The sick pots were prepared by using *Fusarium* colonized sorghum grain described above. The uninoculated pot was kept as control. Three replications were maintained. In cases where isolates produced typical wilting symptoms, the fungus was successfully re-isolated and Koch's postulates proved.

3.3.4 Growth of *F. solani* on PDA solid media

1. Potato dextrose agar (PDA). The composition of PDA is as follows.

Peeled potato	: 200.0 g
Dextrose	: 20.0 g
Agar-agar	: 20.0 g
Distilled water	: 1000.0 ml (volume to make up)

Two hundred gram of peeled potatoes were cut into small bits and boiled in distilled water and the extract was collected by filtering through muslin cloth. Dextrose of 20.0 g and agar 20.0 g each were dissolved in the potato extract and the final volume was made up to 1000 ml with distilled water and sterilized as described earlier and preserved for further use.

3.4 Screening of chilli genotypes/hybrids against *F. solani* (F25)

Germplasms collected from various institutes of India were evaluated against *Fusarium* wilt using seed inoculation technique, sick pot technique and rapid root dip transplanting technique (Naik *et al.*, 1996). List of chilli genotypes used for screening against *F. solani* is presented in Table 1.

3.4.1 Computation of disease index

The disease incidence was computed by taking into consideration of pre-emergence and post-emergence seedling death.

Pre-emergence and post-emergence seedling death was calculated by using formula.

$$\text{Pre emergence seedling death} = \frac{\text{Number of seedlings emerged in healthy soil} - \text{Number of seedling emerged in sick soil}}{\text{Number of seedling emerged in healthy soil}} \times 100$$

$$\text{Post emergence seedling wilt} = \frac{\text{Number of seedlings wilted}}{\text{Number of seedlings emerged}} \times 100$$

3.5 Methodology

The experimental material for *Fusarium* wilt study consists of three CMS lines, two maintainer lines and 56 restorer lines (Table 3 and 4). Fifty six restorer lines were screened for resistance to *Fusarium* wilt. Six lines were selected based on their survival per cent for *Fusarium* wilt and crossed with three CMS lines and two maintainer lines to produce 30 CMS based F₁ hybrids in line x tester fashion (Kempthorne, 1957). While, eight non CMS based F₁ hybrids were also developed. These 38 F₁ hybrids were evaluated for resistance to *Fusarium* wilt using rapid root dip transplanting technique and pot culture technique.

Fifty six restorer lines were screened for *Fusarium* wilt resistance in lab condition by seed inoculation technique and rapid root-dip transplanting technique. Chilli seeds were selected, surface sterilized with mercuric chloride (0.1%) and raised in plastic trays containing sterilized soil. Three weeks old seedlings were uprooted, roots were washed thoroughly in running tap water and 3mm tip of roots were cut and immersed in spore suspension of *Fusarium solani* and planted in trays. Data on per cent disease incidence (PDI) was recorded. The screening was repeated for resistance to *Fusarium* wilt using pot culture as well as sorghum giant culture technique.

Table 3. Three available cytoplasmic male sterile lines along with their maintainers

Sl. No.	Male sterile Lines	Maintainer lines	Source	Characterization
1.	JNA1	JNB1	JNKVV, Jabalpur	Resistance to powdery mildew
2.	ACA1	ACB1	UAS, Dharwad	Tolerance to leaf curl
3.	JNA2	-	UAS, Dharwad	Tolerance to leaf curl

Table 4. List of selected restorer lines for identification of *Fusarium* wilt resistance

Sr. No.	Genotypes	Source	Characterization
1.	9608D	UAS, Dharwad	Fruiting downward, fruits dark green, Low pungent.
2.	K1-4DS	UAS, Dharwad	Tolerant to leaf curl, fruits in cluster.
3.	P3	-	Yellow colour anthers and broad fruits
4.	Sankeshwar	MPKV, Rahuri	Fruits long (20-30 cm), Retain red colour.
5.	Phule Jyoti	MPKV, Rahuri	Tolerant to leaf curl and powdery mildew, resistant to lodging.
6.	Hisar vijay	Hisar	Fruits borne in clusters upright, pungent.
7.	JM-218	JNKVV, Jabalpur	Tolerant to leaf curl and powdery mildew.
8.	Pant-C1	GBPAU, Panthnagar	Highly pungent, tolerant to mosaic & leaf curl.
9.	G-4	RARS, Lam, Guntur	Fairly tolerant to pest & disease, wider Adaptability.
10.	H0413	UAS, Dharwad	Highly pungent, suitable for single picking.
11.	K1-4C	UAS, Dharwad	Tolerant to leaf curl, fruits in cluster.
12.	9608-U	UAS, Dharwad	Fruiting skyward, fruits dark green, Low pungent.
13.	BVC-1	UAS, Dharwad	Fruits long 10-12 cm, dark red colour, moderately pungent.
14.	GUK-1	UAS, Dharwad	Tolerant to leaf curl, moderately pungent.
15.	GUK-2	UAS, Dharwad	Tolerant to leaf curl, dark red colour.
16.	GUK-2-1	UAS, Dharwad	Tolerant to leaf curl, dark red colour.
17.	GUK2-1-1	UAS, Dharwad	Tolerant to leaf curl, dark red colour.
18.	IC119243	UAS, Dharwad	Highly pungent, tolerant to leaf curl.
19.	IC112109	UAS, Dharwad	Highly pungent, tolerant to leaf curl.
20.	IC119578	UAS, Dharwad	Highly pungent, tolerant to leaf curl.
21.	IC119561	UAS, Dharwad	Highly pungent, tolerant to leaf curl.
22.	LCA 235	RARS, Lam, Guntur	Export quality, Red colour
23.	LCA 304	RARS, Lam, Guntur	Red colour
24.	LCA 310	RARS, Lam, Guntur	Red colour, Long fruit
25.	LCA 310A	RARS, Lam, Guntur	Early maturity
26.	LCA 334	RARS, Lam, Guntur	Highly pungent
27.	LCA 960	RARS, Lam, Guntur	Red colour,
28.	BVC-37	UAS, Dharwad	Red color, low pungency, leaf curl resistant
29.	ACB1	JNKVV, Jabalpur	Medium sized fruits and red in colour

Table 4. Contd...

Sr. No.	Genotypes	Source	Characterization
30.	RAJPUT	Jabalpur	High pungency, fruits are small and yellow in color.
31.	JNB1	JNKVV, Jabalpur	Small fruits
32.	GPC 82	UAS, Dharwad	Wider adaptability, leaf curl tol.
33.	D. DABBI	UAS, Dharwad	Dark red colour, low pungency, resistance to leaf curl.
34.	KDSC-210-10-1	UAS, Dharwad	Dark red colour, low pungency, resistance to leaf curl.
35.	KDSC-210-10-2	UAS, Dharwad	Dark red colour, low pungency, resistance to leaf curl.
36.	KDSC-210-10-3	UAS, Dharwad	Dark red colour, low pungency, resistance to leaf curl.
37.	KDSC-210-10-4	UAS, Dharwad	Dark red colour, low pungency, resistance to leaf curl.
38.	KDSC-210-10	UAS, Dharwad	Dark red colour, low pungency, resistance to leaf curl.
39.	KDSC-510-10-1	UAS, Dharwad	Dark red colour, low pungency, resistance to leaf curl.
40.	KDSC-510-10-2	UAS, Dharwad	Dark red colour, low pungency, resistance to leaf curl.
41.	KDSC-510-10	UAS, Dharwad	Dark red colour, low pungency, resistance to leaf curl.
42.	HCS-3	UAS, Dharwad	Dark red colour, low pungency,
43.	SUM05-2R	UAS, Dharwad	Tolerant to leaf curl
44.	JM 283	JNKVV, Jabalpur	Tolerant to leaf curl and fruit rot
45.	P. Jwala	JNKVV, Jabalpur	Highly pungent, Fruits skywar
46.	KA-2	IIVR, Varanasi	Medium long (long 6.5-7 cm)
47.	K1-4D	UAS, Dharwad	Tolerant to leaf curl
48.	HMT-1	UAS, Dharwad	Red colour, leaf curl tol.
49.	B.KADDI	UAS, Dharwad	Export quality, Mildly pungent,
50.	JAYANTI	MPKV, Rahuri	Resistance to Anthracnose,
51.	GCV 111	JNKVV, Jabalpur	Long fruit (15 cm)
52.	GCV 121 Res	JNKVV, Jabalpur	Red colour
53.	SADABAHAR	IARI, New Delhi	Fruits born in bunches of 6-9
54.	AVNPC 131	JNKVV, Jabalpur	Dark Red colour
55.	X-235	RARS, Lam	Turning red up on ripening
56.	B. DABBI	UAS, Dharwad	Export quality, Mildly pungent

3.6 Yield performance of genotypes and hybrids

3.6.1 Experimental material

The experimental material for the present study consists of twenty three genotypes and five hybrids.

3.6.2 Layout of experiment

Twenty three genotypes and five hybrids were sown in raised seed bed in the month of July 2012 and transplanted in August 2012 in the main field using Randomized Complete Block Design (RCBD) with three replications consisting of two rows of 10 plants each. A spacing of 60 cm x 60 cm followed and the crop was raised as per the recommended package of practices.

3.6.3 Recording of observations

Five representative plants per genotype were selected randomly, tagged and observations were recorded on these plants for different characters as described below. The data recorded on five plants per genotype was averaged for use in statistical analysis.

3.6.3.1 Days to 50 per cent flowering

It was recorded by counting the number of days after transplanting (DAT) to 50 per cent anthesis.

3.6.3.2 Plant height (cm)

Height of the plant in centimeters from ground level to tip of plant at harvest was recorded using a meter scale.

3.6.3.3 Number of primary branches per plant

Number of branches arising from the main stem above the ground level at harvest was recorded and expressed in numbers.

3.6.3.4 Number of secondary branches per plant

Number of secondary branches arising from the primary branches was recorded at harvest and expressed in number.

3.6.3.5 Closed stigma

Recorded the number of closed stigma by taking 20 flowers of five plants and converted into per cent.

3.6.3.6 Opened stigma

Recorded the number of opened stigma by taking 20 flowers of five plants and converted into per cent.

3.6.3.7 Days to fifty per cent maturity

It was recorded by counting the number of Days After Transplanting (DAT) to 50 per cent fruit maturity.

3.6.3.8 Fruit length (cm)

Average fruit length of five fruits from three plants was measured from tip to the base of the fruit and expressed in centimeters.

3.6.3.9 Fruit diameter (mm)

Average diameter of five fruits from three plants was measured at the widest point/shoulder in centimeters.

3.6.3.10 Number of fruits per plant

Number of fruits per plant were counted at each picking and added to get total number of fruits per plant.

3.6.3.11 Green fruit weight (g)

Weight of five green fruits from each of the randomly selected five plants was recorded in grams and average fruit weight in gram was worked out.

3.6.3.12 Dry fruit weight (g)

The matured red fruits harvested on five randomly selected plants were dried, weight was recorded in grams and average fruit weight in gram was worked out.

3.6.3.13 Green fruit yield (g plant⁻¹)

The green fruits harvested on five randomly selected plants, weight was taken and averaged, which was recorded as green fruit yield per plant in grams.

3.6.3.14 Dry fruit yield (g plant⁻¹)

The matured red fruits harvested on five randomly selected plants were dried and the weight was taken and averaged, which was recorded as dry fruit yield per plant in grams.

3.6.3.15 Number of seeds per fruit

Seeds were extracted and counted carefully from the five matured fruits and average number of seeds per fruit was recorded.

3.6.3.16 Test weight (1000 seeds in g)

Seeds from the randomly selected 5 fruits were extracted and thousand seeds were counted and their test weight was recorded.

3.7 Statistical analysis

The data was collected on randomly selected five plants per replication for each character and subjected to various statistical analyses. It involves the analysis of variance and computation of mean performance, estimation of phenotypic and genotypic correlations and path coefficient analysis.

3.7.1 Variability analysis

The mean, range and coefficient of variation were calculated cross wise separately for each environment.

3.7.1.2 Arithmetic mean

The arithmetic mean of each character was calculated by dividing the totals by the corresponding number of observation.

$$\bar{X} = \sum^n X_i / n$$

where,

$\bar{X}$ = Mean value of the characters

X_i = Value of the i^{th} observation

n = Total number of observations

3.7.1.3 Range

The lowest and the highest value for each character were taken as the range.

3.7.1.4 Coefficient of variation

Genotypic and phenotypic coefficient of variation was computed using the formula given by Burton (1952).

$$\text{Genotypic coefficient of variation (\%)} = \frac{\text{Genotypic standard deviation}}{\text{General mean}} \times 100$$

$$\text{Phenotypic coefficient of variation (\%)} = \frac{\text{Phenotypic standard deviation}}{\text{General mean}} \times 100$$

3.7.1.5 Heritability

Broad sense heritability [$h^2(\text{bs})$] was calculated using the formula given by Singh and Chaudhary (1985).

$$h^2(\text{bs}) = \frac{\sigma^2_p}{\sigma^2_g} \times 100$$

Where,

$h^2(\text{bs})$ = heritability (broad sense)

σ^2_g = genotypic variance

σ^2_p = phenotypic variance

3.7.1.6 Expected genetic advance and genetic advance per cent to mean

The expected genetic advance (GA) was calculated as suggested by Johnson *et al.* (1955).

$$GA = K.h^2. \sqrt{V_p}$$

where,

K = selection differential in standard unit

h^2 = heritability in broad sense

V_p = phenotypic standard deviation

Genetic advance as per cent mean was calculated as

$$GA \% \text{ mean} = \frac{GA}{\text{Mean}} \times 100$$

3.7.1.7 Correlation

Simple correlation coefficients among the yield and its components were calculated in parents and F₁ hybrids in each environment separately as per formula suggested by Miller *et al.* (1958) as

$$r_{x_i x_j} = \frac{\text{Cov } x_i x_j}{\sqrt{V(x_i)V(x_j)}}$$

where, $r_{x_i x_j}$ = Coefficient of correlation between characters x_i and x_j

$V(x_i)$ = Variance of i^{th} character

$V(x_j)$ = Variance of j^{th} character

3.7.1.8 Path coefficient analysis

The direct and indirect contribution of various characters to yield were calculated through path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

3.8 Screening for powdery mildew disease resistance

Twenty three genotypes and five hybrids with three replications were screened against powdery mildew under natural epiphytotic conditions at Agriculture College Farm, Raichur during *kharif* 2012.

3.8.1 Observations recorded

Van der Plank (1963) studied the rate of disease development per unit per day. Powdery mildews and rusts are compound interest diseases which complete many generations on the crop in a season. Initially disease starts very slowly, builds up the inoculum (Logarithmic phase). Often nearly half the amount of time needed for an epidemic is spent in logarithmic phase itself. From around 0.5 or one per cent severity, disease growth is very rapid and multiplication is at an exponential rate.

3.8.2 Per cent Disease Index (PDI)

The intensity of the disease was recorded by scoring all the individual ten plants in each cultivar using 0-9 scale (Mayee and Datar, 1986). Further the PDI was calculated with the above scales using the formula of Wheeler (1969).

$$PDI = \frac{\text{Sum of numerical values grades}}{\text{Number of plants observed}} \times \frac{100}{\text{Maximum disease rating}}$$

Observations on intensity of disease were recorded using five randomly selected plants from each replication.

Scale	Score Description	Reaction
0	No symptom of powdery mildew	Immune
1	Small scattered powdery mildew specks covering 1% or less leaf area	Resistant
3	Small powdery lesions covering 1-10% of leaf area	Moderately resistant
5	Powdery lesions enlarged covering 11-25% of leaf area	Moderately susceptible
7	Powdery lesions coalesce to form big patches covering 26-50% of leaf area	Susceptible
9	Big powdery patches covering 51% or more of leaf area and defoliation occur.	Highly susceptible

3.9 Screening for chilli fruit borer resistance

Available 23 genotypes and five hybrids with three replications were screened against powdery mildew under natural epiphytotic conditions at Agriculture College Farm, Raichur during *kharif* 2012-13. The observations on total number of chilli fruits and infested fruits were recorded on five randomly selected plants in each replication.

Rating system by Kashyap and Verma (1986) followed for estimating the resistance and susceptibility for fruit borer.

Sl. No.	Damage level	Rating
1.	No damage	Highly Resistant.
2.	0 - 10.0 per cent fruits damaged	Resistant
3.	10.1- 20.0 per cent fruits damaged	Moderately Resistant
4.	20.1 - 30.0 per cent fruits damage	Moderately susceptible
5.	30.1 - 40.0 per cent fruits damaged	Susceptible
6.	40.1 per cent fruits damaged & above	Highly susceptible

IV. EXPERIMENTAL RESULTS

The results of the research, towards promoting disease resistance and development of hybrids resistant to *Fusarium* wilt of chilli are presented here under.

4.1 Symptomatology

On the young seedlings initially, water soaked areas developed at the collar region and a brown sunken lesion which soon appeared as girdled resulting in seedling collapse. Foliage of such seedlings turned yellow and plants exhibited wilt symptoms and dried there off (Plate 1). On adult plant initially, slight drooping of leaves which led to drying of leaves starting from lower ones extended from root to stem region and plants exhibited wilting symptom.

4.2 Screening of chilli genotypes and hybrids against *F. Solani*

In order to identify the resistant source, 56 chilli genotypes and 38 hybrids were screened against *F. solani* (F25) in laboratory. Three methods were employed for identifying resistant sources viz., seed inoculation technique, root dip transplanting technique and sick pot technique as described in material and methods.

4.2.1 Seed inoculation technique

Among 56 genotypes (Table 5) screened, none of the genotypes showed immune as well as resistant reaction. However, genotype P3 exhibited moderately resistant and three genotypes viz., Rajput, JNB1 and LCA 960 showed susceptible reaction. While, remaining 52 genotypes exhibited highly susceptible reaction to *Fusarium* wilt. The genotypes tested were further categorized into five groups based on reaction (Table 5.1). Based on the above, categorization of chilli genotypes against *F. solani* under seed inoculation technique.

4.2.2 Rapid root dip transplanting technique

The observation on wilt reaction in rapid root dip transplanting technique is presented in Table 6. Among the genotypes screened, P3 showed moderately resistance. Some of the genotypes namely KA2 and Rajaput were identified as susceptible. However, genotypes viz., PANT-C1, GCV121, H0413, K1-4D, SNK, JNB1, G4, LCA960 and 9608D were highly susceptible to *Fusarium* wilt. The genotypes tested were further categorized into five groups based on reaction and is presented in Table 6.1.



Plate 1. a) Wilting symptoms on chilli seedlings b) Resistant seedlings

Table 5. Screening of chilli genotypes for *Fusarium* wilt (*Fusarium solani*) using seed inoculation technique

Sl. No.	Genotypes	Per cent wilt at 15 DAS	Per cent wilt at 30 DAS	Disease reaction
1.	9608D	53.33	56.67	Highly susceptible
2.	K1-4D	40.33	52.67	Highly susceptible
3.	K1-4DS	100.00	100.00	Highly susceptible
4.	KA2	56.67	56.67	Highly susceptible
5.	P3	8.33	21.67	Moderately resistant
6.	BVC37	86.67	100.00	Highly susceptible
7.	ACB1	85.00	100.00	Highly susceptible
8.	RAJPUT	33.33	40.00	Susceptible
9.	GCV121RES	100.00	100.00	Highly susceptible
10.	B.DABBI	86.67	100.00	Highly susceptible
11.	JNB1	38.33	43.33	Susceptible
12.	G4	100.00	100.00	Highly susceptible
13.	SANKESHWAR	66.67	100	Highly susceptible
14.	PHULE JYOTI	100	100	Highly susceptible
15.	HISAR VIJAY	100	100	Highly susceptible
16.	JM-218	100	100	Highly susceptible
17.	PANT-C1	46.67	65	Highly susceptible
18.	H0413	45.67	51.67	Highly susceptible
19.	K1-4C	100	100	Highly susceptible
20.	9608-U	30	63.33	Highly susceptible
21.	BVC-1	100	100	Highly susceptible
22.	GUK-1	100	100	Highly susceptible
23.	GUK-2	100	100	Highly susceptible
24.	GUK-2-1	100	100	Highly susceptible
25.	GUK2-1-1	100	100	Highly susceptible
26.	IC119243	100	100	Highly susceptible
27.	IC112109	100	100	Highly susceptible
28.	IC119578	100	100	Highly susceptible
29.	IC119561	100	100	Highly susceptible

Table 5. Contd...

Sl. No.	Genotypes	Per cent wilt at 15 DAS	Per cent wilt at 30 DAS	Disease reaction
30.	LCA 235	100	100	Highly susceptible
31.	LCA 304	100	100	Highly susceptible
32.	LCA 310	100	100	Highly susceptible
33.	LCA 310A	100	100	Highly susceptible
34.	LCA 334	100	100	Highly susceptible
35.	LCA 960	41.67	50	Susceptible
36.	GPC 82	100	100	Highly susceptible
37.	KDSC-210-10-1	100	100	Highly susceptible
38.	KDSC-210-10-2	100	100	Highly susceptible
39.	KDSC-210-10-3	100	100	Highly susceptible
40.	KDSC-210-10-4	100	100	Highly susceptible
41.	KDSC-210-10	100	100	Highly susceptible
42.	KDSC-510-10-1	100	100	Highly susceptible
43.	KDSC-510-10-2	100	100	Highly susceptible
44.	KDSC-510-10	100	100	Highly susceptible
45.	HCS-3	100	100	Highly susceptible e
46.	SUM05-2R	100	100	Highly susceptible
47.	JM 283	100	100	Highly susceptible
48.	P. JWALA	78.33	81.67	Highly susceptible
49.	HMT-1	100	100	Highly susceptible
50.	B.KADDI	73.33	80	Highly susceptible
51.	JAYANTI	100	100	Highly susceptible
52.	GCV 111	100	100	Highly susceptible
53.	GCV 121	100	100	Highly susceptible
54.	SADABAHAR	100	100	Highly susceptible
55.	AVNPC 131	100	100	Highly susceptible
56.	X-235	100	100	Highly susceptible

DAS – Days after sowing

Table 5.1: Reaction of chilli genotypes against *Fusarium* wilt under seed inoculation technique

Per cent infection	Disease reaction	Genotypes
0	Immune	Nil
1-10	Resistant	Nil
11-25	Moderately resistant	P3,
26-50	Susceptible	RAJPUT, JNB1 and LCA 960
51-100	Highly susceptible	9608D, K1-4D, K1-4DS, KA2, BVC37, ACB1, GCV121RES, B.DABBI, G4, SANKESHWAR, PHULE JYOTI, HISAR VIJAY, JM-218, PANT-C1, H0413, K1-4C, 9608-U, BVC-1, GUK-1, GUK-2, GUK-2-1, GUK2-1-1, IC119243, IC112109, IC119578, IC119561, LCA 235, LCA 304, LCA 310, LCA 310A, LCA 334, LCA 960, GPC 82, KDSC-210, 10-1, KDSC-210-10-2, KDSC-210-10-3, KDSC-210-10-4, KDSC-210-10, KDSC-510-10-1, KDSC-510-10-2, KDSC-510-10, HCS-3, SUM05-2R, JM 283, P. JWALA, HMT-1, B.KADDI, JAYANTI, GCV 111, GCV 121, SADABAHAR, AVNPC 131 and X-235

Table 6. Screening of chilli genotypes for *Fusarium* wilt (*Fusarium solani*) using rapid root dip transplanting technique

Sl. No.	Genotypes	Per cent wilt at 15 DAT	Per cent wilt at 30 DAT	Disease reaction
1.	PANTC1	36.67	100.00	Highly susceptible
2.	KA2	40.00	41.33	Susceptible
3.	H0413	66.67	93.33	Highly susceptible
4.	RAJAPUT	49.67	49.67	Susceptible
5.	K1-4D	73.33	73.33	Highly susceptible
6.	SNK	83.33	100.00	Highly susceptible
7.	P3	13.33	16.67	Moderately resistant
8.	JNB1	80.00	90.00	Highly susceptible
9.	GCV121	73.33	76.67	Highly susceptible
10.	G4	83.33	100.00	Highly susceptible
11.	LCA960	76.67	86.67	Highly susceptible
12.	9608D	80.00	100.00	Highly susceptible

DAT – Days after transplanting

Table 6.1: Reaction of chilli genotypes against *Fusarium* wilt (*Fusarium solani*) under rapid root dip transplanting technique

Per cent infection	Disease reaction	Genotypes
0	Immune	Nil
1-10	Resistant	Nil
11-25	Moderately resistant	P3
26-50	Susceptible	KA2 and RAJAPUT
51-100	Highly susceptible	PANTC1, GCV121, H0413, K1-4D, SNK, JNB1, GCV121RES, G4, LCA960 and 9608D

Among 38 hybrids screened, 12 hybrids viz., JNA2 x JNB1 x K1-4D, JNA2 x JNB1 x KA2, JNA2 x JNB1 x H0413, JNA2 x JNB1 x 9608D, JNA2 x JNB1 x Rajaput, JNA1 x Rajaput, JNA1 x P3, JNA2 x ACB1 x H0413, JNA2 x ACB1 x Rajaput, P3 x K1-4D, P3 x KA2 and SNK x P3 showed moderately resistant. While, 10 hybrids viz., JNA2 x JNB1 x P3, JNA1 x KA2, JNA2 x ACB1 x 9608D, JNA2 x ACB1 x P3, JNB1 x K1-4D, JNB1 x KA2, JNB1 x Rajaput, JNB1 x P3, ACB1 x K1-4D and Rajaput x P3 were susceptible and 16 hybrids viz., JNA1 x K1-4D, JNA1 x H0413, JNA1 x 9608D, JNA2 x ACB1 x K1-4D, JNA2 x ACB1 x KA2, JNB1 x H0413, JNB1 x 9608D, ACB1 x H0413, ACB1 x 9608D, ACB1 x Rajaput, ACB1 x P3, ACB1 x H0413, P3 x Rajaput, P3 x SNK, K1-4D x P3 and KA2 x P3 were showed highly susceptible to *Fusarium* wilt. The genotypes tested were further categorized into five groups based on reaction and is presented in Table 7, 7.1 and Plate 2.

4.2.3 Sick pot method (Sorghum giant culture technique)

The observation on wilt reaction in sick pot technique is presented in Table 8. Here 38 hybrids were screened. Among the hybrids tested 2 hybrids viz., JNA2 x ACB1 x 9608D and Rajaput x P3 showed resistant. However 10 hybrids each showed moderately resistant viz., JNA2 x JNB1 x K1-4D, JNA2 x JNB1 x 9608D, JNA1 x H0413, JNA2 x JNB1 x P3, JNA1 x K1-4D, JNA2 x ACB1 x H0413, JNB1 x H0413, JNB1 x Rajaput, KA2 x P3 and SNK x P3 and susceptible reaction viz., JNA2 x JNB1 x KA2, JNA2 x JNB1 x H0413, JNA2 x JNB1 x Rajaput, JNA2 x JNB1 x P3, JNA1 x K1-4D, JNA1 x KA2, JNA2 x JNB1 x Rajaput, JNB1 x KA2, JNB1 x 9608D and ACB1 x K1-4D. However 11 hybrids viz., JNA2 x ACB1 x P3, JNA2 x ACB1 x P3, JNB1 x P3, ACB1 x KA2, ACB1 x H0413, ACB1 x 9608D, ACB1 x Rajaput, ACB1 x P3, P3 x KA2, P3 x SNK and KA2 x P3 were showed highly susceptible reaction to *Fusarium* wilt. The genotypes tested were further categorized into five groups based on reaction and is presented in Table 8.1 and Plate 3.

4.2.4 Screening of six important parents/genotypes for *Fusarium* wilt in sick pot method

Six important parents were again screened for conformation in sick pot method. None of the parents showed resistant reaction to *Fusarium* wilt, whereas, parent P3 was showed moderately resistant reaction to *F. solani*. Parents viz., K1-4D and KA2 showed susceptible reaction whereas, H0413 and 9608D showed highly susceptible reaction to *Fusarium* wilt. The parents tested were presented in Table 9.

Table 7. Screening of chilli hybrids for *Fusarium* wilt (*Fusarium solani*) using rapid root dip transplanting technique

Sl. No.	Genotypes	Per cent wilt at 15 DAT	Per cent wilt at 30 DAT	Disease reaction
1.	JNA2 x JNB1 x K1-4D	3.33	23.33	Moderately resistant
2.	JNA2 x JNB1 x KA2	0.00	23.33	Moderately resistant
3.	JNA2 x JNB1 x H0413	0.00	20.00	Moderately resistant
4.	JNA2 x JNB1 x 9608D	0.00	20.00	Moderately resistant
5.	JNA2 x JNB1 x Rajaput	0.00	16.67	Moderately resistant
6.	JNA2 x JNB1 x P3	0.00	36.67	Susceptible
7.	JNA1 x K1-4D	100.00	100.00	Highly susceptible
8.	JNA1 x KA2	40.00	50.00	Susceptible
9.	JNA1 x H0413	50.00	53.33	Highly susceptible
10.	JNA1 x 9608D	56.67	63.33	Highly susceptible
11.	JNA1 x Rajaput	3.33	23.33	Moderately resistant
12.	JNA1 x P3	16.67	20.00	Moderately resistant
13.	JNA2 x ACB1 x K1-4D	56.67	56.67	Highly susceptible
14.	JNA2 x ACB1 x KA2	100.00	100.00	Highly susceptible
15.	JNA2 x ACB1 x H0413	100.00	23.33	Moderately resistant
16.	JNA2 x ACB1 x 9608D	100.00	30.00	Susceptible
17.	JNA2 x ACB1 x Rajaput	100.00	13.33	Moderately resistant
18.	JNA2 x ACB1 x P3	100.00	36.67	Susceptible
19.	JNB1 x K1-4D	100.00	36.67	Susceptible
20.	JNB1 x KA2	3.33	36.67	Susceptible
21.	JNB1 x H0413	10.00	60.00	Highly susceptible
22.	JNB1 x 9608D	6.67	53.33	Highly susceptible
23.	JNB1 x Rajaput	0.00	33.33	Susceptible
24.	JNB1 x P3	0.00	53.33	Susceptible
25.	ACB1 x K1-4D	6.67	30.00	Susceptible
26.	ACB1 x KA2	46.67	73.33	Highly susceptible
27.	ACB1 x H0413	53.33	53.33	Highly susceptible
28.	ACB1 x 9608D	100.00	100.00	Highly susceptible
29.	ACB1 x Rajaput	60.00	70.00	Highly susceptible
30.	ACB1 x P3	60.00	70.00	Highly susceptible
31.	P3 x K1-4D	6.67	13.33	Moderately resistant
32.	P3 x KA2	20.00	20.00	Moderately resistant
33.	P3 x Rajaput	100.00	100.00	Highly susceptible
34.	P3 x SNK	100.00	100.00	Highly susceptible
35.	K1-4D x P3	0.00	63.33	Highly susceptible
36.	KA2 x P3	0.00	66.67	Highly susceptible
37.	Rajaput x P3	0.00	36.67	Susceptible
38.	SNK x P3	0.00	23.33	Moderately resistant

DAT – Days after transplanting

Table 7.1: Reaction of chilli hybrids against *Fusarium* wilt (*Fusarium solani*) under rapid root dip transplanting technique

Per cent infection	Disease reaction	Genotypes
0	Immune	Nil
1-10	Resistant	Nil
11-25	Moderately resistant	JNA2 x JNB1 x K1-4D, JNA2 x JNB1 x KA2, JNA2 x JNB1 x H0413, JNA2 x JNB1 x 9608D, JNA2 x JNB1 x Rajaput, JNA1 x Rajaput JNA1 x P3, JNA2 x ACB1 x H0413, JNA2 x ACB1 x Rajaput, P3 x K1-4D, P3 x KA2 and SNK x P3
26-50	Susceptible	JNA2 x JNB1 x P3, JNA1 x KA2, JNA2 x ACB1 x 9608D, JNA2 x ACB1 x P3, JNB1 x K1-4D, JNB1 x KA2, JNB1 x Rajaput, JNB1 x P3, ACB1 x K1-4D and Rajaput x P3
51-100	Highly susceptible	JNA1 x K1-4D, JNA1 x H0413, JNA1 x 9608D, JNA2 x ACB1 x K1-4D, JNA2 x ACB1 x KA2, JNB1 x H0413, JNB1 x 9608D, ACB1 x H0413, ACB1 x 9608D, ACB1 x Rajaput, ACB1 x P3, ACB1 x H0413, P3 x Rajaput, P3 x SNK, K1-4D x P3 and KA2 x P3

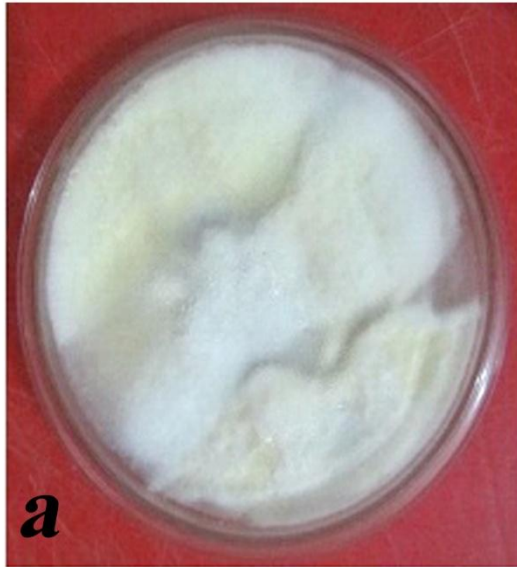


Plate 2. Screening of chilli genotypes/ hybrids against *Fusarium solani*
a) *Fusarium* culture on solid medium b) Wilted and healthy seedlings
c) Control d) Rapid root dip transplanting technique

Table 8. Screening of chilli genotypes for *Fusarium* wilt (*Fusarium solani*) using pot culture method (Sorghum giant culture technique)

Sl. No.	Genotypes	Per cent wilt at 15 DAS	Per cent wilt at 30 DAS	Disease reaction
1.	JNA2 x JNB1 x K1-4D	15	25	Moderately resistant
2.	JNA2 x JNB1 x KA2	30	35	Susceptible
3.	JNA2 x JNB1 x H0413	65	65	Susceptible
4.	JNA2 x JNB1 x 9608D	25	25	Moderately resistant
5.	JNA2 x JNB1 x Rajaput	5	50	Susceptible
6.	JNA2 x JNB1 x P3	40	40	Susceptible
7.	JNA1x K1-4D	30	50	Susceptible
8.	JNA1 x KA2	45	55	Susceptible
9.	JNA1 x H0413	20	20	Moderately resistant
10.	JNA2 x 9608D	60	40	Susceptible
11.	JNA2 x Rajput	5	20	Moderately resistant
12.	JNA1 x P3	20	20	Moderately resistant
13.	JNA2 x ACB1 x K1-4D	70	75	Highly susceptible
14.	JNA2 x ACB1 x KA2	80	90	Highly susceptible
15.	JNA2 x ACB1 x H0413	25	25	Moderately resistant
16.	JNA2 x ACB1 x 9608D	0	2	Resistant
17.	JNA2 x ACB1 x Rajaput	100	100	Highly susceptible
18.	JNA2 x ACB1 x P3	65	70	Highly susceptible
19.	JNB1 x K1-4D	95	100	Highly susceptible
20.	JNB1 x KA2	20	30	Susceptible
21.	JNB1 x H0413	20	20	Moderately resistant
22.	JNB1 x 9608D	35	35	Susceptible
23.	JNB1 x Rajaput	20	20	Moderately resistant
24.	JNB1 x P3	25	70	Highly susceptible
25.	ACB1 x K1-4D	35	40	Susceptible
26.	ACB1 x KA2	90	95	Highly susceptible
27.	ACB1 x H0413	35	60	Highly susceptible
28.	ACB1 x 9608D	20	55	Highly susceptible
29.	ACB1 x Rajaput	70	75	Highly susceptible
30.	ACB1 x P3	50	65	Highly susceptible
31.	P3 x K1-4D	90	100	Highly susceptible
32.	P3 x KA2	25	70	Highly susceptible
33.	P3 x Rajaput	75	100	Highly susceptible
34.	P3 x SNK	100	100	Highly susceptible
35.	K1-4D x P3	40	90	Highly susceptible
36.	KA2 x P3	10	20	Moderately resistant
37.	Rajaput x P3	5	5	Resistant
38.	SNK x P3	10	20	Moderately resistant

DAS – Days after sowing

Table 8.1: Reaction of chilli hybrids against *Fusarium* wilt (*Fusarium solani*) under pot culture technique (Sorghum giant culture technique)

Per cent infection	Disease reaction	Genotypes
0	Immune	Nil
1-10	Resistant	JNA2 x ACB1 x 9608D and Rajaput x P3
11-25	Moderately resistant	JNA2 x JNB1 x K1-4D, JNA2 x JNB1 x 9608D, JNA1 x H0413, JNA2 x JNB1 x P3, JNA1 x K1-4D, JNA2 x ACB1 x H0413, JNB1 x H0413, JNB1 x Rajaput and SNK x P3
26-50	Susceptible	JNA2 x JNB1 x H0413, JNA2 x JNB1 x KA2, JNA2 x JNB1 x P3, JNA2 x JNB1 x Rajaput, JNA1 x K1-4D, JNA1 x KA2, JNA2 x 9608D , JNB1 x KA2, JNB1 x 9608D, ACB1 x K1-4D
51-100	Highly susceptible	JNA2 x ACB1 x P3, JNA2 x ACB1 x P3, JNB1 x P3, ACB1 x KA2, ACB1 x H0413, ACB1 x 9608D, ACB1 x Rajaput, ACB1 x P3, P3 x KA2, P3 x SNK and KA2 x P3



Plate 3. Sick pot method (Sorghum giant culture technique)

Table 9. Screening of six important parents for *Fusarium* wilt (*Fusarium solani*) in sick pot method

Sl. No.	Genotypes	Per cent wilt at 15 DAS	Per cent wilt at 30 DAS	Disease reaction
1.	K1-4D	36	41.00	Susceptible
2.	KA2	43	48.33	Susceptible
3.	H0413	50.33	51.46	Highly susceptible
4.	9608D	46.50	53.50	Highly susceptible
5.	Rajput	40	42.57	Susceptible
6.	P3	24.26	24.26	Moderately resistant

4.3 Analysis of variance for yield and its components

The analysis of variance was carried out for all the characters and the mean squares due to different sources of variation are presented in Table 10.

Analysis of variances showed that mean sums of squares due to genotypes were highly significant for all the characters indicating significant variation among all the genotypes for all the characters.

4.3.1 Mean *per se* performance of the characters

Twenty three genotypes and five hybrids were tested during 2012-13. Performance of genotypes and hybrids are presented in Table 10.1. Among them the hybrid JCH 46 and genotype P1SUM (50.67) were on par and recorded significantly highest days to fifty per cent flowering, genotype KDC-1 (116.53 cm) recorded significantly highest plant height. However, significantly highest number of primary branches was recorded by Sitara (3.00). While KDC-1 (29.33) recorded significantly highest number of secondary branches and KA2 (52.67) recorded more number of closed stigma. Genotype P1SUM registered significantly highest number of days to fifty per cent maturity. However, genotype 5-SUM produced significantly more number of fruits per plant (495.14). While significantly longer fruit length was observed in Sitara (13.68 cm) and LCA960 recorded significantly highest fruit diameter (15.93). Genotype P3 (125.77) recorded significantly highest seeds per fruit. However, significantly higher test weight was observed in LCA960 (7.65). Significantly highest dry fruit weight fruit (2.00 g) and green fruit weight (8.48) were registered by BVC-47. F₁ hybrid JCH 46 (263.30 g) recorded significantly highest dry fruit weight plant⁻¹ as well as green fruit weight per plant (806.14 g).

4.3.2 Variation for yield and its components.

The parameters of genetic variability viz., mean, range, phenotypic and genotypic coefficient of variation were calculated for 16 different traits studied for 23 genotypes and five hybrids are presented in Table 10.2.

4.3.2.1 Days to fifty per cent flowering

Days to fifty per cent flowering ranged from 42.33 to 50.67 days with a mean of 46.46 days. The PCV of 6.31 per cent was greater than GCV (6.06%).

Table 10. Analysis of variance for yield and its components

Characters	df →	Replications	Genotypes
		2	27
Days to 50% flowering		1.86	24.45**
Plant height (cm)		33.4	697.39**
Primary branches per plant		0.23*	0.16**
Secondary branches per plant		7.39	17.84**
Closed stigma		1.94	874.24**
Opened stigma		2.21	872.49**
Days to 50% maturity		0.94	137.09**
Number of fruits per plant		1505.63*	27180.02**
Fruit length (cm)		0.83	17.07**
Fruit diameter (mm)		1.07	13.84**
Seeds per fruit		8.95	995.92**
1000 test weight (g)		0.24	0.24**
Dry fruit weight (g)		0.02	0.46**
Green fruit weight (g)		1.27*	8.44**
Green fruit weight (g plant ⁻¹)		7100.16**	139103.05**
Dry fruit weight (g plant ⁻¹)		308.32*	10027.10**

4.3.2.2 Plant height (cm)

Minimum and maximum plant height recorded for this trait was 51.37 and 116.53 cm respectively with a population mean of 87.43 cm. The GCV exhibited by this trait was 17.11 per cent with PCV 18.09 per cent.

4.3.2.3 Number of primary branches per plant

Number of primary branches varied from 2.20 to 3.00 per plant with an average of 2.58. The degree of estimate of GCV was 7.05 and PCV 11.86 recorded for this trait.

4.3.2.4 Number of secondary branches per plant

Number of secondary branches varied from 19.77 to 29.33 per plant with an average of 24. The degree of estimate of GCV was 9.25 and PCV 11.77 recorded for this trait.

4.3.2.5 Closed stigma (%)

Per cent closed stigma ranged from 0.00 to 52.67 plant⁻¹ with an average of 16.3. The GCA recorded for this trait was 103.54 per cent with PCV 107.01 per cent.

4.3.2.6 Closed stigma (%)

Per cent closed stigma ranged from 47.33 to 100.00 per plant with an average of 83.73. The GCA recorded for this trait was 20.14 per cent with PCV 20.80 per cent.

4.3.2.7 Days to fifty per cent maturity

Days to fifty per cent flowering ranged from 90.67 to 100.00 days with a mean of 98.56 days. The PCV of 6.97 per cent was greater than GCV 6.80 per cent.

4.3.2.8 Number of fruits per plant

Number of fruits per plant ranged from 45.52 to 495.14 with an average of 147.07 fruits per plant. The GCV recorded for this trait was 64.29 per cent with PCV 65.57 per cent.

4.3.2.9 Fruit length (cm)

Fruit length ranged from 5.15 cm to 13.68 cm with an average population mean of 8.95 cm. This trait recorded 26.40 and 27.18 per cent genotypic and phenotypic coefficient of variation respectively.

Table 10.1: Mean *per se* performance of the genotypes for various traits

Genotypes	DFF	PH	PB	SB	CS	OS	DFM	NFP	FL	FD	SF	TW	DFW	DFWP	GFW	GFWP
SITARA	44.67	88.10	3.00*	26.00*	0.00	100.00*	91.00	164.99	13.68*	10.43	94.73	3.93	1.16	191.56	4.23	690.53
JCH 42	42.33	97.27	2.67*	21.53	4.50	95.50*	100.00	183.40	9.72	10.19	110.17*	4.76	1.18	216.57	4.08	762.48*
BCH 42	45.33	94.47	2.33	24.70	0.00	100.00*	91.33	169.34	8.85	11.00	60.17	5.46	1.14	190.42	4.86	803.35*
JCH 40	50.33*	93.63	2.73*	23.03	0.00	100.00*	91.00	240.68	7.59	9.25	83.83	4.11	1.05	245.36	2.52	591.55
JCH 24	46.33	85.73	2.23	21.13	18.00	82.00	91.33	176.66	8.49	12.48	103.23*	5.53	1.30	232.54	3.50	606.16
KDCS-210-10-4	45.33	101.57	2.50	27.83*	10.00	90.00*	90.67	112.54	8.32	13.42	92.40	4.09	1.54	155.58	3.13	340.48
HDC 75	45.33	82.03	2.87*	25.60	21.50	78.50	99.67	170.93	8.49	9.09	90.10	3.79	1.05	171.06	2.75	458.21
B KADDI	43.00	97.13	2.20	25.17	43.33	56.67	91.67	66.88	11.55	13.07	120.67*	7.06*	1.80	123.90	5.25	316.09
KDCS-210-10-2	50.33*	102.90	2.53	27.13*	0.00	100.00*	108.67*	117.41	12.84*	13.08	102.97*	6.05	1.61	154.15	5.96	717.02
JCH-46	50.67*	100.73	2.57	27.60*	0.00	100.00*	99.00	287.51	5.81	9.51	112.90*	4.88	0.94	263.30*	2.85	806.14*
B DABBI	50.00*	89.20	2.43	24.20	45.33	54.67	108.67*	45.52	7.51	11.81	93.33	5.56	1.46	63.10	4.48	215.19
P3	50.00*	69.90	2.40	22.53	0.00	100.00*	90.67	62.22	7.77	14.36	125.77*	5.43	1.53	102.08	3.45	225.20
LCA-960	45.33	87.30	2.53	21.70	22.00	78.00	91.33	82.64	7.86	15.93*	106.23*	7.65*	1.60	144.75	3.64	343.53
9608D	45.67	65.20	2.33	21.40	12.33	87.67*	91.33	137.95	8.61	13.23	123.33*	4.88	1.35	208.04	4.17	762.52*
SNK	45.00	95.20	2.80*	21.70	30.83	69.17	101.00	119.94	13.56*	8.68	87.43	5.05	1.11	145.71	4.39	417.28
JNB1-1	45.33	99.97	2.67*	24.80	32.67	67.33	107.67*	322.07	5.72	7.64	63.67	4.26	0.59	176.55	1.51	475.95
ACB1	50.33*	68.83	2.47	24.27	29.00	71.67	101.67	116.44	5.15	12.37	72.67	5.84	0.80	97.22	1.82	218.38
P1 SUM	50.67*	75.30	2.83*	23.70	9.00	91.00	109.67*	163.74	7.94	13.63	118.47*	5.98	1.63	198.40	3.37	570.91
5 SUM	42.67	70.37	2.97*	23.73	49.50*	50.50	99.67	495.14*	6.36	8.06	82.23	4.24	0.58	262.71	1.38	571.20
MSSF	43.00	102.27	2.90*	28.57*	0.00	100.00*	91.67	91.44	8.45	13.44	115.33*	5.29	1.92	168.15	3.62	360.91
LCA 310A	45.00	94.40	2.30	22.83	15.33	85.00	91.67	123.64	10.86	12.71	73.27	5.45	1.31	118.67	3.34	307.95
T2-1	45.67	66.43	2.53	21.53	0.00	100.00*	107.67*	90.71	11.47	12.67	107.83*	4.79	1.30	118.64	1.78	161.38
BVC-1	50.33*	108.17*	2.50	22.43	9.17	90.83	100.00	100.02	12.15	12.55	88.77	6.16	1.83*	183.32	7.55	749.64
GVK2-2	44.67	80.23	2.38	23.23	29.83	70.17	101.33	124.04	6.77	14.01	104.07*	5.43	1.48	178.07	4.80	626.73
BVC-47	45.67	90.23	2.69*	23.50	21.50	78.50	101.67	55.80	10.69	13.68	109.20*	5.53	2.00*	112.09	8.48*	538.15
9608U	49.67*	73.43	2.53	22.97	0.00	100.00*	100.00	145.38	8.12	12.54	122.90*	5.36	1.14	169.24	3.55	506.55
KDC-1	42.67	116.53*	2.93*	29.33*	0.00	100.00*	108.67*	60.70	9.99	9.79	81.03	6.35	1.07	56.99	3.67	169.50
KA2	45.67	51.37	2.37	19.77	52.67*	47.33	101.00	90.35	6.19	9.34	92.97	3.62	0.58	53.39	1.35	129.24
Mean	46.46	87.43	2.58	24.00	16.30	83.73	98.56	147.07	8.95	11.71	97.85	5.23	1.29	160.77	3.77	480.08
CV	1.78	5.88	9.54	7.28	27.03	5.20	1.51	12.93	6.47	6.49	15.17	13.41	8.09	5.91	13.64	6.41
CD at 5%	1.35	8.41	0.40	2.86	7.21	7.12	2.43	31.14	0.95	1.24	24.29	1.15	0.17	15.55	0.84	50.35

*Significant at 5%

DFF = Days to 50% flowering
CS = Closed stigma
FL = Fruit length
DFW = Dry fruit weight

PH = Plant height
OS = Opened stigma
FD = Fruit diameter
GFW = Green fruit weight

PB = Primary branches
DFM = Days to fifty % maturity
SF = Seeds per fruit
GFWP = Green fruit weight per plant

SB = Secondary branches
NFP = Number of fruits per plant
TW = 1000 test weight
DFWP = Dry fruit weight per plant

4.3.2.10 Fruit diameter (mm)

An average mean performance for fruit diameter was 11.71 mm with minimum 7.64 mm and maximum 15.93 mm. This trait recorded 17.95 per cent GCV with PCV of 19.09 per cent.

4.3.2.11 Number of seeds per fruit

Number of seeds per fruit ranged from 60.17 to 125.77 with an average of 97.85 seeds per fruit. The estimated GCV was 16.43 per cent and PCV per cent.

4.3.2.12 Test weight (1000 seeds)

Test weight varied from 3.62 to 7.65 with population mean of 5.23 and both the estimate of GCV was 16.66 per cent and PCV was 21.39 per cent.

4.3.2.13 Green fruit weight (g)

The GCV recorded for this trait was 43.84 per cent with PCV 45.91 per cent. Average population mean for this trait was 3.77 g with a range of 1.35 to 8.48 g

4.3.2.14 Green fruit weight (g plant⁻¹)

Mean performance for fresh fruit weight plant⁻¹ ranged from 129.24 to 806.14 g with a population mean of 480.08 g. This trait exhibited 44.70 per cent GCV and 45.16 per cent PCV.

4.3.2.15 Dry fruit weight (g)

Mean performance for dry fruit weight ranged from 0.58 to 2.00 g with a population mean of 1.29 g per fruit. This trait recorded 29.92 per cent GCV and 43.09 per cent PCV.

4.3.2.16 Dry fruit weight plant⁻¹ (g)

The estimate of GCV was 35.80 per cent and PCV 36.28 per cent for this trait. Average population mean for dry fruit weight per plant was 160.77 g with a range of 53.39 to 263.30 g.

4.4 Heritability and genotypic advance

Heritability (broad sense) [$h^2(\text{bs})$] and genetic advance as percentage of mean (GA% mean) for yield and yield contributing traits have been calculated and presented in

Table 10.2. In general these estimates were observed to be higher for number of primary branches and 1000 seed weight. Heritability and genetic advance in respect to various traits are described character wise as given below.

4.4.1 Days to 50 per cent flowering

The estimate of heritability was very high for days to 50 per cent flowering (92.05%) with moderate genetic advance in percentage to mean 11.97 at 5 per cent level and 15.34 at 1 per cent level.

4.4.2 Plant height (cm)

Plant height recorded very high estimate of heritability (89.44%). This trait was also exhibited high genetic advance in percentage to mean 33.32 and 42.70 at 5 and 1 per cent level respectively.

4.4.3 Number of primary branches per plant

Estimate of heritability was 35.28 per cent with high genetic advance in percentage to mean 8.62 and 11.04 at 5 and 1 per cent level respectively for number of primary branches per plant.

4.4.4 Number of secondary branches per plant

Estimate of heritability was 61.77 per cent with high genetic advance in percentage to mean 14.97 and 19.19 at 5 and 1 per cent level respectively for number of primary branches per plant.

4.4.5 Closed stigma

Very high heritability was estimated 93.62 per cent coupled with low genetic advance in percentage to mean 206.36 at 5 per cent level and 264.47 at 1 per cent level for closed stigma.

4.4.6 Opened stigma

Very high heritability was estimated 93.76 per cent coupled with low genetic advance in percentage to mean 40.18 at 5 per cent level and 51.49 at 1 per cent level for opened stigma.

Table 10.2. Genetic parameters for different traits in chilli

Characters	Range		Mean	GCV (%)	PCV (%)	Heritability (%)	GA as percentage of mean	
	Min.	Max.					5%	1%
Days to 50% flowering	42.33	50.67	46.46	6.06	6.31	92.05	11.97	15.34
Plant height (cm)	51.37	116.53	87.43	17.11	18.09	89.44	33.32	42.70
Primary branches per plant	2.20	3.00	2.58	7.05	11.86	35.28	8.62	11.04
Secondary branches per plant	19.77	29.33	24	9.25	11.77	61.77	14.97	19.19
Closed stigma	0.00	52.67	16.3	103.54	107.01	93.62	206.36	264.47
Opened stigma	47.33	100.00	83.73	20.14	20.80	93.76	40.18	51.49
Days to 50% maturity	90.67	100.00	98.56	6.80	6.97	95.31	13.68	17.53
Number of fruits per plant	45.52	495.14	147.07	64.29	65.57	96.11	129.82	166.38
Fruit length (cm)	5.15	13.68	8.95	26.40	27.18	94.33	52.81	67.68
Fruit diameter (cm)	7.64	15.93	11.71	17.95	19.09	88.45	34.77	44.57
Seeds per fruit	60.17	125.77	97.85	16.43	22.36	54.01	24.88	31.88
1000 test weight (g)	3.62	7.65	5.23	16.66	21.39	60.68	26.73	34.26
Dry fruit weight (g)	0.58	2.00	1.29	29.92	31.00	93.19	59.50	76.25
Green fruit weight (g)	1.35	8.48	3.77	43.84	45.91	91.18	86.23	110.51
Green fruit weight (g plant ⁻¹)	129.24	806.14	480.08	44.70	45.16	97.99	91.15	116.81
Dry fruit weight (g plant ⁻¹)	53.39	263.30	160.77	35.80	36.28	97.35	72.75	93.24

4.4.7 Days to fifty per cent maturity

Days to fifty per cent maturity exhibited very high heritability estimate 95.31 per cent and low genetic advance in percentage to mean 13.68 at 5 per cent level with moderate genetic advance 17.53 at 1 per cent level.

4.4.8 Number of fruits per plant

Number of fruits per plant showed very high heritability (96.11%) with high genetic advance of 129.82 and 166.38 at 5 and 1 per cent level respectively.

4.4.9 Fruit length (cm)

Fruit length recorded very high heritability estimate (94.33%) with high genetic advance of 52.81 and 67.68 per cent at 5 and 1 per cent level, respectively.

4.4.10 Fruit diameter (mm)

The estimate of heritability was very high 88.45 per cent with high genetic advance in percentage to mean 34.77 and 44.57 at 5 and 1 per cent level, respectively for fruit diameter.

4.4.11 Number of seeds per fruit

Number of seeds per fruit registered estimate of heritability (54.01%) coupled with genetic advance in percentage to mean 24.88 and 31.88 at 5 and 1 per cent level, respectively.

4.4.12 Test weight (g)

The estimate of heritability was high 60.68 per cent with high genetic advance in percentage to mean 26.73 and 34.26 at 5 and 1 per cent level respectively for 1000 seed weight.

4.4.13 Green fruit weight (g)

Very high heritability estimate (91.18%) coupled with high genetic advance in percentage to mean 86.23 and 110.51 at 5 and 1 per cent level respectively exhibited for fresh fruit weight per fruit.

4.4.14 Dry fruit weight (g)

The estimate of heritability (93.19 %) was very high for fresh fruit weight per fruit coupled with high genetic advance in percentage to mean 59.50 and 76.25 at 5 and 1 per cent level, respectively.

4.4.15 Green fruit weight (g plant⁻¹)

Very high heritability (97.99%) with high genetic advance in percentage to mean 91.15 and 116.81 at 5 and 1 per cent level respectively was recorded for fresh fruit weight per plant.

4.4.16 Dry fruit weight (g plant⁻¹)

Dry fruit weight per plant recorded very high estimate of heritability (97.35%). This trait was also exhibited high genetic advance in percentage to mean 72.75 and 93.24 at 5 and 1 per cent level, respectively.

4.5 Correlation coefficient

The data was pooled and correlation analysis was carried out between yield and its contributing component in all possible combinations for all the characters studied and are presented in Table 11 and 12. The results of phenotypic correlation are presented character wise.

4.5.1 Days to 50 per cent flowering

This trait was positively correlated with opened stigma (0.21), days to fifty per cent maturity (0.20), fruit diameter (0.18), seeds per fruit (0.09), test weight (0.09), dry fruit weight (0.07), green fruit weight (0.06), green fruit weight per plant (0.11) and dry fruit weight per plant (0.03) while, plant height (-0.12), primary branches (-0.15), secondary branches (-0.11), closed stigma (-0.21), number of fruits plant⁻¹ (-0.09) and fruit length (-0.18) were found negatively correlated.

4.5.2 Plant height (cm)

Primary branches (0.20), secondary branches (0.53), opened stigma (0.32), fruit length (0.34), test weight (0.25), dry fruit weight (0.30), green fruit weight (0.40), green fruit weight per plant (0.23) and dry fruit weight per plant (0.10) were positively correlated with plant height. However, other traits viz., closed stigma (-0.33), number of fruits per plant (-0.05), fruit diameter (-0.09) and seeds per fruit (-0.22), were negatively correlated. Interestingly this trait was neither positively nor negatively associated with days to fifty per cent maturity.

Table 11. Estimate of genotypic correlation coefficient between fruit yield and its components in chilli

Characters	PH	PB	SB	CS	OS	DFM	NFP	FL	FD	SF	TW	DFW	GFW	GFWP	DFWP
DFF	-0.14	-0.25	-0.05	-0.24	0.24	0.22	-0.08	-0.20	0.19	0.15	0.13	0.07	0.08	0.12	0.03
PH		0.23	0.68**	-0.34	0.34	0.00	-0.07	0.40*	-0.10	-0.27	0.31	0.32	0.45*	0.24	0.11
PB			0.42*	-0.19	0.19	0.35	0.45*	0.18	-0.55**	-0.23	-0.40*	-0.21	-0.18	0.09	0.27
SB				-0.35	0.35	0.09	0.04	0.05	-0.09	-0.12	0.07	0.14	0.06	0.02	0.00
CS					-1.00	0.17	0.15	-0.30	-0.23	-0.24	-0.04	-0.28	-0.18	-0.35	-0.27
OS						-0.17	-0.15	0.30	0.23	0.24	0.04	0.28	0.17	0.35	0.27
DFM							0.01	-0.03	-0.25	-0.13	0.04	-0.17	-0.02	-0.16	-0.29
NFP								-0.38	-0.64**	-0.35	-0.51**	-0.63**	-0.47**	0.44*	0.74**
FL									0.12	0.11	0.22	0.46*	0.60**	0.14	-0.12
FD										0.61**	0.68**	0.80**	0.44*	-0.12	-0.24
SF											0.35	0.60**	0.25	0.06	0.08
TW												0.63**	0.55**	-0.12	-0.29
DFW													0.77**	0.06	-0.14
GFW														0.39*	-0.08
GFWP															0.81**

*, **, Significant at p = 0.05 and 0.01, respectively.

DFF = Days to 50% flowering

CS = Closed stigma

FL = Fruit length

DFW= Dry fruit weight

PH = Plant height

OS = Opened stigma

FD = Fruit diameter

GFW= Green fruit weight

PB = Primary branches

DFM = Days to fifty % maturity

SF = Seeds per fruit

GFWP = Green fruit weight per plant

SB = Secondary branches

NFP = Number of fruits per plant

TW = 1000 test weight

DFWP = Dry fruit weight per plant

4.5.3 Primary branches per plant

Secondary branches (0.40), opened stigma (0.18), days to fifty per cent maturity (0.20), number of fruits per plant (0.25), fruit length (0.07), green fruit weight per plant (0.06) and dry fruit weight per plant (0.15) were positively correlated with primary branches. Whereas other traits viz., closed stigma (-0.19), fruit diameter (-0.37), seeds per fruit (-0.02), test weight (-0.23), green fruit weight (-0.09) and dry fruit weight (-0.14) were registered negative association with this trait.

4.5.4 Secondary branches

Opened stigma (0.27), days to fifty per cent maturity (0.09), number of fruits per plant (0.03), fruit length (0.01), test weight (0.01), green fruit weight (0.06) and dry fruit weight (0.09) and green fruit weight per plant (0.01) were positively correlated with secondary branches. However, traits such as closed stigma (-0.27), fruit diameter (-0.09), seeds per fruit (-0.13) and dry fruit weight per plant (-0.01) were negatively associated with this trait.

4.5.5 Closed stigma

This trait was positively correlated with days to 50 per cent maturity (0.18) and number of fruits per plant (0.13) while, opened stigma (-1.00), fruit length (-0.29), fruit diameter (-0.21), seeds per fruit (-0.19), test weight (-0.06), green fruit weight (-0.16), dry fruit weight (-0.27), green fruit weight per plant (-0.34) and dry fruit weight per plant (-0.26) were found negatively correlated.

4.5.6 Opened stigma

Fruit length (0.28), fruit diameter (0.21), seeds per fruit (0.19), test weight (0.06), green fruit weight (0.16), dry fruit weight (0.27), green fruit weight per plant (0.34) and dry fruit weight per plant (0.26) were positively correlated with opened stigma trait. However, days to 50 per cent maturity (-0.18) and number of fruits per plant (-0.13) were found negatively correlated with it.

4.5.7 Days to 50 per cent maturity

Association of days to 50 per cent maturity was positive with number of fruits per plant (0.01) and test weight (0.06). However, association of this trait was negative with fruit length (-0.03), fruit diameter (-0.23), seeds per fruit (-0.09), green fruit weight (-0.03) and dry fruit weight (-0.17), green fruit weight per plant (-0.15) and dry fruit weight per plant (-0.28).

Table 12. Estimate of phenotypic correlation coefficient between fruit yield and its components in chilli

Chara- acters	PH	PB	SB	CS	OS	DFM	NFP	FL	FD	SF	TW	DFW	GFW	GFWP	DFWP
DFF	-0.12	-0.15	-0.11	-0.21	0.21	0.20	-0.09	-0.18	0.18	0.09	0.09	0.07	0.06	0.11	0.03
PH		0.20	0.53**	-0.33	0.32	0.00	-0.05	0.34	-0.09	-0.22	0.25	0.30	0.40*	0.23	0.10
PB			0.40*	-0.19	0.18	0.20	0.25	0.07	-0.37*	-0.02	-0.23	-0.14	-0.09	0.06	0.15
SB				-0.27	0.27	0.09	0.03	0.01	-0.09	-0.13	0.01	0.09	0.06	0.01	-0.01
CS					-1.00	0.18	0.13	-0.29	-0.21	-0.19	-0.06	-0.27	-0.16	-0.34	-0.26
OS						-0.18	-0.13	0.28	0.21	0.19	0.06	0.27	0.16	0.34	0.26
DFM							0.01	-0.03	-0.23	-0.09	0.06	-0.17	-0.03	-0.15	-0.28
NFP								-0.37	-0.58**	-0.24	-0.39*	-0.59**	-0.43*	0.43*	0.72**
FL									0.10	0.08	0.15	0.43*	0.55**	0.12	-0.12
FD										0.47**	0.56**	0.75**	0.39*	-0.11	-0.22
SF											0.10	0.44*	0.20	0.06	0.07
TW												0.47*	0.34	-0.08	-0.22
DFW													0.71**	0.06	-0.13
GFW														0.38*	-0.06
GFWP															0.80**

*, **, Significant at P = 0.05 and 0.01, respectively.

DFF = Days to 50% flowering

CS = Closed stigma

FL = Fruit length

DFW= Dry fruit weight

PH = Plant height

OS = Opened stigma

FD = Fruit diameter

GFW= Green fruit weight

PB = Primary branches

DFM = Days to fifty % maturity

SF = Seeds per fruit

GFWP = Green fruit weight per plant

SB = Secondary branches

NFP = Number of fruits per plant

TW = 1000 test weight

DFWP = Dry fruit weight per plant

4.5.8 Number of fruits per plant

Number of fruits per plant was positively associated with green fruit weight per plant (0.43) and dry fruit weight per plant (0.72). However, fruit length (-0.37), fruit diameter (-0.58), seeds per fruit (-0.24), test weight (-0.39), green fruit weight (-0.43), dry fruit weight (-0.59) were negatively correlated with it.

4.5.9 Fruit length (g)

Positive correlation was seen among the fruit diameter (0.10), seeds per fruit (0.08), test weight (0.15), dry fruit weight (0.43), green fruit weight (0.55), green fruit weight per plant (0.12) while this trait was negatively correlated with dry fruit weight per plant (-0.12).

4.5.10 Fruit diameter (mm)

Fruit diameter was positively correlated with number of seeds per fruit (0.47), Dry fruit weight (0.75), test weight (0.56) and green fruit weight (0.39), While it was negatively correlated with green fruit weight per plant (-0.11) and dry fruit weight per plant (-0.22).

4.5.11 Number of seeds per fruit

Number of seeds fruit was positively correlated with test weight (0.10), green fruit weight (0.20), dry fruit weight (0.44), green fruit weight per plant (0.06) and dry fruit weight per plant (0.07).

4.5.12 Test weight (g)

This trait was positively correlated with green fruit weight (0.34) and dry fruit weight (0.47), while it was negatively correlated with green fruit weight per plant (-0.08) and dry fruit weight per plant (-0.22).

4.5.13 Dry fruit weight (g)

Positive association was observed between green fruit weight (0.71) and green fruit weight per plant (0.06) whereas, negative association was observed with dry fruit weight per plant (-0.13).

4.5.14 Green fruit weight (g)

This trait was positively correlated with green fruit weight per plant (0.38) while it was negatively correlated with dry fruit weight per plant (-0.06).

4.5.15 Green fruit weight (g plant⁻¹)

Association between green fruit weight per plant and with dry fruit weight per plant (0.80) was positive and very strong.

4.6 Path co-efficient analysis

The data was pooled and path analysis was carried out between dry fruit yield per plant and its contributing components. The positively correlated parameters were used for its analysis with all possible combinations. In general, it was observed that genotypic direct and indirect effects were higher than their corresponding phenotypic values. The results obtained in genotypic and phenotypic direct and indirect effects are being presented in Table 13 and discussed character wise at phenotypic level here under.

4.6.1 Days to fifty per cent flowering V/s dry fruit yield per plant

An examination of the path analysis revealed that contribution of this trait was found negative direct influence (-0.024) up on dry fruit yield per plant and the indirect positive effect *via* plant height (0.003), primary branches (0.004) and number of fruits per plant (0.002). Whereas, it contributes negative indirect effect through opened sigma (-0.005), number of seeds per fruit (-0.002) and green fruit weight per plant (-0.003).

4.6.2 Plant height V/s dry fruit yield per plant

This trait was found negligible (0.001) direct influence on dry fruit yield per plant with a negligible positive indirect effect through all other traits *viz.*, days to 50 per cent flowering (0.000), primary branches (0.000), opened sigma (0.000), number of seeds per fruit (0.000), seeds per fruit (0.000) and green fruit weight per plant (0.000).

4.6.3 Primary branches V/s dry fruit yield per plant

This trait was found negative direct influence (-0.056) up on dry fruit yield per plant and the positive indirect effect *via* days to fifty per cent flowering (0.008) and seeds per fruit (0.001). It contributes negative indirect effect through other traits *viz.*, plant height (-0.011), opened sigma (-0.010), number of fruits per plant (-0.014) and green fruit weight per plant (-0.003).

Table 13. Genotypic and phenotypic path coefficients of the characters affecting dry fruit yield per plant

Characters		Days to 50% flowering	Plant height (cm)	Primary branches per plant	Opened stigma	Number of fruits per plant	Seeds per fruit	Green fruit weight per plant
Days to 50 % flowering	G	-0.049	0.007	0.012	-0.012	0.004	-0.007	-0.006
	P	-0.024	0.003	0.004	-0.005	0.002	-0.002	-0.003
Plant height	G	-0.013	0.093	0.021	0.031	-0.006	-0.025	0.023
	P	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Primary branches	G	0.025	-0.023	-0.098	-0.018	-0.045	0.022	-0.009
	P	0.008	-0.011	-0.056	-0.010	-0.014	0.001	-0.003
Opened stigma	G	0.041	0.057	0.032	0.170	-0.025	0.040	0.059
	P	0.033	0.050	0.028	0.153	-0.020	0.029	0.052
Number of fruits per plant	G	-0.060	-0.049	0.333	-0.108	0.735	-0.260	0.324
	P	-0.051	-0.026	0.146	-0.077	0.573	-0.136	0.249
Seeds per fruit	G	0.043	-0.077	-0.065	0.067	-0.100	0.284	0.018
	P	0.014	-0.032	-0.004	0.028	-0.035	0.148	0.010
Green fruit weight per plant	G	0.049	0.098	0.036	0.139	0.177	0.026	0.401
	P	0.055	0.116	0.029	0.168	0.215	0.032	0.495
Correlation with dry fruit weight per plant	G	0.030	0.110	0.270	0.270	0.74**	0.080	0.81**
	P	0.030	0.100	0.150	0.260	0.72**	0.070	0.8**

G – Genotype P – Phenotype

*, **Significant at p = 0.05 and 0.01, respectively.

4.6.4 Opened Sigma V/s dry fruit yield per plant

Direct contribution of this trait was low (0.153) with negligible positive influence through days to 50 per cent flowering (0.033), plant height (0.050), primary branches (0.028), seeds per fruit (0.029) and green fruit weight per plant (0.052). Its influence *via* number of fruits per plant (-0.020) was negative.

4.6.5 Number of fruits per plant V/s dry fruit yield per plant

High positive influence (0.573) was exhibited directly by number of fruits per plant with low indirect effect *via* primary branches (0.146) and green fruit weight per plant (0.249) on dry fruit yield per plant. Whereas, negative indirect effect through, days to fifty per cent flowering (-0.051), plant height (-0.026), opened sigma (-0.077) and seeds per fruit (-0.136).

4.6.6 Number of seeds per fruit V/s dry fruit yield per plant

Low positive influence (0.148) was registered directly by number of seeds per fruit up on dry fruit yield per plant. However, it contributed negligible indirect effect through, days to fifty per cent flowering (0.014), opened sigma (0.028) and green fruit weight per plant (0.010) while negative indirect influence through, plant height (-0.032), primary branches (-0.004) and number of fruits per plant (-0.035).

4.6.7 Green fruit weight per plant V/s dry fruit yield per plant

Direct contribution of this trait was high (0.495) up on dry fruit yield per plant with negligible influence through rest all the traits *viz.*, days to fifty per cent flowering (0.055), plant height (0.116), primary branches (0.029), opened sigma (0.168), number of fruits per plant (0.215) and number of seeds per fruit (0.032).

4.7 Screening for powdery mildew (*Leveillula taurica*) disease resistance

Disease severity was recorded by using 0-9 scale (Mayee and Datar, 1986) and presented in Table 14. Out of 23 genotypes and five hybrids screened against powdery mildew under natural epiphytotic conditions. None of them were found to be immune and resistant. However, only genotype JNB1-1 was found moderately resistant. While, F₁ hybrids *viz.*, JCH 40, JCH 46 and genotypes P3, SNK, MSSF and 9608U showed moderately susceptible. However F₁ hybrids JCH 42, BCH 42 and genotypes HDC 75, B.KADDI, KDCS-210-10-2, B DABBI, LCA- 960, 9608D, ACB-1, P1 SUM, 5 SUM,

LCA 310A, T2-1, BVC-1, BVC-47, KDC-1 and KA2 showed susceptible and SITARA, JCH 24, KDCS-210-10-4 and GVK2-2 showed highly susceptible reaction to powdery mildew of chilli (Table 14.1).

4.8 Screening for chilli fruit borer (*Helicoverpa armigera*) resistance

Pest severity was recorded based on per cent infestation and presented in Table 15. Among 23 genotypes and 5 hybrids screened against chilli fruit borer under natural conditions. Genotypes, viz., P1SUM, 5 SUM, LCA 310A, T2-1, BVC-1 and 9608U were found highly resistant. However, genotypes, viz., JCH 46, BVC-47 and KDC-1 showed resistant and JCH-42, JCH-24, KDCS-210-10-4, B.DABBI, JNB1-1 and GVK2-2 moderately resistant for fruit borer. While, remaining hybrid BCH-42 and genotypes B.KADDI and MSSF showed susceptible reaction. However genotypes, viz., P3, LCA-960, SNK, 9608D, KA2 and hybrids viz., SITARA, HDC 75 showed highly susceptible in reaction to fruit borer (Table 15.1).

Table 14. Screening of chilly genotypes for powdery mildew

Sl. No.	Genotypes	Powdery mildew (PDI)	Ratings
1.	SITARA	9	Highly susceptible
2.	JCH 42	7.57	Susceptible
3.	BCH 42	8.97	Susceptible
4.	JCH 40	5.1	Moderately susceptible
5.	JCH 24	9	Highly susceptible
6.	KDCS-210-10-4	9	Highly susceptible
7.	HDC 75	8.83	Susceptible
8.	B. KADDI	8.6	Susceptible
9.	KDCS-210-10-2	8.47	Susceptible
10.	JCH 46	5.53	Moderately susceptible
11.	B DABBI	7.63	Susceptible
12.	P3	6.03	Moderately susceptible
13.	LCA-960	8.97	Susceptible
14.	9608D	8.87	Susceptible
15.	SNK	6.2	Moderately susceptible
16.	JNB1-1	3.6	Moderately resistant
17.	ACB1	7.33	Susceptible
18.	P1 SUM	7.6	Susceptible
19.	5 SUM	8.07	Susceptible
20.	MSSF	6.57	Moderately susceptible
21.	LCA 310A	7.73	Susceptible
22.	T2-1	7.53	Susceptible
23.	BVC-1	7.2	Susceptible
24.	GVK2-2	9	Highly susceptible
25.	BVC-47	8.47	Susceptible
26.	9608U	6.93	Moderately susceptible
27.	KDC-1	7	Susceptible
28.	KA2	7.5	Susceptible

PDI – Per cent disease index

Table 14.1: Reaction of chilli genotypes for powdery mildew (*Leveillula taurica*) under natural condition

Scale	Score Description	Genotypes	Reaction
0	No symptom of powdery mildew	Nil	Immune
1	Small scattered powdery mildew specks covering 1% or less leaf area	Nil	Resistant
3	Small powdery lesions covering 1-10% of leaf area	JNB1-1	Moderately resistant
5	Powdery lesions enlarged covering 11-25% of leaf area	JCH 40, JCH 46, P3, SNK, MSSF and 9608U	Moderately susceptible
7	Powdery lesions coalesce to form big patches covering 26-50% of leaf area	JCH 42, BCH 42, HDC 75, B. KADDI, KDCS-210-10-2, B. DABBI, LCA- 960, 9608D, ACB-1, P1 SUM, 5 SUM, LCA 310A, T2-1, BVC-1, BVC-47, KDC-1 and KA2	Susceptible
9	Big powdery patches covering 51% or more of leaf area and defoliation occur.	SITARA, JCH 24, KDCS-210-10-4 and GVK2-2	Highly susceptible

Table 15. Screening of chilly genotypes against for fruit borer

Sl. No.	Genotypes	Fruit borer incidence (%)	Ratings
1.	SITARA	64.47	Highly susceptible
2.	JCH 42	16.67	Moderately resistant
3.	BCH 42	34	Susceptible
4.	JCH 40	28	Moderately susceptible
5.	JCH 24	14.43	Moderately resistant
6.	KDCS-210-10-4	15.33	Moderately resistant
7.	HDC 75	52.33	Highly susceptible
8.	B. KADDI	33.33	Susceptible
9.	KDCS-210-10-2	23.33	Moderately susceptible
10.	JCH 46	7.67	Resistant
11.	B DABBI	11.67	Moderately resistant
12.	P3	46.67	Highly susceptible
13.	LCA-960	87.67	Highly susceptible
14.	9608D	69	Highly susceptible
15.	SNK	61	Highly susceptible
16.	JNB1-1	17.67	Moderately resistant
17.	ACB1	23.33	Moderately susceptible
18.	P1 SUM	0	Highly resistant
19.	5 SUM	0	Highly resistant
20.	MSSF	31.67	Susceptible
21.	LCA 310A	0	Highly resistant
22.	T2-1	0	Highly resistant
23.	BVC-1	0	Highly resistant
24.	GVK2-2	12.33	Moderately resistant
25.	BVC-47	4.67	Resistant
26.	9608U	0	Highly resistant
27.	KDC-1	3.33	Resistant
28.	KA2	40.33	Highly susceptible

Table 15.1: Reaction of chilli genotypes against fruit borer (*Helicoverpa armigera*) under natural condition

Sl. No.	Damage level	Genotypes	Rating
1.	No damage	P1 SUM, 5 SUM, LCA 310A, T2-1, BVC-1and 9608U	Highly Resistant.
2.	0 - 10.0 per cent fruits damaged	JCH 46, BVC-47 and KDC-1	Resistant
3.	10.1-20.0 per cent fruits damaged	JCH 42, JCH 24, KDCS-210-10-4, B.DABBI, JNB1-1 and GVK2-2	Moderately Resistant
4.	20.1-30.0 per cent fruits damage	JCH 40, KDCS-210-10-2, ACB1	Moderately susceptible
5.	30.1-40.0 per cent fruits damaged	BCH 42, B.KADDI and MSSF	Susceptible
6.	40.1 per cent fruits damaged & above	SITARA, HDC 75, P3, LCA-960, SNK, 9608D and KA2	Highly susceptible

PDI – Per cent disease index

V. DISCUSSION

Chilli is an indispensable spice crop of the world food industries. The fruit is used as important constituent in food which also provides flavours, colours, vitamin-A, B and C, besides pungency to food items.

The crop is commercially important in India for the home market as well as export purpose. While fruits are used for pungency and it has high medicinal properties. However, the production potential of the crop has not been exploited owing to several constraints. High stabilized yields are a must for meeting the demands of ever increasing domestic and global consumers.

Although the black cotton soil is very ideal for cultivation of chilli, the crop also suffers from some important diseases such as anthracnose, powdery mildew and *Fusarium* wilt in addition to several viral diseases. *Fusarium* wilt of chilli is posing a serious threat in chilli cultivation and is responsible for huge losses in many parts of India (Singh *et al.*, 1998).

The pathogen being typically soilborne and is very difficult to achieve economic control of the disease. Literature search indicated the need to take up the resistance breeding programme. History of success in various soilborne diseases indicated that the host plant resistance or developments of resistant hybrids/varieties are the appropriate strategies to overcome the wilt of chilli. Keeping these points in view, the present investigations was to identify *Fusarium* wilt disease resistant genotypes and to develop chilli hybrids resistant to *Fusarium* wilt.

Many qualitative changes were observed in an infected field that distinguished diseased from healthy field which could be expressed in numbers or any characteristics that is frequently altered due to infection. The sequence of symptoms encountered were quite distinct with stunting of the plants, leaf yellowing and drooping, necrosis and subsequently gradual or sudden wilting, with leaves retained on wilted plants. Wilted plants when splited longitudinally showed brown vascular discolouration. A diverse and complex symptomatology of wilt induced by *Fusarium* spp. had been described in tomato (Kapoor, 1998).

5.1 Screening of chilli genotypes and hybrids

Host plant resistance has been an apt choice in all the crop improvement programmes and is essential to recommend the cultivars directly for cultivation in endemic area, infested with soil borne fungus, although the resistant variety is always one of the best ways and will go a long way in reducing loss due to wilt. Ironically, the three popular and dominant cultivars viz., Byadagi Kaddi, Guntur and G-4 grown are susceptible in the region. Nevertheless, identification of diverse and stable field source of resistance to *Fusarium* wilt is imperative and pre-requisite to a resistance breeding programme.

Among the 56 genotypes screened for resistance against *F. solani*, none of them were found to be immune or resistant and only genotype P3 was found moderately resistant in both seed inoculation and rapid root dip transplanting technique. Among 38 hybrids screened by rapid root dip transplanting technique and pot culture technique, hybrids viz., JNA2 x ACB1 x 9608D and Rajaput x P3 showed resistant in pot culture technique. None of the hybrids showed resistant reaction in rapid root dip transplanting technique.

Six important parents were again screened for confirmation in sick pot method, none of the parents showed resistant reaction to *Fusarium* wilt. However, parent P3 was showed moderately resistant reaction to *F. solani*. The parents viz., K1-4D and KA2 showed susceptible reaction to *Fusarium* wilt.

However, rapid root dip transplanting encountered higher percentage of mortality obviously due to forcible inoculation. Genotypes commonly cultivated in Northern Karnataka region such as Byadagi Kaddi, Byadagi Dabbi, Guntur and G-4 are susceptible, it is a cause of concern to the farming community. Such wide response of chilli genotypes to *Fusarium* wilt disease was earlier observed by Ahmed *et al.* (1994), Nayeema *et al.* (1995) and Singh *et al.* (1998). Similar type of response was observed by several workers (Singh *et al.*, 1996 and Singh *et al.*, 1997) in crops such as watermelon, pigeonpea, chickpea cumin, potato and linseed *etc.*

5.2 Analysis of variance for yield and its component

Analysis of variances showed that mean sum of squares due to genotypes were found to be highly significant for all the characters indicating significant variation among the genotypes for all the characters studied.

5.2.1 Mean *per se* performance of the characters

Hybrid JCH 46 and genotype P1SUM were on par and registered significantly highest days to fifty per cent maturity. However, genotype KDC-1 recorded significantly highest plant height and hybrid Sitara gave significantly highest number of primary branches and longest fruit length recorded. While, genotype KDC-1 recorded significantly highest number of secondary branches and KA2 recorded more number of closed stigma and less number of opened stigma compare to all genotypes and hybrids. However, genotype P1 SUM recorded significantly highest number of days to fifty per cent maturity. While, genotype 5-SUM produced significantly more number of fruits per plant. However, genotype LCA960 recorded significantly highest fruit diameter. Significantly higher test weight was observed by LCA960. More dry fruit weight per fruit as well as more green fruit weight were recorded by genotype LCA960 and BVC-47 respectively. While, newly developed hybrid JCH 46 recorded significantly highest dry fruit weight per plant as well as highest green fruit weight per plant.

5.2.2 Variation for yield and its components

Phenotypic coefficient of variation was higher than their corresponding genotypic coefficient of variation (Fig. 1) for plant height, primary branches, secondary branches, closed stigma, number of fruits per plant, fruit length, fruit diameter, seeds per fruit, 1000 test weight, dry fruit weight, green fruit weight, green fruit weight per plant and dry fruit weight per plant revealed presence of environmental influence for the expression of these characters. All the traits showed least difference between phenotypic and genotypic variance, which indicated additive gene action in the expression of most of the characters.

High magnitude of phenotypic coefficient of variation and genotypic coefficient of variation were recorded for number of fruits per plant fresh fruit weight per fruit, dry fruit weight per fruit, fruit length, fruit diameter, number of seeds per fruit, fresh fruit weight per plant and dry fruit weight per plant. The above findings are in concordance with those obtained

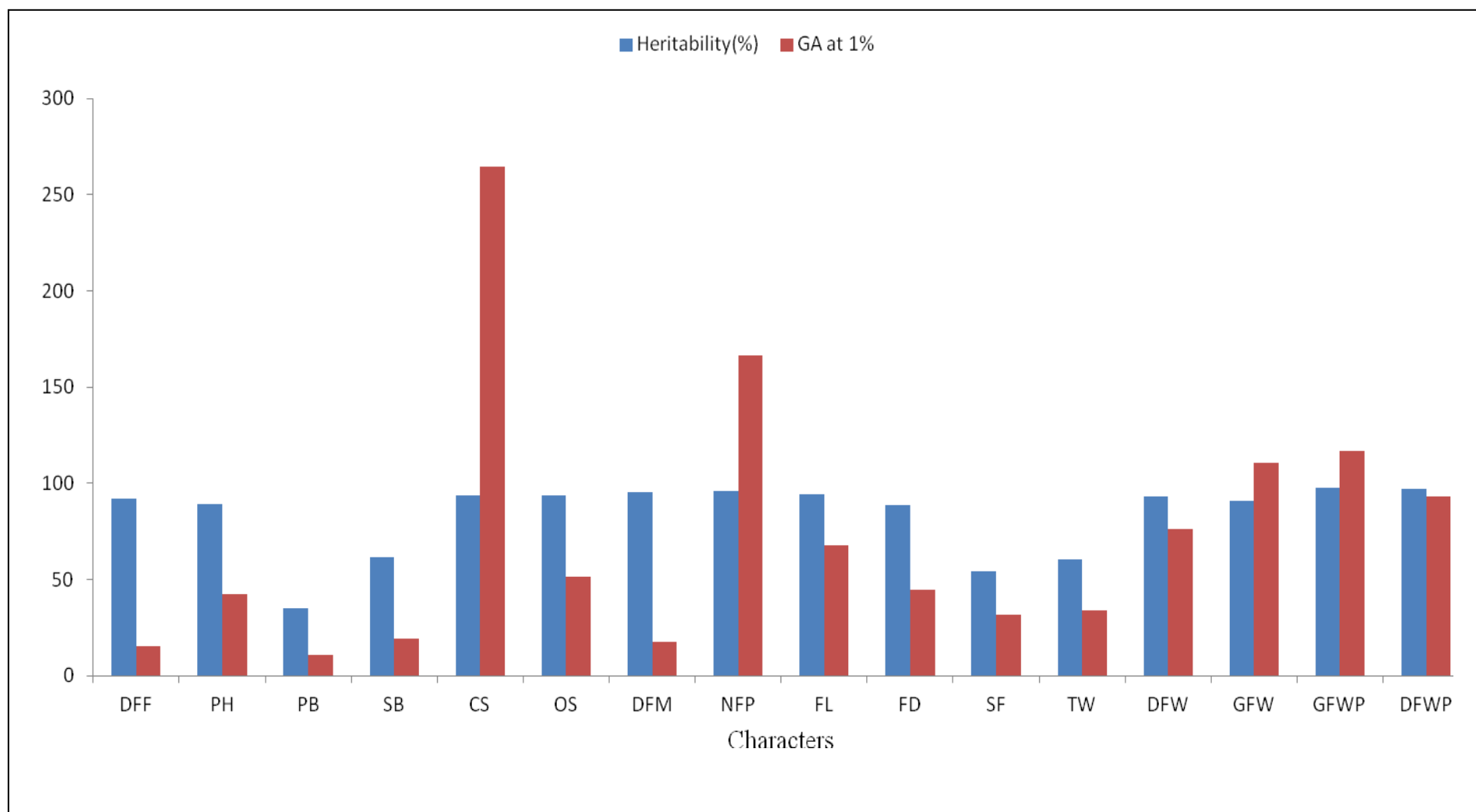


Fig. 2: Heritability and Genetic advance as per mean for sixteen characters in chilli

by Adamu and Ado (1988), Joshi (1988), Sahoo *et al.* (1990), Manju and Sreelathakumary (2002), Mini and Khedar (2004), Abu and Uguru (2006), Farhad *et al.* (2008), Gupta *et al.* (2009) and Wilson and Philip (2009).

However, number of primary branches, plant height, and 1000 seed weight registered moderate and days to first fruit harvest, low phenotypic coefficient of variation and genotypic coefficient of variation as reported by Mishra (2004), while fifty per cent flowering exhibited low genetic coefficient of variation and moderate phenotypic coefficient of variation which is in agreement with the finding of Manju and Sreelathakumary (2002), Shreelathakumary and Rajmony (2003), Mini and Khedar (2004), Mishra (2004), Joshi and Kumar (2007), Farhad *et al.* (2008), Patil *et al.* (2008), Gupta *et al.* (2009) and Wilson and Philip (2009).

5.3 Heritability and genotypic advance

The relative degree at which a character is transmitted to offspring is indicated by heritability. Heritability measures the contribution of genetic variability to the phenotypic variability observed for quantitative traits. The estimate of heritability can be utilized for the prediction of genetic gain. This indicates genetic improvement that would result from the selection of individuals.

In the present study, heritability estimates have been made in the broad sense, which includes variance due to all types of gene expressions. The information obtained on the magnitude of heritability estimates for various characters in genotype is also helpful in determining the extent of possible selection gains through different methods that will be used to handle the material.

The traits with high heritability and low genetic advance in percentage of mean indicates non additive gene effects. However, the characters with low heritability and low genetic advance revealed low scope for selection. High heritability estimates with high genetic advance as per cent mean were observed for most of the characters viz., green fruit weight per fruit, dry fruit weight per fruit, fruit length, fruit diameter, number of primary branches, plant height, number of seeds per fruit, 1000 seed weight, green fruit weight per plant and dry fruit weight per plant (Fig. 2) indicating that these characters are under the control of additive gene action. Hence, there is a greater scope for the improvement of these characters through selection. The above findings are in accordance with those obtained by Thakur (1988), Sahoo *et al.*

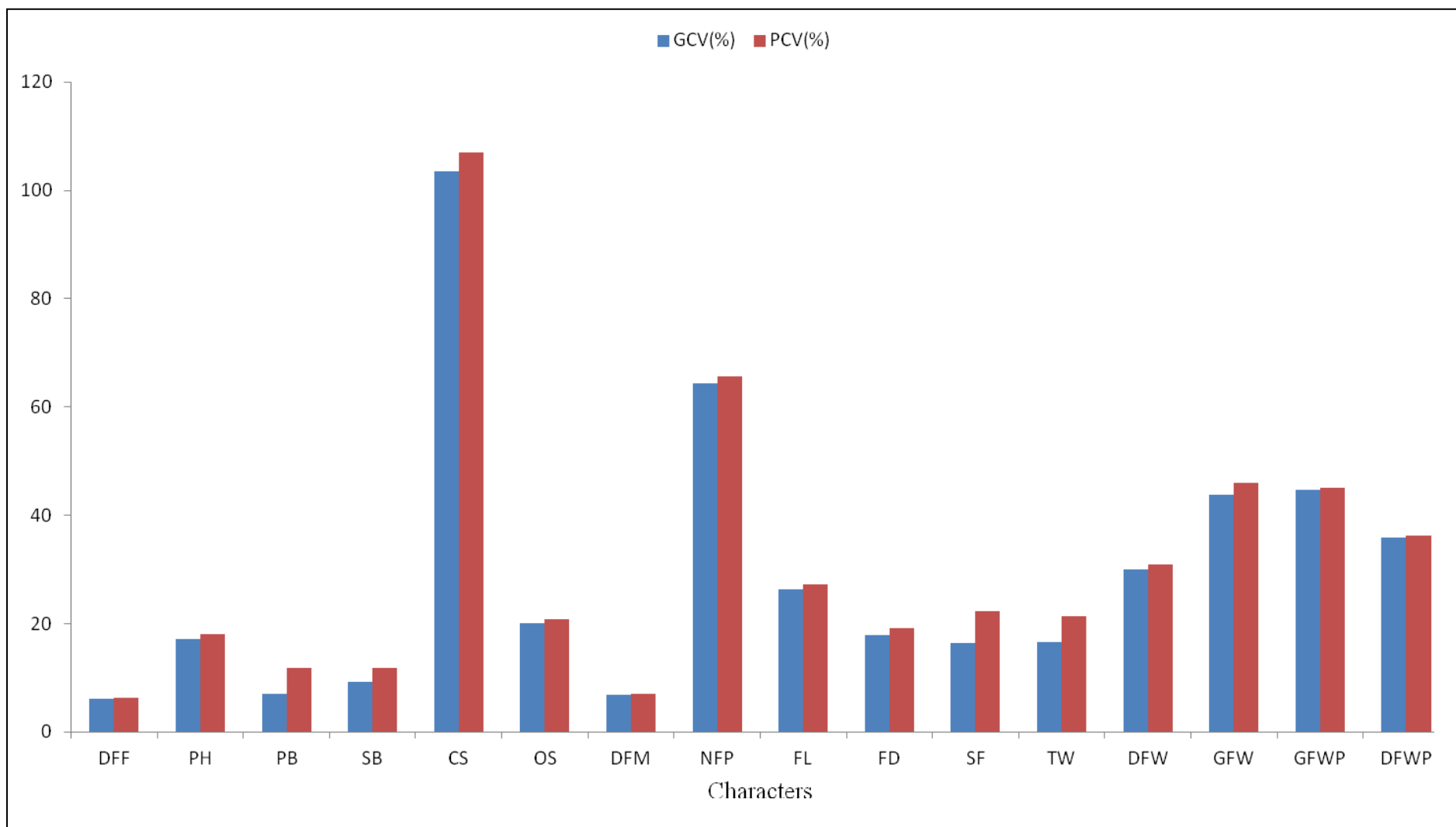


Fig. 1: Genetic coefficient of variation and phenotypic coefficient of variation in chilli

(1990), Manju and Sreelathakumary (2002), Mishra *et al.* (2004), Johari and Kumar (2007), Farhad *et al.* (2008), Singh and Yadav (2008), Wilson and Philip (2009) and Pandit *et al.* (2009).

Days to fifty per cent flowering and days to fifty per cent maturity showed very high heritability with moderate genetic advance as percentage of mean suggested these characters are more important for selecting better genotypes in crop improvement programmes. While, closed stigma and number of fruits per plant exhibited high heritability and very high genetic advance have more scope for selection. However, primary branches registered high heritability with low genetic advance revealed non additive gene effects. None of the traits exhibited low heritability with low genetic advance as percentage of mean indicating low scope for the improvement of this trait through selection.

5.4 Correlation coefficient

The knowledge of correlation is essential to plant breeders before taking up any breeding programme. They indicate the magnitude of association between pairs of characters and form the basis of selection index, thereby aiding the breeder in the crop improvement. Yield being the final outcome of interaction of a group of interrelated and interdependent character. The knowledge of correlation helps to know how the improvement of one character brings a simultaneous change in other characters.

Estimates of genetic correlations along with phenotypic associations not only provide the information about the extent of inherent association but also indicate how much of the phenotypically expressed correlation is influenced by the environment. Though plant breeders are least interested in environmental correlation, never the less it provides information about the relationship of characters irrespective of genotypic differences in the plant material.

Magnitude of genotypic correlations was greater than the corresponding phenotypic correlations which are in agreement with Ahmed *et al.* (1997), Sreelathakumary and Rajmony (2003), Kumar *et al.* (2003) and Sharma *et al.* (2007). This lower phenotypic correlation results due to the masking effects and modifying effect of environment on the association of characters at the genic level.

Number of fruits per plant, fresh fruit weight per fruit, dry fruit weight per fruit, fruit length, fruit diameter, number of primary branches, plant height and number of seeds per fruit showed positive correlation with fresh as well as dry fruit yield per plant. Similar finding was also registered earlier by Kumar *et al.* (2003), Nandadevi and Hosmani (2003), Mathew *et al.* (2004), Tembhurne *et al.* (2008), Naidu *et al.* (2009), Pandit *et al.* (2009) and Tembhurne *et al.* (2009).

However, the characters desirable for earliness viz., days to 50 per cent flowering and days to 50 per cent maturity were associated negatively with fresh as well as dry fruit weight per plant as reported earlier by Sharma *et al.* (2007) and Wilson and Philip (2009).

Days to 50 per cent flowering was positively correlated with opened stigma, days to fifty per cent maturity, fruit diameter, seeds per fruit, test weight, dry fruit weight, green fruit weight, green fruit weight per plant and dry fruit weight per plant.

Primary branches, secondary branches, opened stigma, fruit length, test weight, dry fruit weight, green fruit weight, green fruit weight per plant and dry fruit weight per plant were positively correlated with plant height. Secondary branches, opened stigma, days to fifty per cent maturity, number of fruits per plant, fruit length, green fruit weight per plant and dry fruit weight per plant were positively correlated with primary branches. Opened stigma, days to 50 per cent maturity, number of fruits per plant, fruit length, test weight, green fruit weight and dry fruit weight and green fruit weight per plant were positively correlated with secondary branches. Closed stigma was positively correlated with days to 50 per cent maturity and number of fruits per plant.

Fruit length, fruit diameter, seeds per fruit, test weight, green fruit weight, dry fruit weight, green fruit weight per plant and dry fruit weight per plant were positively correlated with opened stigma trait. Association of days to 50 per cent maturity was positive with number of fruits per plant and test weight. Number of fruits per plant was positively associated with dry fruit weight per plant as investigated by Karima *et al.* (2012) and green fruit weight per plant.

Positive correlation was seen among the fruit diameter, seeds per fruit, test weight, dry fruit weight, green fruit weight and green fruit weight per plant with fruit length. Fruit diameter was positively correlated with seeds per fruit, test weight, dry fruit

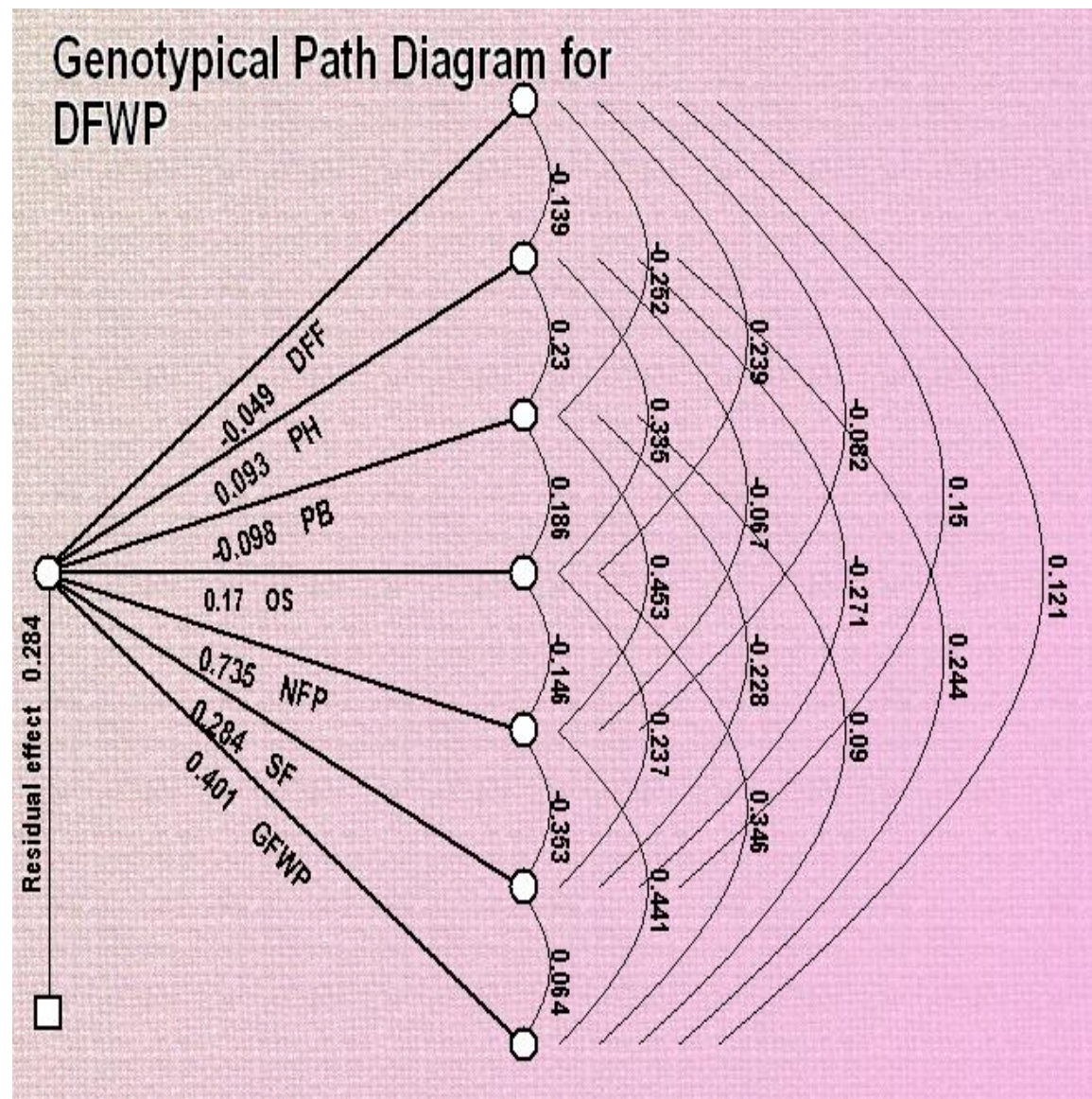
weight and green fruit weight. Number of seeds per fruit was positively correlated with test weight, green fruit weight, dry fruit weight, green fruit weight per plant and dry fruit weight per plant. However, dry fruit weight per plant was positively correlated with number of seeds per fruit. The same investigation was obtained by Surya Kumari *et al.* (2011).

Test weight was positively correlated with green fruit weight and dry fruit weight as reported by Mathew *et al.* (2004). Dry fruit weight was observed positive association with green fruit weight and green fruit weight per plant. Green fruit weight was positively correlated with green fruit weight per plant. Association between green fruit weight per plant and with dry fruit weight per plant was positive and very strong.

5.5 Path coefficient analysis

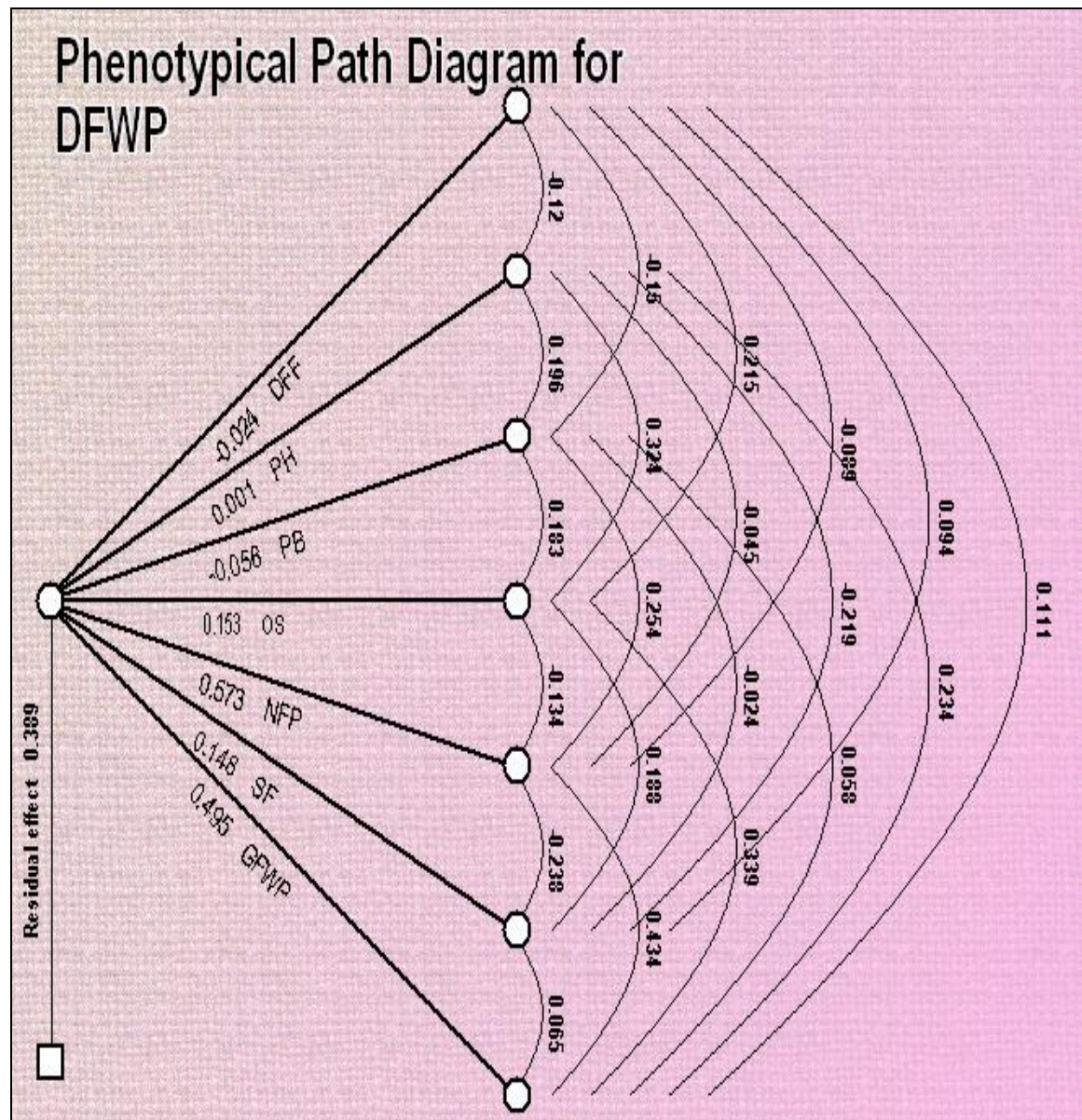
Path coefficient analysis suggested by Dewey and Lu (1959) helps in examining the direct and indirect effect of independent variable on dependent variable. It is standardized partial regression coefficient that partitions the correlation coefficient into direct and indirect effects of an independent variable. Thus path analysis in combination with correlation gives a better understanding of the cause and effect relationship between different character pairs. Traits which are desirable but negatively correlated with yield has indirect selection through the characters with which it is positively associated and gives a positive indirect effect on yield would give greater yield gain than direct selection for that character *per se*.

In the present investigation, the direct effects of genotypic path were slightly higher in magnitude than phenotypic path for the characters plant height, opened stigma, number of fruits per plant and number of seeds per fruit. However, indirect effect of phenotypic path was slightly higher in magnitude than genotypic path for the traits days to 50 per cent flowering and primary branches. The results obtained in phenotypic and genotypic direct and indirect effects are diagrammatically represented in Figure 3 and 4. An examination of the path analysis revealed that contribution of days to 50 per cent flowering was found negative direct influence up on dry fruit yield per plant and the indirect effect *via* plant height, primary branches and number of fruits per plant was quite low. Plant height showed negligible positive direct effect on dry fruit yield per plant Ahmed *et al.* (1997) with a negligible positive indirect effect through all other traits viz., days to 50 per cent flowering, primary branches, opened sigma, number of seeds per fruit,



DFFF	= Days to 50% flowering	PH	= Plant height	PB	= Primary branches
SB	= Secondary branches	CS	= Closed stigma	OS	= Opened stigma
DFM	= Days to fifty % maturity	NFP	= Number of fruits per plant	FL	= Fruit length
FD	= Fruit diameter	SF	= Seeds per fruit	TW	= 1000 test weight
DFW	= Dry fruit weight	GFW	= Green fruit weight	GFWP	= Green fruit weight per plant
DFWP	= Dry fruit weight per plant				

Fig. 3: Genotypical path diagram for dry fruit weight per plant



DFFF	= Days to 50% flowering	PH	= Plant height	PB	= Primary branches
SB	= Secondary branches	CS	= Closed stigma	OS	= Opened stigma
DFM	= Days to fifty % maturity	NFP	= Number of fruits per plant	FL	= Fruit length
FD	= Fruit diameter	SF	= Seeds per fruit	TW	= 1000 test weight
DFW	= Dry fruit weight	GFW	= Green fruit weight	GFWP	= Green fruit weight per plant
DFWP	= Dry fruit weight per plant				

Fig. 4: Phenotypal path diagram for dry fruit weight plant

seeds per fruit and green fruit weight per plant. Primary branches trait found negative direct influence up on dry fruit yield per plant and the indirect effect *via* days to 50 per cent flowering and seeds per fruit. Similar findings were reported earlier by Ahmed *et al.* (1997). Direct contribution of opened stigma trait was low with negligible influence through days to fifty per cent flowering, plant height, primary branches, seeds per fruit and green fruit weight per plant.

Number of fruits per plant exhibited high positive influence directly on dry fruit weight per plant Mathew *et al.* (2004) with indirect effect *via* primary branches and green fruit weight per plant. Number of seeds per fruit registered low positive influence directly up on dry fruit yield per plant which is supported by Nazeer *et al.* (2005). Number of seeds per fruit was positive indirect influence through days to 50 per cent flowering, opened stigma, number of fruits per plant and green fruit weight per plant. Direct contribution of green fruit weight per plant trait was low up on dry fruit yield per plant with negligible influence through all the traits *viz.*, days to fifty per cent flowering, plant height, primary branches, opened sigma, number of fruits per plant and number of seeds per fruit.

5.6 Screening for powdery mildew (*Leveillula taurica*) disease resistance

Use of resistant genotype is an effective, cheapest and safest means to combat the disease. In the present investigation, 23 genotypes and five hybrids of chilli genotypes were screened under natural infection conditions for resistant against powdery mildew. The study revealed that none of the genotype was immune or resistant. Several earlier workers (Deshpande *et al.*, 1985; Pawar *et al.*, 1985; Bidari *et al.*, 1985; Singh and Lodha, 1985; Mulge, 1992; Anand *et al.*, 1987; Sharmila *et al.*, 2001 and Belete *et al.*, 2012) reported different chilli genotypes resistant to powdery mildew.

5.7 Screening for chilli fruit borer (*Helicoverpa armigera*) resistance

Genotypes/hybrids *viz.*, P1 SUM, 5 SUM, LCA 310A, T2-1, BVC-1 and 9608U screened were least infested and classified as highly resistant or immune to the fruit borer (*H. armigera*). However, remaining genotypes/hybrids were classified as resistant, moderately resistant, susceptible and highly susceptible.

VI. SUMMARY AND CONCLUSIONS

The present investigation on *Fusarium* wilt of chilli was carried out during 2012-13 at the Department of Plant Pathology, Department of Genetics and Plant Breeding and the Agriculture College Farm, Raichur. The objectives were identification and development of F₁ hybrids resistant to *Fusarium* wilt disease.

Chilli (*Capsicum annuum* L.) is an important commercial crop of India which is used in daily food for its pungency and aroma. Among the biotic stresses, *Fusarium* wilt of chilli has become an important problem in recent years in chilli cultivation and is responsible for huge losses (Singh *et al.*, 1998).

In the present study chilli genotypes were screened against *Fusarium* wilt using seed inoculation technique, rapid root-dip-transplanting technique and sick pot method. Among the 56 chilli genotypes and 38 hybrids screened against *F. solani* (F25), only P3 showed moderately resistant in seed inoculation technique and rapid root dip transplanting technique. Whereas, among 38 CMS and non CMS based hybrids evaluated against *F. solani*, F₁ hybrids viz., JNA2 x ACB1 x 9608D and Rajaput x P3 showed resistant in sick pot method.

Variability was studied for promising 23 genotypes and five hybrids including local varieties, Byadagi dabbi and G4. Observation were recorded for 16 quantitative characters viz., Days to fifty per cent flowering, plant height, primary branches per plant, secondary branches per plant, closed stigma, opened stigma, days to 50 per cent maturity, number of fruits per plant, fruit length, fruit diameter, seeds per fruit, test weight, dry fruit weight, green fruit weight, green fruit weight per plant, dry fruit weight per plant. Different genetic parameters such as mean, range, genotypic coefficient of variation, phenotypic coefficient of variation and direct and indirect effect of important characters towards genetic divergence were worked out.

The analysis of variance indicated highly significant differences among the genotypes, for all the characters under study. Characters like, primary branches per plant and seeds per fruit had low heritability indicating the influence of environment on the expression of these traits. Traits like days to 50 per cent flowering, secondary branches, days to 50 per cent maturity, fruit length and number of fruits per plant recorded moderate PCV and GCV indicating the existence of high variability among germplasm lines. High heritability coupled with high genetic advance was noticed for closed stigma, green fruit

weight, green fruit weight per plant traits hence, the selection for the above trait will be more effective.

The genotypic correlation was higher than the phenotypic correlation in almost all cases indicating the high heritable nature of the characters. Number of fruits per plant was positively associated with dry fruit weight per plant and green fruit weight per plant. Number of fruits per plant exhibited high positive influence directly on dry fruit weight per plant

Out of 23 genotypes and five F₁ hybrids screened against powdery mildew and fruit borer under natural conditions, only genotype JNB1-1 was found moderately resistant to powdery mildew. Whereas, genotypes P1 SUM, 5 SUM, LCA 310A, T2-1, BVC-1 and 9608U and hybrids JCH 46, BVC-47 and KDC-1 were found highly resistant and resistant to fruit borer respectively.

CONCLUSIONS

Among the 56 chilli genotypes and 38 hybrids screened against *Fusarium* wilt caused by *F. solani* (F25), only P3 was identified as moderately resistant in seed inoculation technique as well as rapid root dip transplanting technique. Whereas, hybrids JNA2 x ACB1 x 9608D and Rajaput x P3 showed resistant in sick pot method.

The analysis of variance indicated highly significant differences among the genotypes, for all the characters under study. Characters like, primary branches per plant and seeds per fruit had low heritability indicating the influence of environment on the expression of the traits. Traits like days to fifty per cent flowering, secondary branches, days to fifty per cent maturity, fruit length and number of fruits per plant recorded moderate PCV and GCV indicating the existence of high variability among genotypes. High heritability coupled with high genetic advance was noticed for closed stigma, green fruit weight, green fruit weight per plant traits hence, the selection for the above trait will be more effective.

The genotypic correlation was higher than the phenotypic correlation in almost all cases indicating the high heritable nature of the characters. Number of fruits per plant was positively associated with dry fruit weight per plant and green fruit weight per plant. Genotypic path for number of fruits per plant was exhibited high positive influence

directly on dry fruit weight per plant with positive indirect effect *via* primary branches and green fruit weight per plant.

Out of 23 genotypes and five hybrids screened against powdery mildew and fruit borer under natural conditions, only genotype JNB1-1 was found moderately resistant to powdery mildew. Whereas, genotypes P1 SUM, 5 SUM, LCA 310A, T2-1, BVC-1 and 9608U and hybrids JCH 46, BVC-47 and KDC-1 showed highly resistant and resistant reaction to fruit borer respectively.

Suggestions for further work

- Genotype P3 showed moderately resistant reaction in seed inoculation as well as rapid-root-dip-transplanting technique. Hence, it may be utilized as donor for *Fusarium* wilt (*F. solani*) resistant breeding programme and could be promoted for multilocation testing for fruit yield.
- Use of F₁ hybrids such as JNA2 x ACB1 x 9608D and Rajput x P3 which showed resistant reaction to *Fusarium* wilt in sick pot method may be retested for disease resistance and evaluated for their yielding ability by conducting the replicated yield trials.
- Because of the positive correlation and high magnitude of path coefficient for number of fruits and green fruit weight, selection must be based on without compromising between the above two traits if the maximum fruit yield is to be obtained.
- It is suggested to utilize genotype JNB1-1 for powdery mildew resistant breeding programme as it showed moderately resistant reaction.
- Promising genotypes *viz.*, BVC-1 and 9608U exhibited highly resistant to fruit borer could be reevaluated in the areas where fruit borer is the problem.

VII. REFERENCES

- Abu, N. E. and Uguru. M. I., 2006, Evaluation of genetic variations in growth and yield components of aromatic pepper lines in a derived savanna ecology of Nigeria. *Agron. Sci.*, **5**(1): 1-7.
- Adamu, S. U. and Ado. S. G., 1988, Genotypic variability in fruit characteristics of pepper (*Capsicum* spp.). *Capsicum Newslett.*, **7**: 46.
- Ahmad, M. A., Iqbal, S. M., Ayub, N., Ahmad, Y. and Akram, A., 2012, Identification of resistant sources in chickpea against *Fusarium* wilt. *Pakistan J. Botany*, **30**(2): 341-342.
- Ahmed, N., Bhat, M. A., Tanki, M. I. and Singh, A. K., 2006, Correlation and path coefficient analysis in paprika (*Capsicum annuum* var *grossum* L.). *Indian J. Hort.*, **63**(1): 92-95.
- Ahmed, N., Dey, S. K. and Hundal, J. S., 1991, Inheritance of resistance to anthracnose in chilli. *Indian Phytopathol.*, **44**: 402-403.
- Ahmed, N., Khan, S. H. and Tanki, M. I., 1997, Combining ability analysis for fruit yield and its component characters in sweet pepper (*Capsicum annuum* L.). *Capsicum and Eggplant Newslett.*, **6**: 72-75.
- Ahmed, N., Nayeema, J. and Tanki, M. I., 1997, Character association in hot pepper (*Capsicum annuum* L.). *Capsicum and Eggplant Newslett.*, **16**: 68-71.
- Ahmed, N., Singh, S. R and Lal, S., 2013, Character association and path analysis in brinjal (*Solanum melongena*) for yield and yield attributes. *Indian J. Agric. Sci.*, **83**(1): 12-16.
- Ahmed, N., Tanki, M. I. and Mir, N. M., 1994, [Screening of advance breeding lines of chilli and sweet and hot pepper cultivars against *Fusarium* wilt](#). *Pl. Dis. Res.*, **9**(2): 153-154.
- Ali, I., Rab, A. and Hussain, S. A., 2002, Screening of pea germplasm for growth, yield and resistance against powdery mildew under the agro-climatic conditions of Peshawar. *Sarhad J. Agric.*, **18**(2): 177-181.
- Aliyu, L., Ahmed, M. K. and Ado, S. G., 1991, Relationships between some characters in chilli pepper (*Capsicum frutescens*). *Capsicum Newslett.*, **10**: 47-48.

- Allagui, M. B., Paloix, A. and Hamza, N., 1995, Evaluation of resistance and susceptibility to powdery mildew (*L. taurica*) in pepper (*Capsicum* spp) under natural epidemics in Tunisia. *Phytopathologia Mediterranea*, **34**: 143-148.
- Anand, N., Deshpande, A. A. and Sridhar, T. A., 1987, Resistance to powdery mildew in an accession pattern. *Capsicum Newslett.*, **6**: 77-78.
- Andres, A. J. L., Rivera M. A. and Fernandez, P. J., 2005, Resistance of pepper germplasm to *Phytophthora capsici* isolates collected in Northwest Spain. *Spanish J. Agric. Res.*, **3**(4): 429-436.
- Anonymous, 2002, *Krishi Pete*. Karnataka State Agricultural Marketing Committee, Hubli, p. 47.
- Anonymous, 2005, *Annu. Rep. Network project on wilt of crops* submitted to ICAR, New Delhi, p. 7.
- Anonymous, 2011, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.
- Anonymous, 2012, NAIP, Agropedia UAS Raichur.
- Belete. N., Alemayehu, C., Girma, T. and Tiwari, P. K., 2012, Evaluation of farmers Markofana types pepper genotypes for powdery mildew (*Leveillula taurica*) resistance in Southern Ethiopia. *Int. J. Basic Applied Sci.*, **1**(2): 103-108.
- Bhaskaran, R. and Prasad, N. N., 1971, Certain biochemical changes in *Cucumis* spp. In response to *Fusarium* infection. *Phytopathol. Mediterranean*. **10**: 238-243.
- Bidari, V. B., Bhat, B. N. and Hegde, R. K., 1985, Reaction of different genotypes of chilli against *Leveillula taurica*. *Indian J. Agric. Sci.*, **55**(9): 557-559.
- Blazquez, C. H., 1976, A powdery mildew of chilli caused by *Oidiopsis* spp. *Phytopathol.*, **66**: 1155-1157.
- Bohn, G. W. and Tucker, C. M., 1939, Immunity to *Fusarium* wilt in the tomato. *Sci.*, **89**: 603-604.
- Burtan, G. W., 1952, Quantitative inheritance in grasses. In: Proceedings of 6th Int. Grassland Congress, 17-23 August 1952, State College, Pennsylvania, USA 1: 127-183.

- Chander, M. S., 1994, Biochemical properties associated with resistance to powdery mildew in chilli. *Pl. Dis. Res.*, **9**: 103-104.
- Chaudhry, M. A., Muhammad, F. and. Afzal, M., 2006, Screening of chickpea germplasm against *Fusarium* wilt, *J. Agric. Res.* **44**(4): 307-312.
- Chube, H. S., 1968, Combating diseases of arhar and gram. *Indian Farmers Digest*, **1**: 26.
- Davis, D., 1953, The role of enzymes in the etiology of *Fusarium* wilt of tomato. *Phytopathol.*, **43**: 47.
- Depestre, T. and Gomez, O., 1992, Path coefficient analysis in pepper germplasms. In: VIIIth Meeting "Genet. Breed. *Capsicum* and Eggplant" Rome, Itali. pp. 110-115.
- Depestre, T., Olimpia, G. and Espinosa, J., 1985, Genetic parameters in pepper (*Capsicum annuum* L). *Capsicum and Eggplant Newslett.*, **4**: 29.
- Desai, A. G. and Dange, S. R. S., 2003, Standardization of root dip transplanting technique for screening of resistance of wilt of castor. *J. Mycol. Pl. Pathol.*, **33**(1): 73-75.
- Deshpande, A. A., Anand, N., Pathak. C. S. and Sridhar, T. S., 1985, New source of powdery mildew resistance in *Capsicum* species. *Capsicum Newslett.*, **4**: 75-76.
- De Souza, V. L. and Cafe-Filho, A. C., 2003, Resistance to *Leveillula taurica* in the genus *Capsicum*. *Pl. Pathol.*, **52**: 613-619.
- Devika Rani, G. S., Naik, M. K., Patil, M. B. and Patil, M. G., 2008, Screening of chilli genotypes against *Fusarium* wilt caused by *Fusarium solani* (Mart.) Sacc. *Veg. Sci.*, **35**(1): 49-54.
- Dewey, D. R. and Lu, K. H., 1959, A correlation and path coefficient analysis of component of crested wheat grass seed production. *Agron. J.*, **51**: 515-518.
- Dimond, A. E., 1955, Pathogenesis in the wilt diseases. *Annu. Rev. Pl. Physiol.*, **6**: 329-350.
- Dimond, A. E., 1970, Biophysics and biochemistry of the vascular wilt syndrome. *Annu. Rev. Phytopathol.*, **8**: 301-322.
- Eshbaugh, W. H., Guttman, S. I. and McLeod, M. J., 1983, The origin and evolution of domesticated *Capsicum* species. *J. Ethnobiol.*, **3**(1): 49-54.

- Farhad, M., Hasanuzzaman, M., Biswas, B. K., Azad, A. K. and Arifuzzaman, M., 2008, Reliability of yield contributing characters for improving yield potential in chilli (*Capsicum annum* L.). *J. Sustainable Crop Prod.*, **3**(3): 30-38.
- Fassihiani, A. and Shirvani, A., 2005, Evaluation of sources of resistance in tomato germplasm to *Fusarium* wilt (*Fusarium oxysporum* f. sp. *lycopersici*). *Fars Agric. Natural Resources Res.* Zarghan. p. 17.
- Fatima, A. G. and Joseph, S., 2001, Reaction of different chilli (*Capsicum annum* L.) genotypes to bacterial wilt. *Capsicum and Eggplant Newslett.*, **20**: 82-85.
- Fery, R. L. and Dukes, P. D., 1996, The inheritance of resistance to the southern root-knot nematode in Carolina Hot cayenne pepper. *J. American Society Hort. Sci.*, **121**(6): 1024-1027.
- Fisher, R. A., 1918, The correlation among relatives on supposition on Mendelian inheritance. *Trans. Roy. Soc. Edn.*, **52**: 399-433.
- Foster, R. E., 1946, The first symptom of tomato *Fusarium* wilt: clearing of the ultimate veinlets in the leaf. *Phytopathol.*, **36**: 691-694.
- Frederick, L. W., 1940, Epinasty of tomato one of the earliest symptoms of *Fusarium* wilt. *Phytopathol.*, **31**: 281-283.
- Gopalakrishnan, T. R. and Peter, K. V., 1991, Screening and selection for bacterial wilt resistance in chilli. *Indian J. Genet.*, **5**(3): 332-334.
- Gregory, A. C., Peter E. R., and Warwick N. S., 2007, Breeding for resistance to a new strain of *Fusarium* wilt in Australia. *CSIRO Plant Industry*, Narrabri, Australia. p. 59.
- Gupta, A. M., Singh, D. and Kumar, A., 2009, Genetic variability, genetic advance and correlation in chilli (*Capsicum annum* L.). *Indian J. Agric. Sci.*, **79**(3): 221-223.
- Hasanuzzaman, M. and Faruq, G., 2011, Selection of traits for yield improvement in chilli (*Capsicum annum* L.). *J. Innov. Dev. Strategy*, **5**(1): 78-87.
- Haymaker, H. H., 1929, Pathogenicity of 2 strains of the tomato wilt fungus, *Fusarium lycopersici* Sacc. *J. Agric. Res.*, **36**: 675-719.

- Hemon, F. A. and Rosario, T. L., 1999, Evaluation of tomato F₁ hybrids and parental for resistance to *Fusarium* wilt and bacterial wilt. *Philippine Agric. Scientist*, **82**(4): 372-378.
- Hemon, F. A., 1998, Combining genes for resistance to *Fusarium oxysporum* f. sp. *Lycopersici* (Sacc.), *Ralstonia solanacearum* and *Meloidogyne incognita* in tomato (*Lycopersicon lycopersicon* L). Philippines Univ. Los Banos, College, Laguna, p. 78.
- Henderson, W. R. and Winstead, N. N., 1961, Reaction of tomato varieties and breeding lines to *Fusarium oxysporum* f. sp. *lycopersici* race-1. *Pl. Dis. Reporter*, **45**: 272- 273.
- Hex, M. and Wand, M., 1989, Correlation and path coefficient analysis for fruit characters in sweet pepper. In: VIIth EUCARPIA Meet. Genet. Breed. *Capsicum* and Eggplant”, Kragujevac, Yugoslavia. pp. 31-35.
- Hossain, M. M., Shahjahan, M., Salam, M. A. and Begum, M. A., 2002, Screening of some brinjal varieties and lines against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Pakistan J. Biol. Sci.*, **5**(10): 1032-1040.
- Infantino, A., Porta-Puglia, A and Singh, K. B., 1996, Screening wild *Cicer* species for resistance to *Fusarium* wilt. *Pl. Dis.*, **80**(1): 42-44.
- Iqbal, S. M., Zulkiffal, M., Rauf, C. A. and Mahmood, T., 1998, Screening of pea for resistance against powdery mildew under rainfed conditions. *Pakistan J. of Arid Agric.*, **1**(1): 33-35.
- Jabeen, N., Ahmed, N., Khan, M. A., Chattoo, S. H. and Sofi, P. A., 2007, Inheritance of resistance to *Fusarium* wilt [*Fusarium pallidoroseum* (Cooke) Sacc.] in chilli (*Capsicum annuum* L.). *Indian J. Genet.*, **67** (4): 334-336.
- Johari, S. and Kumar, V., 2007., Studies of combining ability variability, heritability and genetic advance for yield and its attributes in bell pepper (*Capsicum annuum* L.). *Veg. Sci.*, **34**(1): 103-105.
- Johnson, W. H., Robinson, M. P. and Comstock, R. E., 1955, Estimates of genetic and environmental variability in soybean. *Agron. J.*, **47**(7): 314-318.
- Joshi, S., 1988, Results of genetic analysis in sweet pepper (*Capsicum annuum* L.). *Capsicum Newslett.*, **7**: 35-36.

- Joshi, M. Srivastava, R. Sharma, A and Anil Prakash., 2012, Screening of resistant varieties and antagonistic *Fusarium oxysporum* for biocontrol of *Fusarium* wilt of chilli. *J. Pl. Pathol. Microbiol.*, **3**(5): 134.
- Kakar, K. L., Bhalla, O. P. and Dhaliwal, M. S., 1990, Screening of tomato germplasms and breeding for resistance against fruit borer, *Heliothis armigera*. *J. Insect Sci.*, **3**(1): 57-61.
- Kapoor, I. J., 1998, Fungi involved in tomato wilt syndrome in Delhi, Maharashtra and Tamil Nadu. *Indian Phytopathol.*, **41**: 208-213.
- Karima, L., Fethi, B. and Mohamed El Gazzah., 2012, Genetic diversity evaluation of pepper (*Capsicum annuum* L.) in Tunisia based on morphologic characters. *African J. Agric. Res.*, **7**(23): 3413-3417.
- Kashyap, R. K. and Verma, A. N., 1986, Screening of tomato genotypes for susceptibility to fruit borer, *Heliothis armigera* (Hubner). *Indian J. Ent.* **48**(1): 46-53.
- Kaur, S., Dhunna. O. S. and Khurana, D. S., 2004, [Identification of resistance genotypes for *Fusarium* wilt disease in chilli and its practical utility.](#) *Environ. and Ecology*, **22**(1): 52-55.
- Kelaiya, D. S. and Parakhia, A. M., 2000, Screening of chilli varieties against *Fusarium* wilt. *Gujarat Agri. Univ. Res. J.*, **25**(2): 101-102.
- Kempthorne, O., 1957, *An Introduction to Genetic Statistics*. John Willey and Sons, New York. pp. 486-211.
- Khanam, U. K. S., Hossain, M., Ahmed, N., Uddin, M. M. and Hossain, M. S., 2003, Varietal screening of tomato to tomato fruit borer, *Helicoverpa armigera* (Hub.) and associated tomato plant characters. *Pakistan J. Biol. Sci.*, **6**(3): 255-263.
- Khiavi, H., Shikhlinski, H., Ahari, A. and Heydari, A., 2010, Evaluation of different grape varieties for resistance to powdery mildew caused by *Uninula Necator*. *Indian J. Agric. Sci.*, **49**(4): 434-439.
- Kumar, B. K., Munshi, A. D., Joshi, S. and Kaur, C., 2003, Correlation and path coefficient analysis for yield and biochemical characters in chilli (*Capsicum annuum* L.). *Capsicum and Eggplant Newslett.*, **22**: 67-70.

- Kumar, S., Heera, K. and Prabhu, T., 2005, Diallel analysis in chilli (*Capsicum annuum* L.) for fruit and capsaicin content. *Res. Crops*, **6**(1): 116-118.
- Kunouski, Z. H. and Todorova, I., 1985, Powdery mildew of pepper (*Leveillula solanacearum*) in Bulgaria II. Source of resistance. *Pochroznanie Agrokhimiya, Rastitelna Zashchita*, **20**: 75-81.
- Lakshmi, R. and Vijayapadma., 2012, Studies on performance, genetic variability, heritability and genetic advances in chilli (*Capsicum annuum* L.) varieties in high altitude and tribal zone of Srikakulam district of Andhra Pradesh. *Pl. Archives*, **12**(2): 717-720.
- Lal, O.P., 1991, Varietal resistance in the eggplant, *Solanum melongena* against the shoot and fruit borer, *Leucinodes orbonalis* Guen. (lepidoptera: Pyralidae). *Zeitschrift fuer Pflanzenkrankheiten und Pflanzenschutz*. **98**(4): 405-410.
- Lee okhee, Hwang, H. S., Kim, J. Y., Han, J. H., Yoo, Y. S. and Kim, B. S., 2001, A search for sources of resistance to powdery mildew in pepper. *Korean J. Horti. Sci. Tech.*, **19**: 7-11.
- Lodha and Singh, 1983, *Simmondsia chinesis* of new host for *Fusarium solani*. *Indian Phytopathol.*, **36**: 728-729.
- Lush, J. L., 1943, *Animal Breeding Plans*. Iowa State College Press.
- Madhukar, H. M. and Naik, M. K., 2004, Evaluation of bioagents against *Fusarium* wilt of chilli (*Capsicum annuum* var *annuum*). In: Proc. 15th Int. Plant Protection Towards 21st Century held in Beijing, China. p. 540.
- Mahdiyeh, M., Mahmoudi, F., Norolahi, K., Shahbazi, S. and Sabagpor, S. H., 2006, Evaluation of chickpea lines resistance to *Fusarium* wilt. *Dry Land Agric. Res. Insti., DARI, Maragheh (Iran)*. p. 21.
- Mahmood, K., Saleem, M. and Ahsan, M., 2011, Inheritance of resistance to *Fusarium* wilts in chickpea. *Pakistan J. of Agric. Sci.*, **48**(1): 55-58.
- Makari, H. K., Patil, H. S. R., Abhilash, M. and Mohan, H. D. K., (2009). Genetic diversity in commercial varieties of chilli as revealed by RAPD method. *Indian J. Sci. Tech.*, **2**(4): 0974- 6846.

- Mamedov M. I. and Pyshnaja, O. N., 2001, Heterosis and correlation studies for earliness, fruit yield and some economic characteristics in sweet pepper. *Capsicum and Eggplant Newslett.*, **20**: 42-45.
- Manju, P. R. and Sreelathakumari, I., 2002, Genetic variability, heritability, and genetic advance in hot chilli (*Capsicum chinense*). *J. Tropocal Agric.*, **40**: 4-6.
- Mariate, H., 1973, Changes in polyphenol oxidase and peroxidases in muskmelon infected by *Fusarium oxysporum* f. sp. *melonis*. *Physiological Pl. Pathol.*, **3**: 29-49.
- Markose, B. L., Vahab, M. A., Peter, K. V., Rajan, S. and Sadhankumar, P. G., 1998, Development of near isogenic lines. *Bacterial Wilt Newslett.*, **15**: 5-6.
- Mathew, D., Doijode, S. D. and Reddy, K. M., 2004, Correlation and path coefficient analysis in five species of *Capsicum*. *Capsicum and Eggplant Newslett.*, **23**: 57-60.
- Mathur, B. L. and Mathur, R. L., 1965, Metabolites of *Fusarium oxysporum* f. sp. *cumin* in relation to cumin wilt. *Indian Phytopathol.*, **18**: 335-339.
- Mayee, C. D. and Datar, V. V., 1986, *Phytopathometry. Technical Bulletin-1* (Special bulletin-3), Marathwada Agric. Univ. Parbhani, Maharashtra, p. 29.
- Miller, P. A., Williams, J. C., Robinson, H. F. and Comstock, R. E., 1958, Estimates of genotypic variance and covariance in upland cotton. *Agron. J.*, **50**: 126-136.
- Mini, S. and Khedar. K. M. A., 2004, Variability, heritability and genetic advance in wax type chilli (*Capsicum annuum* L.). *Capsicum and Eggplant Newslett.*, **23**: 49-52.
- Mishra, A. C., Singh, R. V. and Ram, H. H., 2003, Path coefficient analysis in sweet pepper (*Capsicum annuum* L.) genotypes under mid hills of Uttaranchal. *Veg. Sci.*, **29**(1): 71-74.
- Mishra, A. C., Singh R. V. and Ram, H. H., 2004, Studies on genetic variability in (*Capsicum annuum* L) under mid hills of Uttaranchal. *Capsicum and Eggplant Newslett.*, **23**: 41-44.

- Mishra, P. N., Singh, Y. and Nautiyal, M. C., 1987, Screening of eggplant (*Solanum melongena* L.) varieties for resistance to shoot and fruit borer (*Leucinodes orbonalis* Guen.) (Lepidoptera:Pyralididae). *Int. Congress Pl. Protec.*, Manila (Philippines), p. 1.
- Mohamed, F. G., and Badr. A. A., 2004, Genetic studies on *Fusarium* wilt in tomato. *Fac. Agric.*, Moshtohor, Zagazig Univ., Benha Branch, Egypt. p. 13.
- Muhyi, P and Bosland, P. W., 1995, Evaluation of *Capsicum* germplasm for sources of resistance to *Rhizoctonia solani*, *Horti. Sci., A publication American Society Horti. Sci. (USA)*. **30**(2): 341-342.
- Mulge, R. and Anand, N. 1997, Identification of sweet pepper (*Capsicum annuum* L.) line to develop F₁ hybrids resistant to powdery mildew. *Indian J. Genet. Pl. Breed.*, **57**(2): 193-199.
- Mulge, R., 1992, Early generation testing in bell pepper (*Capsicum annuum* L.) to develop F₁ hybrids resistance to powdery mildew. *Ph.D. Thesis*, Univ. Agric. Sci., Bangalore, India.
- Muneem, K. C., Verma, S. K. and Pant, K. C., 1995, Performance of some chillies against leaf spot, powdery mildew and fruit rot in Kumaon Hills. *Indian Phytopathol.*, **48**: 206.
- Murthy, K. H. M. and Deshpande, A. A., 1997, Studies on genetics of powdery mildew (*Leveillula taurica*) resistance in chilli (*Capsicum annuum*). *Vegetable Sci.*, **24**: 127-131.
- Naidu, A. K., Tembhurne, B. V., Shrivastava, R. K. and Rao, S. K., 2009, Varietal performance of chilli for Kimore Plateau and Satpura Hill Region of Madhya Pradesh. *In: Int. Confer. Horti.*, Bangalore 9-12, November 2009, Dr. Prem Nath Agriculture Foundation (PNASF), Bangalore. p. 45.
- Naik, M. K., Devika Rani. G. S. and Madhukar. H. M., 2008, Identification of resistance sources against wilt of chilli (*Capsicum annuum* L.) caused by *Fusarium solani* (Mart.) Sacc. *J. Mycopathol.*, **46**(1): 93-96.
- Naik, M. K., Pramanick, K., Deshpande, A. H. and Sinha Poonam, 1996, Standardization of screening technique against *Fusarium* wilt of chilli. National Symposium of *Indian Society Mycol. Pl. Pathol.* held at Shantiniketan, West Bengal.

- Nandadevi, A. U. and Hosamani, R. M., 2003, Variability, correlation and path analysis in *kharif* grown chilli (*Capsicum annuum* L.) genotypes for different characters. *Capsicum and Eggplant Newslett.*, **22**: 43-46.
- Nayeema, J., Ahmed, N., Tanki, M. I. and Das, G. M., 1995, Screening of hot pepper germplasm for resistance to *Fusarium* wilt [*F. pallidroseum* (Cook) Sacc.]. *Capsicum and eggplant Newslett.*, **14**: 68-71.
- Nazeer, G., Narayanan, K., Ahmed, N. and Bhat. K., 2005, Correlation and path coefficient analysis in sweet pepper (*Capsicum annuum* var *grossum* L.) *Veg. Sci.*, **32**(1): 88-89.
- Nehru, S. D., Manjunath, V. and Rangaiah, V. 2003, Genetic variability and stability for fruit yield and other metrical characters in chilli (*Capsicum annuum* L.). *Karnataka J. Agric. Sci.*, **16**(1): 44-47.
- Okiror, M. A., 2002, Genetics of resistance to *Fusarium udum* in pigeon pea [*Cajanus cajan* (L.) Millsp.]. *Indan. J. Genet. Pl. Breed.*, **62**(3): 218-220.
- Olimpia, T. D. and Gomez. Y. J., 1988, Path coefficient analysis in sweet pepper. *Capsicum Newslett.*, **7**: 37-38.
- Opena, R. T., Hartman, G. L., Chen, J. T. and Yang, C. H., 1990, Breeding for bacterial wilt resistance in tropical tomato. *Malaysian Pl. Protec. Society*, Kuala Lumpur. pp. 967-994.
- Pandey, R. N., Pawar, S. E. and Bhatia, C. R., 1997, Interaction between *Fusarium udum* and wilt susceptible and resistant pigeonpea genotypes: Fungal growth and histology. *Indian Phytopathol.*, **50**(1): 53-58.
- Pandit, M. K., Muthukumar, P. and Mukhopaghyay, T. P., 2009, Genetic variability, character association and path analysis studies in chilli (*Capsicum annuum* L.) genotypes. *Int. Confer. Horti*, Prem Nath Agriculture Foundation (PNASF), Bangalore. p. 41.
- Pandravada, S. R., Anitha, K., Chakrabarty, S. K. and Reddy, K. J., 2007, Identification of sources of resistance to fungal biotic stresses and sunscald in paprika chilli germplasm. *Indian J. Pl. Protec.*, **35**(2): 313-315.

- Patil, S. D., Bidari, B. I. Shashidhara, G. B. and Hegde, N. K., 2008, Genetic variability in chilli (*Capsicum annuum* L.) genotypes. *Asian J. Hort.*, **3**(2): 310-312.
- Park, H. K., Kim, B. S. and Lee, W. S., 1990, Inheritance of resistance to anthracnose (*Colletotrichum* spp.) in pepper (*Capsicum annuum* L.), Genetic analysis of anthracnose resistance by diallel crosses, *J. Korean Society Hort. Sci.*, **31**(2): 91- 105.
- Parvez, A., Alam, M. A. and Ilyas, M. B., 1996, Screening of chickpea germplasm against *Helicoverpa armigera* (Hb.) for the sources of resistance. *Pakistan Entomologist*, **18**(12): 70-72.
- Pawar, R. N., Utikar, P. G. and Shinde, P. A., 1985, Field evaluation and economics of fungicidal control of powdery mildew (*Leveillula taurica*) of chilli. *Pesticides*, **19**: 69-70.
- Pawliczuk, Z. and Orlikowski, L. B., 1994, Resistance of Carnation hybrids F₁ in the direction of *Fusarium oxysporum* f. sp. *dianthi*. *J. Huazhong Agric. Univ.*, **14**(1): 15-20.
- Rakholiya, K. B., Jani, S. M., Chheladiya, K. K. and Kikani, B. K., 2003, *Fusarium* wilt of bitter gourd, *Indian Phytopathol.*, **56** (4): 503.
- Rao, V. and Krishnappa, K., 1999, Reaction of some chickpea cultivars to *Fusarium oxysporum* f. sp. *ciceri* and *Meloidogyne incognita* disease complex. *Indian Phytopathol.*, **52**(1): 84-85.
- Roberts, D. D. and Kraft, J. M., 1971, A Rapid technique for studying *Fusarium* wilt of peas. *Phytopathol.*, **61**: 342-343.
- Sajjad, M., Ashfaq, M., Suhail, A. and Akhtar, S., 2011, Screening of tomato genotypes for resistance to tomato fruit borer *Helicoverpa armiger* (Hubner). *Pakistan J. Agric. Sci.*, **48**(1): 59-62.
- Sahoo, S. C., Mishra. S. N. and Mishra, R. S., 1990, Genetic variation in P₂ generation of chilli. (*Capsicum annuum* L.) *Capsicum Newslett.*, **8**(10): 29-30.
- Sakata, Y., Monma, S., Narikawa, T. and Komachi, S., 1996, Evaluation of resistance to bacterial wilt and *Verticillium* wilt in eggplants (*Solanum melongena* L.) collected in Malaysia. *J. Japanese Society Hort. Sci.*, **65**(1): 81-88.

- Saleem, A., Hameed, K., Jamil, F. F. and Ansar, M., 1999, Screening of *Capsicum* germplasm against *Phytophthora capsici*. *Pakistan J. Bio. Sci.*, **2**(2): 459-461.
- Sathyanarayana, H. V. and Anand, N., 1993, Developing bacterial wilt resistant F₁ hybrids for processing in tomato (*Lycopersicon esculentum*). (Conference paper) *ACIAR Proc: Australian Centre for Int. Agric. Res.*, p. 45.
- Schroeder, H. D., Boosalis, M. G. and Moore, M. B., 1953, An improved inoculum of plant diseases fungi. *Phytopathol.*, **43**: 401-403.
- Seki, K., Miyasaka, M. and Shigemori, I., 2007, Resistance breeding to carnation wilt disease with the simple inoculation method. *Bulletin of the Nagano Vegetable and Ornamental Crops Experiment Station*. **13**: 45-47.
- Shahriyari, D., Mahmudi, F., Mahdihyeh, M. and Karami, I., 2009, Study on development of wilt sick plot for identifying resources of resistance to *Fusarium* wilt. *Dryland Agric. Res. Insti., Maragheh (Iran)*. p. 31.
- Shankarnag, B. and Madalageri, M. B., 2005, Screening in chilli against *Helicoverpa armigera* Hubner. *J. Phytological Res.*, **18**(2): 271-274.
- Shanthalakshmi, M., Prasad, M., Srinivas Prasad, Sangith Kumar. and Sathish Chandra., 1999, *Fusarium* wilt, a new groundnut disease in Meghalaya-Rapid screening technique for disease resistance. *Indian Phytopathol.*, **52**(1): 82-83.
- Sharma, A., Singh, Y. and Sharma, S., 2007, Association of characters and their direct and indirect contributions for bell pepper (*Capsicum annuum* var *grossum* L.) improvement. *Veg. Sci.*, **34**(1): 74-76.
- Shifris, C. Pilowsky, M. and Zacks, J. M., 1992, Resistance of *Leveillula taurica* in *Capsicum annuum*. *Phytoparasitica*, **20**: 279-283.
- Shivaramu, K. and Kulkarni K. A., 2008, Screening of chilli germplasm for resistance to *Helicoverpa armigera* (Hubner) in chilli. *Pest Management in Horticultural Ecosystems*. **14**(1): 51-58.
- Shrilekha, M., Lal, R. K., Mahendra P. D. and Suman P. S., 2010, Genetic associations and path-coefficient analysis of the economic traits in the chilli (*Capsicum annuum* L.). *E. J. Pl. Breed.*, **1**(3): 346-350.

- Singh, R. K. and Chaudhary, B. D., 1985, *Biometrical Methods in Quantitative Genetic Analysis*. Kalyani Publications, Ludhiyana, p. 54.
- Sindhu, J., S. Singh, K. P. and Slinkard, A. E., 1983, Inheritance of resistance to *Fusarium* wilt in chickpeas, *J. Hered.*, **74**(1): 68.
- Singh, A., Singh, A. K. and Singh, A., 1998, Screening of chilli germplasms against *Fusarium* wilt. *Crop Res.*, **15**: 132- 133.
- Singh, D. K., Jha, D. K. and Haque, M. F., 1997, Field screening chickpea cultivar against *Fusarium* wilt. *J. Res.*, **9**: 201-202.
- Singh, R. P., Harichand and Chand, H., 1996, Identification of multiple disease resistance in chickpea at Hissar, Haryana. *Int. Chickpea Pigeonpea Newslett.*, **3**: 32-33.
- Singh, S. and lodha, S., 1985, Varietal reaction and evaluation of fungicides in vitro and *in vivo* against powdery mildew of chilli. *Indian J. Agric. Sci.*, **55**: 85-87.
- Singh, V. P. and Yadav, S. K. 2008, Genetic variability, heritability and genetic advance in chilli (*Capsicum annuum* L.). *Int. J. Pl. Sci.*, **3**(2): 498-501.
- Smith, S. N. and Synder, W. C., 1971, Relationship of inoculum density and soil types to severity of *Fusarium* wilt to sweet potato. *Phytopathol.*, **61**: 1049-1051.
- Sonia, S., Naveen K., Chandel, K. S. and Parveen, S., 2011, Determination of genetic variation for morphological and yield traits in bell pepper. *Indian J. Agric. Sci.*, **8**: 7.
- Sreelathakumary, I. and Rajmony, L., 2003, Correlation and path coefficient analysis in bell pepper (*Capsicum annuum* L.). *Capsicum and Eggplant Newslett.*, **22**: 71-74.
- Sreelathakumary, I. and Rajmony, L., 2004, Correlation and path coefficient analysis for yield in hot chilli (*Capsicum annuum* L.). *Capsicum and Eggplant Newslett.*, **23**: 53-56.
- Srivastava, R., Sharma, S. K., Singh, J. P. and Sharma, A. K., 2009, Evaluation of tomato (*Solanum lycopersicum* L.) germplasms against *Fusarium oxysporum* f. sp. *lycopersici*, causing wilt. *Pantnagar J. Res.*, **7**(2): 192-195.

- Suresh, M., Singh, B. K., Baruah and Singh, K. I., 2013, Field screening of certain tomato varieties for their resistant reaction against (*Helicoverpa armigera*) in Manipur valley, India. *Clarion*, **2**(1): 56-58.
- Surya Kumari, S., Uma Jyothi, K., Chenga Reddy, V., Srihari, D., Siva Sankar, A. and Ravi Sankar, C., 2011, Character association in paprika (*Capsicum annuum* L.). *J. Spices and Aromatic Crops*. **20**(1): 43–47.
- Tembhurne, B. V., R. K. Shrivastava, A. K. Naidu and S. K. Rao (2009). Yield performance of chilli hybrids for Kymore Plateau and Satpura Hill Region of Madhya Pradesh. In: *International Conference on Horticulture*, Bangalore 9-12, November 2009, Dr. Prem Nath Agriculture Foundation (PNASF), Bangalore, p. 41.
- Tembhurne, B. V., Revanappa. and Kuchanur, P. H., 2008, Varietal performance, genetic variability and correlation studies on chilli (*Capsicum annuum* L.). *Karnataka J. Agric. Sci.*, **21**(4): 541-543.
- Thakur, P. C., 1988, Correlation studies in sweet pepper (*Capsicum annuum* L.). *Capsicum and Eggplant Newslett.*, **12**: 55-56.
- Todorava., V. Y., Pevicharova, G. T. and Todorav, Y. K., 2003, Correlation studies for quantitative characters in red pepper cultivars for grinding (*Capsicum annum* L.). *Capsicum and Eggplant Newslett.*, **22**: 653-66.
- Trapero, A. and Jimenez, R. M., 1981, Occurrence and etiology of chickpea wilt complex in southern Spain. *Int. Chickpea Newslett.*, **5**: 10-11.
- Ukkund, K. C., Madalageri, M. B., Patil, M. P., Mulage, R. and Kotlkal, Y. K., 2007, Variability studies in green chilli (*Capsicum annuum* L.). *Karnataka J. Agric. Sci.*, **20**(1): 102–104.
- Ullasa, B. A., Rawal, R. D., Sohi, H. S., Singh, D. P. and Joshi, M. C., 1981, Reaction of sweet pepper genotypes to anthracnose, cercospora leaf spot and powdery mildew. *Pl. Dis.*, **65**: 600-601.
- Upadhaya, R. S. and Rai, B., 1989, Wilt diseases of pigeonpea and its causal organism *Fusarium udum*. In: *Perspectives Phytopathol.*, Today and Tomorrows Printers and Publishers, New Delhi, p. 388.

- Van Der Plank, J. E., 1963, *Plant Disease, Epidemics and Control*. Academic Press, New York, pp. 35-71.
- Vandrew, L. L. and Peterson, R. A., 1988, *Fusarium solani*, the causes of root rot of tomato in Central Queensland. *Australian Pl. Pathol.*, **17**: 24-25.
- Wang, L. and Wang M., 1991, Studies on the resistance to *Fusarium* wilt of pepper (*Capsicum annuum* L.) germplasm at the seedling stage. *Acta Horticulturae Sinica*, **18**(2): 153-158.
- Watcharachaiyakup, J., Thaveechai, N., Chunwongse, J. and Kositratana, W., 2005, Mechanism of resistance to bacterial wilt disease of chilli pepper caused by *Ralstonia solanacearum*. *Proc: 43rd Kasetsart Uni. Annu. Confer.*, Thailand.
- Wellman, F. L., 1939, A technique for studying host resistance and pathogenicity in tomato *Fusarium oxysporum* f. sp. *melonis*. *Canadian J. Microbiol.*, **8**: 818-819.
- Wheeler, B. E. J., 1969, *Introduction to Plant Disease*. John Wiley and Sons Ltd., London, p. 301.
- White, R. P., 1927, Studies on tomato wilt caused by *Fusarium lycopersici* Sacc. *J. Agric. Res.*, **34**: 197-239.
- Wilson, D. and Philip, B., 2009, Genetic variability and genetic divergence in paprika (*Capsicum annuum* L.). *Int. Confer. Horti.*, Bangalore. Dr. Prem Nath Agriculture Foundation (PNASF), Bangalore. P. 16.
- Wright, S., 1921, Correlation and causation. *J. Agric. Res.*, **20**: 557-585.
- Yedeta, B., Belew, D., Gebreselassie, W. and Marame, F., 2011, Variability, heritability and genetic advance in hot pepper (*Capsicum annuum* L.) in west shoa, Ethiopia. *American- Eurasian J. Agric. Environ. Sci.*, **10**(4): 587-592.
- Zhang, J., Lu, F., Nie, Y., Guo, J., Sun, J. and Liu, J., 1995, Analysis of *Fusarium* wilt resistance in F₁ hybrids of upland cotton. *J. Huazhong Agric. Univ.*, **14**(1): 15-20.

APPENDIX – I

**Monthly meteorological data for the year 2012-13 and mean of the last 81 years (1931-2012)
at Main Agricultural Research Station, Raichur**

Month	Rainfall (mm)		Temperature (°C)				Relative Humidity (%)	
			Maximum		Minimum			
	1931-2012	2012-2013	1931-2012	2012-2013	1931-2012	2012-2013	1931-2012	2012-2013
April	12.81	41.00	39.90	38.5	24.37	23.9	52.31	25
May	42.00	02.00	39.71	39.9	25.24	25.5	59.19	23
June	113.30	57.90	35.30	36.2	23.26	23.8	78.169	36
July	74.03	110.60	33.39	32.4	22.54	22.0	76.56	54
August	72.73	50.00	32.87	32.8	22.44	21.7	79.57	50
September	180.43	126.00	32.18	31.9	22.2	20.7	81.49	55
October	61.96	44.60	31.53	32.2	20.48	18.3	78.38	47
November	20.87	36.80	31.31	31.3	19.06	17.0	78.23	48
December	3.95	0.00	30.50	32.0	16.17	15.6	75.10	34
January	1.62	0.00	31.30	34.6	16.73	15.8	76.33	34
February	1.07	0.00	32.53	34.2	18.45	18.1	61.44	25
March	43.21	0.00	36.53	37.7	22.53	19.9	55.33	19
Total	627.98	468.90						

EVALUATION OF CHILLI (*Capsicum annuum* L.) GENOTYPES AND HYBRIDS AGAINST *Fusarium* WILT

MARUTI, T. B

2013

B. V. TEMBHURNE
MAJOR ADVISOR

ABSTRACT

Among the 56 genotypes screened for resistance against *F. solani*, genotype P3 was found moderately resistant in both seed inoculation and rapid-root-dip-transplanting technique. None of the hybrids showed resistant reaction in rapid root dip transplanting technique and pot culture technique out of 38 hybrids. Hybrids namely, JNA2 x 9608D and Rajaput x P3 showed resistant in pot culture technique.

Analysis of variances showed that mean sum of squares due to genotypes were found to be highly significant for all the characters indicating significant variation among all the genotypes for all the characters. Phenotypic coefficient of variation was higher than their corresponding genotypic coefficient of variation for plant height, primary branches, secondary branches, closed stigma, number of fruits per plant, fruit length, fruit diameter, seeds per fruit, 1000 test weight, dry fruit weight, green fruit weight, green fruit weight per plant and dry fruit weight per plant revealed presence of environmental influence for the expression of these characters. High heritability estimates with high genetic advance as per cent mean for most of the characters viz., green fruit weight per fruit, dry fruit weight per fruit, fruit length, fruit diameter, number of primary branches, plant height, number of seeds per fruit, 1000 seed weight, green fruit weight per plant and dry fruit weight per plant revealed these characters are under the control of additive gene action. Hence, there is a greater scope for the improvement of these characters through selection.

Magnitude of genotypic correlation was greater than the corresponding phenotypic correlation. This lower phenotypic correlation results due to the masking effects and modifying effect of environment on the association of characters at the genic level. An examination of the path analysis revealed that contribution of days to fifty per cent flowering was found negative direct influence up on dry fruit yield per plant. However, number of fruits per plant exhibited high positive influence directly on dry fruit weight per plant. 23 genotypes and 5 hybrids of chilli were screened under natural infection epiphytotic condition for resistant against powdery mildew. Genotypes viz., P1 SUM, 5 SUM, LCA 310A, T2-1, BVC-1 and 9608U were least infested and classified as highly resistant. However, genotypes/hybrids namely, JCH 46, BVC-47 and KDC-1 showed resistance to fruit borer.

