GENETIC VARIABILITY FOR YIELD AND RESISTANCE TO CHILLI THRIPS (*Scirtothrips dorsalis* H.) AND YELLOW MITE (*Polyphagotarsonemus latus* Banks) IN CHILLI (*Capsicum annuum* L.)

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DECLARATION

I hereby declare that this thesis entitled **"Genetic variability for yield and resistance to chilli thrips (*Scirtothrips dorsalis* H.) and yellow mite (*Polyphagotarsonemus latus* Banks) in chilli (*Capsicum annuum* L.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled**"Genetic variability for yield and resistance to chilli thrips (*Scirtothrips dorsalis* H.) and yellow mite (*Polyphagotarsonemus latus* Banks) in chilli (*Capsicum annuum* L.)"** is a record of research work done independently by Mr. Narsi Reddy, A. (2005-11-118) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Introduction

1. INTRODUCTION

Chilli, *Capsicum annuum* (L.) is one of the most important vegetable-cum spice crops valued for its aroma, taste, flavour and pungency. It is a rich source of vitamins A, C and E. The quality of chilli powder is based on visual and extractable colour, pungency level and the nutritive value (Bosland, 1993).The active principle of pungency in chilli is capsaicin which is mixture of 20 capsaicinoids. Chilli is a rich source of red pigments *viz*., capsorubin, cryptoxanthin and related carotenoids which are esters of capsanthin. Oleoresin extracted from chilli is widely used in the west in food preperations for uniform quality, longer shelf life, taste and flavour. Chilli has cosmetic and medicinal value also. The crop is widely cultivated in central and south America, Peru, Bolivia, Costarica, Mexico and India (Bose et al., 1993).

Chilli is native of tropical America and the seeds were brought to the old world by Columbus. The crop was introduced to India by the Portuguese in the 16^{th} century AD and by the 19^{th} century its cultivation spread throughout the country. The cultivation of the crop for centuries in the country resulted in rich varietal diversity. The wide variation in domestic germplasm offers immense scope for genetic improvement of the crop.

India is the largest producer, consumer and exporter of chillies in the world. In India chilli is grown in an area of 9.65 lakh hectares with an annual production of 10.75 lakh tonnes (Peter et al., 2004).The productivity is rather low at 1.11 tonnes per ha compared to the world average of 2 tonnes per ha. The crop is grown across the country. Andhra Pradesh is the state that accounts for 46 per cent of the total production.

Eventhough chilli is an important vegetable of Kerala, the production and productivity of the crop are comparatively low in the state. The area under chilli cultivation in the state is only 465 ha.

The major reasons for the low productivity of chilli are the paucity of varieties adapted to different agro-climatic situations and growing conditions and the incidence of pest and diseases. Among the pests, chilli thrips and yellow mite are important not only as damaging pests but also as vectors of virus diseases.

Collection and evaluation of genotypes for yield and biotic stresses is important in crop improvement endeavors. In yield improvement efforts, estimation of heritability and genetic advance of yield and its component characters is a prerequisite.

Knowledge of inter-relationships of yield and other characters from correlation studies would facilitate effective selection for simultaneous improvement of one or several yield contributing characters. Assessment of direct and indirect effects of each component towards yield will help in identifying characters to which attention is to be given in crop improvement efforts. Grouping of characters based on genetic distance between them would provide a way to identify the parents for recombination breeding programmes.

Keeping all these facts in view, the present investigation was undertaken with in following objectives:

a. To study genetic variability for different characters by estimating phenotypic and genotypic coefficients of variation.
b. To estimate heritabilty and genetic advance for different characters.
c. To study association between yield and its components by estimating correlation coefficients.
d. To understand the direct and indirect effects of yield contributing characters by path coefficient analysis.
e. To group varieties based on genetic distance.
f. To identify high yielding genotypes and accessions with tolerance to chilli thrips and yellow mite.

Review of literature

2. REVIEW OF LITERATURE

The present study aimed at the evaluation of genetic variability for yield and resistance to chilli thrips and yellow mite in a collection of chilli varieties. The literature pertinent to the study is reviewed under different headings.

2.1 Yield and yield components

2.1.1. Genetic variability, heritability and genetic advance

Genetic variability for yield and yield contributing traits in the base population is essential for successful crop improvement. Larger the variability, better are the chances of identifying superior genotypes. Genetic parameters like coefficient of variation, heritability and genetic advance provide an exact picture of variability in a population.

Singh et al. (1981) evaluated 35 genotypes of chilli and reported high heritability for weight of fruits, number of fruits per plant and fresh fruit weight per plant Ramkumar et al. (1981) studied variability for biometric characters and reported high GCV for yield and fruits per plant. Heritability and genetic advance were high for height, number of fruits per plant and girth of fruits.

Shah et al. (1986) evaluated twelve cultivars for eight quantitative characters and found that plant height, number of primary branches, fruit length, fruit width and number of fruits per plant showed high heritability and high expected genetic advance. Evaluating 13 genotypes of chilli, Meshram (1987) also reported high heritability and high genetic advance for length of fruits.

Sahoo et al. (1989) studied 11 yield traits in 45 intervarietal crosses and reported high GCV, heritability and genetic advance for plant spread, number of fruits per plant and number of seeds per fruit.

Vijayalakshmi et al. (1989) reported high variability, heritability and genetic advance for fruit characters such as fruit weight, fruit length, fruit girth and number of seeds per fruit in a study with 11 chilli varieties.

High variability for yield and component characters in chilli has been reported by various workers. Das et al. (1990) observed significant variation among 30 chilli cultivars for six component characters of fruit yield and observed that fruit yield and number of fruits per plant recorded high heritability.

In a study with six parents and their 15 hybrids, Bhagyalakshmi et al. (1990) observed that heritability estimates were moderate for plant height, fresh fruit weight, number of seeds per fruit and 100-seed weight. Heritability estimates were high for days to 50 per cent flowering, fruit length, fruit girth and fruits per plant.

Varalakshmi and Haribabu (1991) studied 10 characters in 32 chilli genotypes and observed considerable genotypic and phenotypic variation for fruits per plant, fruit weight and yield. High heritability coupled with high genetic advance was observed for fruits per plant, fruit weight, seeds per fruit, plant height and fruit length.

Wide variation for fruiting period was reported by Rajput et al. (1991) after evaluating twelve cultivars. Acharya et al. (1992) reported high variability in 19 cultivars of chilli for fruits per plant, yield per plant, circumference and length of fruits and seeds per fruit. Pitchaimuthu and Pappiah (1992) inferred high variability for plant height and number and fresh weight of fruits per plant from their data on fourteen F_6 families. Nandi (1993) studied eight characters in nine cultivars and observed high genotypic coefficient of variation for length and weight of fruits and yield per plant.

Variability studies by Kumar et al. (1993) in four F_2 populations and their five parents suggested high heritability combined with high genetic advance for number of fruits per plant, number of seeds per fruit and fruit yield per plant.

Singh et al. (1994) studied nine yield related traits in 20 chilli genotypes and observed that variability was high for weight of fresh red ripe fruits per plant. High heritability estimates were obtained for fruit length, weight of fresh red ripe fruits per plant, dry fruit weight, number of fruits per plant and fruit diameter.

Rani and Singh (1996) evaluated 19 agronomic characters in 79 genotypes of chilli and reported high genotypic and phenotypic coefficients of variation for fruits per plant, mean fruit weight, yield per plant and fruit length. High heritability coupled with high genetic advance as percentage of mean were observed for yield per plant, fruits per plant and mean fruit weight.

Bhatt and Shah (1996) reported high variability among 50 *Capsicum annuum* and *C. frutescens* genotypes for nine characters including fruit yield. Ghildiyal et al. (1996) in a study with 24 cultivars reported high heritability and genetic advance for fruits per plant, fruit weight, fruit length and circumference of fruits.

Singh and Singh (1998) observed considerable genetic variability for fruit yield and six other polygenic traits in 30 genotypes of chilli. Heritability estimates were high for all traits except days to 50% flowering. High heritability linked with moderate genetic advance was observed for fruit per plant, fruit yield, fresh and dry weight of fruits.

Kataria et al. (1997) observed high range of phenotypic variability for plant height, fresh weight of fruits and number of fruits per plant among 54 genotypes of chilli. High heritability and genetic advance were observed for fruit length, yield and fruit weight. Nayeema et al. (1998) reported high variability for all the characters studied including fruit yield in 71 genotypes of chilli. They reported high heritability coupled with high genetic advance for fruit yield per plant and fruit weight. In study conducted with 71 genotypes of chilli, Jabeen et al. (1998) reported high variability for fruit yield and several other characters.

Das and Choudhary (1999a) assessed genetic variability, heritability and genetic advance in 25 genotypes of chilli and reported that fruit length had the highest genotypic and phenotypic variance among the various characters studied. Heritability was high for fruit length, fruit diameter, fruits per plant, weight of fruits and yield per plant.

Devi and Arumugam (1999a) reported moderate variation for plant height, days to first flowering and dry fruit yield per plant.

Genetic variability analysis in segregating progenies of chilli by Subashri and Natarajan (2000) indicated high heritability and genetic advance for yield per plant, number of fruits per plant and number of seeds per fruit.

In a study involving 30 genotypes, Munshi and Behera (2000) observed existence of considerable amount of genetic variability for number of fruits per plant, fruit weight, fruit length and yield per plant. GCV ranged from 5.32 percent (days to first fruit harvest) to 59.44 per cent (number of fruits per plant). They reported high estimates of broad sense heritability and genetic advance for fruit length, number of fruits per plant and yield per plant.

Mishra et al. (2001) evaluated nine genotypes of chilli for fruit characters and found considerable variability for fruits per plant and fruit length.

Ibrahim et al. (2001) observed high phenotypic and genotypic coefficients of variation for fruit length, dry fruit yield and number of branches per plant. The heritability was highest for plant height (98.12%) followed by fruit length (96.74%) and number of fruits per plant (96.18). Fruit width and dry fruit yield per plant showed high genetic advance.

Fresh and dry fruit yield per plant showed high phenotypic and genotypic coefficients of variation in a study by Gogoi and Gautam (2002) with 52 chilli genotypes. Heritability estimate was low for number of primary branches. High genetic advance along with high heritability was recorded for fresh fruit yield per plant.

Rathod et al. (2002) studied eight yield components in 13 chilli cultivars and observed high genotypic coefficients of variation for number of fruits per plant and plant height. Heritability estimates were high for days to 50% flowering, plant height, number of primary branches and fruits per plant, length and diameter of fruit. Number of fruits per plant and plant height showed high heritability and high genetic advance.

Manju and Sreelathakumary (2002) evaluated 32 hot chilli (*Capsicum chinense* Jacq.) accessions and observed high phenotypic and genotypic coefficients of variation for fruits per plant, yield per plant, seeds per fruit and fruit weight. The study revealed high heritability coupled with high genetic advance for several characters including yield per plant, fruits per plant, fruit weight, fruit girth and length.

Nandadevi and Hosamani (2003) observed high degree of genotypic and phenotypic coefficients of variation for number of primary branches, fruit length number of fruits per plant and green fruit yield per plant in their study with 26 genotypes. High heritability coupled with high genetic advance as percentage of mean was observed for fruit length and green fruit yield per plant.

Mini and Khader (2004) evaluated 25 genotypes of wax type chilli and reported high values of genotypic and phenotypic coefficients of variation for green fruit yield per plant, number of fruits per plant and average fruit weight. High heritability coupled with high genetic advance was observed for fruit length, fruit weight, number of fruits per plant, green fruit yield per plant and number of secondary branches.

Following evaluation of variability in nine breeding lines of chilli, Jadhav et al. (2004) reported low coefficients of variation as well as low values of heritability and genetic advance for days for 50 percent flowering and plant height. Fruit weight and fruit length exhibited higher PCV and GCV along with high values of heritability and expected genetic advance. Yield per plant, number of fruits per plant and number seeds per fruit showed relatively lower values of heritability and expected genetic advance.

Genetic variability analysis in 12 chilli genotypes by Verma et al. (2004) showed that the phenotypic coefficient of variation was higher than the genotypic coefficient of variation in several characters including days to 50% flowering, plant height, fruit length and number of fruits per plant. Number of fruits per plant, pod length and plant height showed high estimates of genetic advance as percentage of mean coupled with high heritability. High heritability along with moderate genetic advance was observed for number of branches per plant and fruit width.

Sreelathakumary and Rajamony (2004a) following variability analysis in chilli with 35 genotypes reported high phenotypic and genotypic coefficients of variation for fruits per plant and yield per plant as well as fruit characters such as fruit weight, fruit length and fruit girth. High heritability coupled with high genetic advance was observed for these characters.

Prabhakaran et al. (2004) in a study involving 18 characters in 97 genotypes of chilli observed that genotypic coefficient of variation was high for number of fruits per plant, yield per plant, fruit length and fruit weight. High heritability estimates coupled with high genetic advance as percentage of mean were observed for yield per plant and mean fruit weight.

Wasule et al. (2004) reported high variability among 17 genotypes of chilli for several biometric characters including days to 50 per cent flowering, plant height, number of fruits per plant, fruit length, fruit girth and yield of red chillies per plant. Number of fruits per plant showed high genotypic coefficient of variation, heritability and genetic advance.

Ajith and Manju (2006) reported high heritability for fruit weight per plant, fruit length and number of seeds per fruit following evaluation of 76 genotypes. High genetic advance was observed for fruit weight per plant, number of fruits per plant, average green fruit weight and number of seeds per fruit. High heritability coupled with high genetic advance was shown by all the above characters.

2.1.2 Correlation studies

Yield is a complex character determined by many component characters. Selection for a specific character results in correlated response for some other characters. Interrelationship between fruit yield and its contributing characters have been reported by many workers in chilli.

Ramkumar et al. (1981) reported that fruit yield was positively correlated with number of fruits per plant, height and plant spread following correlation studies in 12 chilly varieties. Rao and Chhonkar (1981) reported negative correlation of yield with days to flowering. Bavaji and Murthy (1982) found that yield was positively correlated with number of fruits per plant and number of branches per plant.

Nair et al. (1984) found positive correlation of fruit yield with fruits per plant, number of secondary branches per plant, fruit weight, fruit circumference and duration. Choudhary et al. (1985) observed positive correlation of yield per plant with girth and weight of fruits, which in turn was positively correlated with number of seeds per fruit. However, Gopalakrishnan et al. (1985) observed negative correlation of fruit girth with fruit yield per plant while fruit length showed positive correlation with yield.

Ghai and Thakur (1987) found that yield was correlated with fruit length, number of branches, and number of fruits per plant and plant spread. Depestre et al. (1989b) also reported the positive association of yield and number of fruits per plant. Das et al. (1989) found that yield per plant was significantly and positively correlated with number of primary and secondary branches per plant and number of seeds per fruit.

Bhagyalakshmi et al. (1990) reported significant positive association of yield per plant with fruits per plant and branches per plant and negative association with days to 50 per cent flowering.

Ali (1994) observed positive correlation of yield with plant height, number of primary braches per plant and number of secondary branches per plant. Similarly, Pawade et al. (1995) reported significant and positive correlation of fruit yield with number of fruits, number of branches, plant height and fruit length.

Ahmed et al. (1997) reported that fruit yield was positively associated with number of fruits, plant height, fruit length and fruit weight.

Rani (1997) found positive correlation of fruit yield with vegetative characters viz., plant height, number of primary and secondary branches. Todorova and Todorov (1998) reported positive association of length, diameter and weight of fruits with yield. Strong positive correlation of yield per plant with fruit weight at genotypic and phenotypic levels was reported by Mishra et al. (1998). They also found that number of fruits had positive and significant association with fruit weight, plant height and days to flowering. Positive correlation of yield with fruit weight was also reported by Dimova and Panyotov (1999).

Devi and Arumugam (1999b) reported significant positive correlation between dry fruit yield per plant and the number of fruits per plant.

Correlation studies in 25 genotypes by Das and Choudhary (1999b) revealed positive association of yield with fruit weight, number of fruits and number of primary branches.

Subhasri and Natarajan (1999) conducted correlation studies in F_2 generation of 10 chilli crosses and reported positive association of yield with number of branches, number of fruits, fruit weight and fruit length in all crosses.

Munshi et al. (2000) reported that yield per plant was significantly and positively correlated with number of fruits per plant and fruit weight. But fruit weight and number of fruits per plant were negatively correlated. Positive correlation of fruit weight with fruit length was also noticed.

According to Aliyu et al. (2000) yield per plant was negatively correlated with plant height. Chaim and Paran (2000) reported that fruit weight had high genetic correlation with diameter and low correlation with fruit length.

Wyrzykowska et al. (2000) reported that fruit yield depended on mean fruit weight and fruits per plant in a study on quantitative traits and their correlation in sweet paprika. Positive association of number of fruits and yield per plant in chilli was also reported by other workers (Mishra et al., 2001; Nandadevi and Hosamani, 2003).

Chatterjee et al. (2001) found significant and positive association of fruit yield with fruit weight and number of seeds per fruit.

Rathod et al. (2002) found that yield of chilli was positively and significantly correlated with the number of fruits per plant and100-seed weight.

Ibrahim et al. (2001) studied association between dry fruit yield and its five component characters in 17 genotypes of chilli and found that dry fruit yield exhibited significant positive correlation with all the characters considered, viz., number of fruits per plant, number of branches, fruit length, fruit width and plant height.

Jose and Khader (2002) reported positive correlation of yield with fruit weight, number of fruits, primary branches per plant, secondary branches per plant, plant height, fruit length, fruit girth and duration. Positive correlation of fruit yield with number of fruits, fruit length, fruit diameter and plant height was also reported by Khurana et al. (2003). Both of these studies indicated negative correlation of yield with days to flowering.

Correlation analysis by Gogoi and Gautam (2003) using 52 genotypes indicated positive correlation of fresh fruit yield per plant with fruits per plant, flowers per plant, fresh fruit weight, dry fruit weight, 1000-seed weight, plant height, plant spread, fruit length, seeds per fruit and number of primary branches. The association of yield with days to first flowering, days to maturity and harvest duration was negative.

Kumar et al. (2003) studied correlation among characters in 30 chilli genotypes. Yield per plant expressed positive correlation with number of primary branches, number of secondary branches and number of fruits per plant. Fruit length and fruit width showed positive correlation with fruit weight and negative correlation with number of fruits per plant

Correlation analysis with 15 accessions by Sreelathakumary and Rajamony (2004b) showed that yield had significant and positive correlation with fruits per plant, fruit length, fruit girth and fruit weight.

2.1.3 Path coefficient analysis

Path coefficient is a standardized partial regression coefficient which measures the direct influence of one variable upon another and permits the separation of correlation coefficients into components of direct and indirect effects (Dewey and Lu, 1959).

The information obtained from path analysis helps in indirect selection for genetic improvement of yield.

Path-coefficient analysis in chilli by Rao and Chhonkar (1981) revealed that number of fruits per plant, fruit weight and dry yield per plant had direct positive effects on ripe-fruit yield per plant. Studies by Nair et al. (1984) indicated that number of fruits, secondary branches, fruit weight, fruit circumference and duration had positive direct effect on yield.

Chouvey et al. (1986) reported positive direct effect of number of fruits per plant, fruit weight, number of seeds per fruit and fruit circumference on yield. Path coefficient analysis by Solanki et al. (1986) suggested that the characters that exert positive direct effect on yield as the number of fruits per plant, height, number of primary branches per plant and fruit length.

Path coefficient analysis with 21 varieties showed that fruit weight, fruits per plant and fruit width had the greatest direct effects on yield (Depestre et al., 1989b). Following path coefficient analysis Sarma and Roy (1995) identified fruit diameter, fruit length and days to 50% flowering as important characters to be considered in selection programmes for yield improvement in chilli

In a study using 20 varieties of chilli, Korla and Rastogi (1997) reported that number of fruits per plant had the highest direct effect on fruit yield followed by weight per fruit. Das and Choudhary (1999b) also found high positive direct effect of these characters on yield.

Path analysis by Devi and Arumugam (1999b) revealed that number of fruits per plant had the most positive effect on dry fruit yield per plant. Plant height exhibited a negative direct effect, but influenced yield indirectly through number of fruits per plant, fruit shape index, number of secondary branches, capsaicin content and number of seeds per fruit.

Legesse et al. (1999) reported positive direct effects of number of fruits per plant and pericarp thickness on yield in 18 hot pepper genotypes.

Path analysis in a 6x6 diallel excluding reciprocals revealed the strong positive direct effect of total fruit number on total fruit weight (Tavares et al. 1999).

Aliyu et al. (2000) reported that fruit diameter and number of seeds per fruit had large positive direct effect on yield while plant height showed negative direct contribution to yield.

Direct positive effect of number of fruits per plant, fruit weight and fruit girth on yield per plant was observed in a study involving 30 chilli genotypes by Munshi and Behera (2000).

Ibrahim et al. (2001) studied six yield related characters in 17 genotypes of chilli and observed that fruit length and number of fruits per plant had strong positive association with dry fruit yield.

Path coefficient analysis by Jose and Khader (2002) indicated that selection for mean fruit weight, fruits per plant, duration and earliness in flowering and yielding might lead to increase in yield.

Rathod et al. (2002.) found that one-hundred seed weight recorded the highest positive direct effects on the wet red chilli yield per plant, followed by seed percentage, days to 50% flowering and number of primary branches per plant

Path coefficient analysis conducted by Nandadevi and Hosamani (2003) using 26 chilli genotypes revealed that number of fruits per plant is important in determining fruit yield and suggested that the character should be given due consideration for yield improvement of chilli.

Association among yield components and their direct and indirect effects on yield in chilli was investigated by Kumar et al. (2003) and reported 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 yield. The direct effect of number of fruits per plant was high, counteracting its negative indirect effects through fruit length and fruit width to render a positive correlation with yield. Number of fruits per plant showed positive indirect effect through fruit weight. Fruit length and fruit width recorded positive direct effect towards yield and their indirect effect through each other were also positive. Although fruit weight had negative direct effect on yield, its genotypic correlation was positive due to its positive indirect effects through fruit length, fruit width and days to first harvest. Both number of primary branches and number of secondary branches showed low direct effect but they recorded positive correlation with yield.

Path coefficient analysis carried out using 52 genotypes of chilli by Gogoi and Gautam (2003) revealed that number of fruits per plant exerted highest positive direct effect (0.7148) on yield, followed by fruit length (0.3155) and fruit diameter (0.3138), indicating the importance of these characters in yield improvement.

Sreelathakumary and Rajmony (2004b) reported positive direct effects of fruits per plant, fruit weight and fruit girth on yield. Fruit length had negative direct effect on yield, but its indirect effects through fruits per plant, fruit girth and fruit weight were high and positive. They suggested that selection for fruits per plant, fruit weight, fruit length and fruit girth might lead to an increase in the yield of hot chilli.

2.1.4 Genetic divergence

Genetic divergence is a basic requirement for effective selection within the existing population. One of the potent techniques of measuring genetic divergence is D^2 statistic (Mahalonobis, 1936).

Singh and Singh (1976a) grouped 45 genotypes of chilli into ten clusters based on D^2 values. The clustering pattern of the strains did not follow the geographic distribution. Considerable diversity within and between the clusters was noted. The characters contributing substantially towards total divergence were number of branches, fruit thickness, number of fruits per plant and yield per plant.

Gill et al. (1982) conducted diversity study with six parents and their 15 hybrids of sweet pepper and the grouped 21 genotypes into seven clusters.

Varalakshmi and Haribabu (1991) grouped 32 diverse chilli genotypes into 11 clusters based on D^2 values. Grouping of genotypes into different clusters was not related to their geographical origin. Considerable differences existed between clusters for all the characters. Fruits per plant, fruit weight and total yield were reported to be the chief contributors towards genetic divergence.

Forty *C. annuum* genotypes of indigenous and exotic origin were subjected to diversity analysis and based on D^2 values the genotypes were grouped into eight clusters. D^2 values arranged between 0.1032 and 8.7702. Fresh fruit weight and fruits per plant had high contribution towards divergence (Karad et al., 2002).

2.1.5 Selection Index

Use of selection Index will increase the efficiency of selection in any breeding programme; superior genotype can be selected from the germplasm using a selection index employing the discriminant function.

Singh and Singh (1976b) obtained maximum yield advance in F_2 generation through selection based on the seven characters *viz.*, plant height, number of branches, days to flowering, days to maturity, fruit length, fruit thickness and number of fruits per plant. The comparison of different discriminant functions revealed that days to flowering, fruit length and number of fruits per plant were major yield components.

Singh and Singh (1977) studied 45 strains of chilli and reported that discriminant functions using seven characters at a time. Selection considering Plant height, number of branches, days to maturity, fruit length, fruit size and fruits per plant was more efficient than straight selection for yield.

Ramkumar et al. (1981) reported that selection based upon discriminant function involving fruit length and number of fruits may be more efficient than straight selection for yield. Rani and Usha (1996) evaluated 73 *C. annuum* genotypes for fruit yield and related characters. Correlation and regression analysis were carried out to determine the selection index.

Vallejo et al. (1997) used selection Index to evaluate individual genotypes and to select best families from F2 generation of 19 hybrids obtained from a 7x7 half diallel cross.

Mini (2003) constructed selection index based on 14 characters in *C. annuum* genotypes and the genotypes were ranked based on this and observed high selection index value for high yielding types.

Ajith (2004) used selection index to evaluate 76 genotypes of chilli based on yield (fruit weight per plant) and its component characters.

2.2 Chilli thrips and yellow mite

Chilli thrips, *Scirtothrips dorsalis* (Hood) and yellow mite, *Polyphagotarsonemus latus* (Banks) are two serious pests of chilli (Ananthakrishnan, 1973; Amin,1979) both in the nursery and main field. Adults and nymphs suck the sap from tender leaves and growing shoot. Affected leaves curl either upward due to thrips or downward due to mite feeding resulting in damage called 'chilli leaf curl'. The overall reduction of in yield of dry chilli ranged from 40 to 70% due to the incidence of thrips and mites (Jagadesha et al., 2000). Chemical protection is not advisable on account of likely health hazards and environmental pollution. Application of chemical pesticides has aggravated problem of resurgence of chilli mite (David, 1991). So identification of sources of resistance has assumed great importance recently. Population count and damage intensity are the criteria usually adopted for evaluation of genotypes for resistance to these pests.

2.2.1.1 Description and biology of the pests and damage symptoms in chilli.

Scirtothrips dorsalis is a polyphagous species with more than 100 recorded hosts from about 40 different families. This includes many crop plants such as amaranthus, cashew, groundnut, tea, chilli, citrus, soybean, tomato, tobacco, brinjal, mung bean and grapes. Field identification of chilli thrips is not easy due to its similarity with other thrips and often difficult to differentiate from other thrips in the field. Adult chilli thrips have a pale body with dark wings and are less than 2 mm in length. Nymphs of chilli thrips are pale in color similar many other thrips species. Some of the distinguishing characteristics of chilli thrips are as follows: antennae are 8-segmented with segments I-II pale, III-VIII dark, head is pale in color with three pairs of ocellar setae, fore wings are brown and paler distally (www.doacs.state.fl.us/pi/enpp/ento/chilli thrips).

According to Amin and Palmer (1985) the duration of each life stage of chilli thrips is as follows: eggs 6-8 days, larval stages 6-7 days, pupal stages 2-3 days, adults up to 22 days with an average of 11 days. Reproduction is both sexually and parthenogenetically. It is mainly a foliage feeder. It spreads virus diseases in many crop plants (Rao et al. 2003; Campbell et al. 2005).

Scirtothrips dorsalis infestation results in upward curling of young top leaves in boat shaped manner and leaf lamina on both sides of the mid-rib becomes corrugated. Leaves become smaller, thickened and brittle. Stunting of plants occur due to severe infestation. (Karmakar, 1995).

Yellow mites are much smaller in size compared to thrips. Adult's female mites are about 0.2 mm long and oval in outline. Their bodies are swollen in profile and are light yellow to amber or green in color with an indistinct median stripe that fork near the back end of the body. Males are similar in color but lack the stripe. The two hind legs of the adult females are reduced to whip-like appendages. The male is smaller (0.11mm) and faster moving than the female (Penna and Campbell, 2005). Yellow mite has a wide host range. Food crops listed as hosts include: apple, avocado, cantaloupe, castor, chilli, citrus, coffee, cotton, eggplant, grapes, guava, jute, papaya, passion fruit, pear, potato, sesame, string or pole beans, mango, tea, tomato (Penna and Campbell, 2005).

The yellow mite has four stages in its life cycle: egg, larva, nymph and adult. Adult females lay 30 to 76 eggs (averaging five per day) on the undersides of leaf surface and in the depressions of small fruit over an eight to 13-day period and then die. Adult males may live five to nine days. While unmated females lay male eggs, mated females usually lay four female eggs for every male egg. The eggs hatch in two or three days and the larvae emerge from the egg shell to feed. Larvae are slow moving and do not disperse far. After two or three days, the larvae develop into a quiescent larval (nymph) stage. Quiescent female larvae become attractive to the males which pick them up and carry them to the new foliage. Males and females are very active, but the males apparently account for much of the dispersal of mite population in their frenzy to carry the quiescent female larvae to new leaves. When females emerge from the quiescent stage, males immediately mate with them.

Feeding by the mites cause downward rolling of leaves, elongation of the petiole of older leaves and clustering of tender leaves at the tip of the branches. The growth of the plant is arrested (Desai et al. 2006).

2.2.2. Sources of resistance to chilli thrips and yellow mite

Sanap and Nawale. (1987) observed the number of *Scirtothrips dorsalis* nymphs and *Polyphagotarsonemus latus* on 40 *Capsicum annuum* varieties and reported LIC 8 as resistant and Pant C1 and LEC 7 as moderately resistant to these pests.

In a field trail with several chilli varieties, Naitam et al. (1990) observed low leaf curl incidence by thrips and mites in chilli varieties Jwala and Pant C1.They also found that yield of these of varieties were higher than the other varieties in the field trail.

Mallapur (2000) while evaluating 62 chilli genotypes for resistance *Scirtothrips dorsalis* and yellow mite observed that 13 varieties showed lower percentage leaf curl due to these pests than local checks.

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

Khalid et al. (2001) screened 77 chilli cultivars to identify yellow mite resistance sources. Based on population count, injury grade and damage index, these varieties were grouped into three categories, resistant, susceptible and highly susceptible. Nine cultivars were included in the resistant category.

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

Desai et al. (2006) screened 21 chilli genotypes against yellow mite and found ACG 77 to be promising on account of low pest population count and leaf curl intensity.

Materials and methods

3. MATERIALS AND METHODS

The present study was undertaken to estimate the genetic variability in a collection of chilli (*Capsicum annuum* L.) genotypes for yield and resistance to chilli thrips and yellow mites and to identify high yielding types tolerant to these pests. The research work was carried out in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 2006-2007. The data for investigation were collected from two field experiments and a pot culture experiment. The objective of the first field experiment was evaluation of the accessions for yield and component characters and the second one aimed at screening for resistance to chilli thrips and yellow mites. The accessions identified as relatively tolerant in the initial screening trial were further evaluated for confirmation of resistance/tolerance to the pests adopting a pot culture experiment.

3.1. Materials

The material for experiments 1and 2 comprised of 50 chilli varieties collected from different sources. These include local cultivars and improved varieties and are denoted by accession numbers, Ca 1 to Ca 50. The identity and source of the test entries are provided in Table 1. The variation in fruit characters shown in Plate 1.

The material for the pot culture experiment for confirmation of resistance/tolerance to chilli thrips comprised of three varieties identified as the most tolerant and two susceptible varieties among the 50 varieties subjected to initial screening. Two genotypes each identified tolerant and susceptible to mite infestation in the initial field screening trail formed the material for the critical evaluation for resistance to yellow mite.

3.2. Methods

3.2.1. Experiment 1- Evaluation for yield and component characters

3.2.1.1. Layout and conduct of the experiment

The crop was raised in randomized block design with three replications during June to October 2006.The entire field was divided into three blocks of fifty plots each

Plate 1. Variation in fruit characters

Table1. Identity and source of the 50 genotypes of chilli

Accession number	Identity	Source
Ca 1	ACS20006	Regional. Agricultural Research Station, Guntur, Andhra Pradesh.
Ca 2	AJIT-3	”
Ca 3	BC-25	”
Ca4	BC-40-2	”
Ca 5	CO-4	”
Ca 6	DCL-352	”
Ca 7	DCL-524	”
Ca 8	DSL-1	”
Ca 9	F112-5-83	”
Ca 10	DSL-2	”
Ca 11	G-4	”
Ca 12	LCA-206	”
Ca 13	HS-HP154	”
Ca 14	HS-HP-111	”
Ca 15	JCA-283	”
Ca 16	KCS-2013	”
Ca 17	HDC-75	”
Ca18	LCA-235	”
Ca 19	LCA-305	”
Ca 20	LCA-334	”
Ca 21	LCA-353	”
Ca 22	LCA-357	”
Ca 23	LCA-760	”
Ca 24	PC-76	”
Ca 25	PC-7	”
Ca 26	SKUV-C-101	”
Ca 27	SELECTION-11	”
Ca 28	SELECTION-12	”

Ca 29	Jwalasakhi	College of Agriculture Vellayani, Thiruvananthapuram
Ca 30	Kattakkada local	Kattakkada
Ca 31	Palapoor local	Palapoor
Ca 32	Manacaud local	Manacaud
Ca 33	Kalliyoor local	Kalliyoor
Ca 34	Kuttichall local	Kuttichall
Ca 35	Poonkulam local	Poonkulam
Ca 36	Thiruvallam local	Thiruvallam
Ca 37	Vellayani local	Vellayani
Ca 38	Srikaryam local	Srikaryam
Ca 39	Kayamkulam local	Kayamkulam
Ca 40	Nedumangadu local	Nedumangadu
Ca 41	Venjarammood local	Venjarammood
Ca 42	Poonthura local	Poonthura
Ca 43	Parasala local	Parasala
Ca 44	Kazhakkuttan local	Kazhakkuttan
Ca 45	Venganoor local	Venganoor
Ca 46	Balaramapuram local	Balaramapuram
Ca 47	Ookkodu local	Ookkodu
Ca 48	Vandithadam local	Vandithadam
Ca 49	Pachaloor local	Pachaloor
Ca 50	Peringamala local	Peringamala

and treatments were allotted to plots in each block at random. Plot size was 4.86 m^2. Spacing was 45 x 45 cm. Seedlings were raised in nursery beds and one month old seedlings were transplanted in the experimental plots at the rate of one seedling per pit. The crop was managed as per the package practices recommendations of the Kerala Agricultural University (Kerala Agricultural University, 2002).

3.2.2. Collection of data

Data on the following characters were obtained from observations recorded on five randomly selected observation plants from each plot and working out the mean values.

a. Plant height (cm): Height was measured from the base of the plant to the tip of the longest branch immediately before the last harvest of fruits.

b. Number of primary branches: The branches originating from the main stem were counted and recorded at the full maturity of the plant.

c. Number of secondary branches: The branches borne on the primary branches were counted and recorded as secondary branches

d. Fruit bearing period: Number of days from first fruit set to last fruit formation.

e. Plant canopy width (cm): Measured immediately after first harvest at the widest point.

f. Number of fruits per plant: Number of fruits harvested from each observational plant at each harvest was counted.

g. Green fruit yield per plant (g): The weight of fresh fruits collected from the observation plants was recorded at each harvest. Total yield was obtained by adding the weight of fruits at each harvest.

h. Duration (days): Number of days from sowing to the last harvest.

Number of days taken from sowing to the day at which 50% of the plants attained flowering in each plot was recorded as the days to 50% flowering. The fruit characters, viz., fruit length (cm), fruit girth (cm), fruit weight (g) and the number of seeds per fruit were recorded from 10 randomly selected fruits at vegetable maturity stage collected at the second harvest from the five observation plants. Fruit length was measured from the peduncle to the tip of the fruit. The circumference at the broadest part of the fruits selected for recording length was measured to obtain fruit girth. Fruit weight was the average weight of the ten fruits taken at random from the five observations plants. The seeds were separately extracted from ten fruits collected at random and number was counted and recorded.

3.2.3. Statistical Analyses

The data collected were subjected to the following statistical analyses.

3.2.3.1 Analysis of Variance

The analysis of variance was carried out for various characters (Panse and Sukhatme, 1957)

i. To test the significance of differences among the genotypes with respect to various characters and

ii. To estimate the variance components and other genetic parameters like coefficients of variation, heritability and genetic advance.

Estimation of components of variance

1. Variance (for a trait X)

Environmental variance, $\sigma^2 e_x = E_{xx}$

$$\text{Genotypic variance, } \sigma^2 g_x = \frac{G_{xx} - E_{xx}}{r}$$

Phenotypic variance, $\sigma^2 p_x = \sigma^2 g_x + \sigma^2 e_x$

where

E_{xx} = observed mean square for error

G_{xx} = observed mean square for genotype

2. Coefficients of variation

Phenotypic and genotypic coefficients of variations (PCV and GCV) for a trait X were estimated as suggested by Singh and Chaudhary (1985).

$$GCV = \frac{\sigma g_x}{\bar{x}} \times 100$$

$$PCV = \frac{\sigma p_x}{\bar{x}} \times 100$$

Where

σg_x = genotypic standard deviation

σp_x = phenotypic standard deviation

$\bar{x}$ = mean of the character under study

3. Heritability (broad sense)

Heritability (H^2) was calculated to estimate the proportion of heritable component of variation

$$H^2 = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where H^2 is the heritability expressed in percentage (Jain, 1982).

Heritability was categorized as low (<30 per cent) moderate (31-60 per cent) and high (>60 per cent) as suggested by Johnson et al. (1955).

4. Genetic advance as percentage of mean

To estimate the change in the mean genotypic value of population brought about by selection, genetic advance is calculated as

$$\text{GA (as \% of mean)} = \frac{k\, H^2 \sigma p}{\bar{x}} \times 100$$

Where k is the standardized selection differential with value 2.06 at 5 per cent selection intensity (Miller et al., 1958) and $\bar{x}$ is the mean of the character.

3.2.3.2 Covariance Analysis

Covariance analysis was done for the estimation of correlation coefficients, path analysis and genetic divergence.

Table 2. Analysis of variance / covariance for two traits X and Y

Source	Degrees of freedom	Observed mean square for X	Expected mean square for X	Observed mean square for Y	Expected mean square for Y	Observed mean sum of products for X & Y	Expected mean sum of products for X & Y
Block	r-1	B_{xx}		B_{yy}		B_{xy}	
Genotype	v-1	G_{xx}	$\sigma^2e_x+\sigma^2g_x$	G_{yy}	$\sigma^2e_y+r\sigma^2g_y$	G_{xy}	$\sigma e_{xy}+r\sigma g_{xy}$
Error	(v-1)(r-1)	E_{xx}	σ^2e_x	E_{yy}	σe_{xy}	E_{xy}	σe_{xy}
Total	(vr-1)						

Where r = number of replications

v = number of treatments

The covariances are estimated for two traits as

Environmental covariance (σe_{xy}) = E_{xy}

Genotypic covariance (σg_{xy}) $= \dfrac{G_{xy} - E_{xy}}{r}$

Phenotypic covariance (σp_{xy}) $= \sigma g_{xy}+\sigma e_{xy}$

3.2.3.3 Correlation Analysis

The correlation coefficients (phenotypic, genotypic and environmental) were worked out as based on the formulae given by Singh and Chaudhary (1985).

Genotypic correlation Coefficient (r_{gxy}) $= \dfrac{\sigma g_{xy}}{\sigma g_x \times \sigma g_y}$

Phenotypic correlation Coefficient (r_{pxy}) $= \dfrac{\sigma p_{xy}}{\sigma p_x \times \sigma p_y}$

Environmental correlation Coefficient (r_{exy}) $= \dfrac{\sigma e_{xy}}{\sigma e_x \times \sigma e_y}$

3.2.3.4 Path Analysis

The path analysis was done by the method developed by Wright (1954) to study the cause and effect relationship among a system of variables which helps to measure the direct influence along each separate path in such a system and to find the degree to which the variation of a given effect is determined by each particular cause.

The residual factor (R) which measures the contribution of other factors not defined in the casual scheme was estimated by the formula

$$R = \sqrt{\left[1 - \sum_{i=1}^{k} P_i r_{iy}\right]}$$

Indirect effect of different characters on yield is obtained as $P_i.r_{ij}$ for the ith character via jth character.

3.2.3.5 D^2 Analysis

Genetic divergence was studied using Mahalanobis' D^2 statistic as described by Rao (1952). The genotypes were clustered by Tocher's method Rao (1952).

3.2.3.6 Selection Index

The various genotypes were discriminated based on various characters using the selection index developed by Smith (1936) using the discriminant function of Fisher (1936).

The selection index is described by the function $I = b_1x_1 + b_2x_2 + \ldots + b_kx_k$. The function $H = a_1G_1 + a_2G_2 + \ldots + a_kG_k$ where H denotes the genetic worth of the plant and $G_1, G_2, \ldots G_k$ are the genotypic values of the plant with respect to the characters $X_1, X_2, \ldots X_k$. . The economic weightages assigned to each character is assumed to be equal to unity i.e., a_1, a_2, ak = 1. The regression coefficients b_1, b_2, bk are estimated in such a way that the correlation between H and I is maximum. The procedure will reduce to an equation of the form $b = P^{-1}G_a$, where P is the phenotypic and G is the genotypic variance covariance matrix respectively from which the b values were solved out.

3.3 Experiment 2 – Evaluation of chilli genotypes for chilli thrips and yellow mite resistance

3.3.1 Layout and conduct of experiment

The crop was raised randomized block design with three replications during February to June 2007.The entire field was divided into three blocks of fifty plots each and treatments were allotted to plots in each block at random. Plot size was 2.43 m^2 with spacing of 45 x 45 cm. The crop was managed as per the package practices recommendations of the Kerala Agricultural university (Kerala Agricultural University, 2002) However, application of insecticides in the field was avoided taking into consideration the possible interference with the population build up of the target pests in the experimental plots.

3.3.2 Collection of data

3.3.2.1 Evaluation for resistance to thrips

a . Number of thrips per leaf: Number of thrips from three leaves per plant, one each from top, middle and bottom regions of five plants selected at random was counted using a 10x hand lens. Adults are swift in movement and fly away while counting. Therefore to avoid errors in thrips count only nymphs were considered for recording observations. The first observation was taken at 30 days after transplanting (DAT) and thereafter at 45 and 60 DAT.

b. Intensity of damage by thrips infestation:

Ten plants were selected at random from each plot and scored on the basis of intensity of damage to leaves on 0-4 scale as given below. The first observation was recorded at 30 days after transplanting and thereafter twice at 45 and 60 DAT.

Damaging score	Symptoms
0	No leaf curl incidence (Healthy plant)
1	<25% leaves showing upward curling in a plant
2	26 to 50% leaves showing upward curling in a plant
3	50 to 75% leaves showing upward curling in a plant
4	>75% leaves showing up ward curling in a plant

3. 3. 2. 2 Evaluation of resistance to mite

a. Number of mites per leaf:

Number of mites on six terminal leaves of five randomly selected plants in each plot was counted using a 10x hand lens. The first observation was taken at 30 days after transplanting and thereafter twice at fortnightly intervals(45 and 60 DAT)

b. Assessment of intensity of damage by mite infestation

Ten plants were selected from each plot and scored for leaf curl symptoms following a 0-4 scale proposed by Desai et al. (2006) described below.

Damaging score	Symptoms
0	No leaf curl incidence
1	<25% leaves showing downward curling in plant
2	26 to 50% leaves showing downward curling in a plant
3	50 to 75% leaves showing downward curling in a plant
4	>75% leaves showing downward curling in a plant

3. 3. 3 Statistical analysis

The data on population count and damage intensity were subjected to the following statistical analyses

3. 3. 3. 1 Analysis of variance

The data on population count and damage intensity of thrips and mites at periodical observations were subjected to analysis of variance. (Panse and Sukhatme, 1985). Data on population count and damage intensity were subjected to square root transformation to satisfy the basic assumptions in ANOVA. Pooled analysis of the data was also done. (Panse and Sukhatme, 1985).

3. 4 Critical evaluation for confirmation of resistance/tolerance

For confirmation of resistance/tolerance to chilli thrips five plants each of the three apparently resistant accessions along with two susceptible ones were grown in pots. The plants were covered with 150 gauge polythene bags of size 60 x 40 cm to protect the plants from pest incidence. Thrips were collected from field and released at the rate of 50 insects per plant on fifteen days old potted plants. The population counts of thrips were made 60 days after the release of the pest following the procedure adopted in the field screening experiment. Similarly damage intensity assessment was also done. For confirmation of resistance/tolerance to yellow mite two resistant and two susceptible accessions selected based on the results of the field screening trial were grown in pots. The plants were covered with 150 gauge polythene bags of size 60 x 40 cm to protect the plants from pest incidence. Mites were introduced to the potted plants 15 days after sowing by placing five severely affected leaves harboring large number of mites for each plant. Population assessment and damage intensity scoring were done 60 days after following the procedure adopted in the field screening experiment.

Results

4. RESULTS

The results of the present investigation are presented under two major headings.

i. Evaluation of genotypes for yield and yield components
ii. Screening for resistance to thrips and mite.

4.1 Evaluation of genotypes for yield and yield components (Experiment-I)

The data on morphological and yield characters were collected from the field experiment with 50 genotypes and statistically analyzed and the results are presented below.

4.1.1 Analysis of variance

The analysis of variance (Table 3) revealed significant differences among the 50 chilli varieties for all 13 characters studied viz., days to 50% flowering, fruit bearing period, duration, primary branches, secondary branches, plant canopy width, plant height, number of fruits per plant, fruit length, fruit weight, fruit girth, number of seeds per fruit and yield per plant.

4.1.2 Mean performance of the varieties

The mean values of each of the 50 genotypes for the 13 characters studied are presented Table 4.

Days to 50% flowering ranged from 42.66 to 66.33 days. Ca 27 was the earliest and Ca 41 was the latest to flower. Twenty-nine varieties were statistically on par with Ca 41 in days to 50 % flowering. Other early flowering genotypes were Ca 8, Ca 15 and Ca19.

The length of fruit bearing period varied from to 51.00 to 81.66 days among the genotypes. Ca 37 had the most staggered fruit bearing period. Ca 41 and Ca 13 were the other genotypes showing lengthy fruit bearing period. Length of fruit bearing period was

Table 3. Analysis of variance of 13 biometric characters in 50 genotypes of chilli

Sl. No	Character	Mean squares		
		Treatment	Replication	Error
	degrees of freedom	49	2	98
1	Days to 50% flowering	74.97**	26.98	13.93
2	Fruit bearing period	187.53**	39.70*	9.50
3	Duration	172.20**	43.17*	11.78
4	Primary branches	4.02**	0.13	0.36
5	Secondary branches	28.79**	3.39	1.94
6	Plant canopy width (cm)	248.90**	33.37	14.45
7	Plant height(cm)	184.88**	103.07**	15.11
8	No. of fruits per plant	1236.51**	13.53	32.58
9	Fruit weight(g)	1.43**	0.05	1.04
10	Fruit girth(cm)	0.52**	0.10**	0.02
11	Fruit length (cm)	7.85**	0.19	0.40
12	No. of seeds per fruit	208.67**	11.91	10.32
13	Yield per plant (g)	391.06**	163.99	0.41

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

Table 4. Mean values of 13 biometric characters in 50 genotypes of chilli

Acc No.	Days to 50% flowering	Fruit bearing period	Duration	Primary branches	Secondary branches	Plant canopy width (Cm)	Plant height (Cm)	Number of fruits per plant	Fruit weight (g)	Fruit girth (cm)	Fruit length (cm)	No of seeds per fruit	Yield per plant (g)
Ca 1	60.66	52.66	124.66	2.66	6.41	52.16	54.33	28.69	3.97	3.39	7.71	45.66	110.94
Ca 2	60.00	60.00	130.00	3.38	8.00	44.20	49.08	54.72	2.98	3.82	9.67	32.00	153.55
Ca 3	60.66	71.66	142.33	3.24	6.50	51.85	54.33	59.49	3.27	3.25	8.41	52.66	193.94
Ca 4	61.00	70.00	142.00	5.50	12.33	43.35	61.76	81.83	2.74	2..45	5.60	55.08	211.99
Ca 5	61.00	65.66	135.33	3.66	7.94	49.66	56.15	71.13	4.35	3.87	8.87	38.50	217.05
Ca 6	61.00	58.66	131.66	2.49	5.38	50.88	53.66	42.03	4.04	3.42	5.23	50.50	165.06
Ca 7	55.00	73.33	143.33	5.00	11.50	62.96	48.5	71.06	3.99	3.47	9.47	33.91	291.90
Ca 8	43.00	54.00	124.00	6.80	13.66	30.05	49.16	39.90	3.10	2.84	5.53	58.08	81.44
Ca 9	59.33	74.00	146.66	2.75	6.83	49.87	46.33	42.16	3.60	3.73	8.04	43.50	132.38
Ca 10	58.00	72.66	142.00	5.50	22.16	42.74	54.16	110.66	2.62	2.74	5.09	57.67	208.91
Ca 11	58.33	67.33	137.33	3.11	8.00	50.37	65.10	45.08	3.14	2.68	8.26	48.11	118.41
Ca 12	60.33	73.33	142.66	3.88	8.00	49.61	61.83	75.61	3.28	2.83	7.60	29.22	201.77
Ca 13	60.66	75.33	147.33	4.33	13.00	52.45	60.86	91.62	3.93	3.23	8.03	43.60	292.88
Ca 14	61.33	54.00	123.33	2.11	4.83	36.05	51.33	55.25	3.22	2.90	6.64	36.41	153.66
Ca 15	46.33	65.00	133.00	2.55	5.00	33.95	44.44	29.86	2.84	2.83	5.00	56.58	74.01
Ca 16	59.66	72.00	142.00	6.66	14.16	35.10	54.52	70.20	2.29	2.86	5.68	49.16	223.96
Ca 17	62.66	64.33	135.00	5.00	8.33	44.54	52.33	51.53	2.81	3.42	9.75	39.58	135.36
Ca 18	60.66	70.66	142.00	3.43	8.83	61.39	66.11	75.08	4.53	3.60	10.58	38.03	289.00
Ca 19	48.66	65.00	135.33	2.72	6.50	49.89	55.66	38.75	2.13	3.22	6.88	39.05	91.33
Ca 20	56.00	63.66	137.33	2.44	5.66	69.55	50.66	43.50	4.41	3.14	7.60	45.94	228.33
Ca 21	62.66	67.33	140.33	2.55	5.83	56.20	66.66	52.96	3.45	3.39	8.48	56.59	156.75
Ca 22	61.00	73.33	144.33	2.72	7.83	57.77	49.61	102.22	2.98	2.76	7.50	51.75	265.97
Ca 23	61.00	58.00	130.66	2.41	5.41	51.55	47.50	42.76	2.75	2.84	8.32	36.75	79.00
Ca 24	59.33	54.00	121.00	2.77	5.88	41.04	67.44	26.55	4.49	3.63	5.82	43.33	108.99
Ca 25	60.66	65.00	137.00	4.5	7.00	49.08	55.77	22.44	3.84	3.32	10.46	39.5	98.77
Ca 26	62.00	53.33	123.33	3.05	9.83	43.86	56.00	25.06	3.61	3.28	8.58	50.18	102.33
Ca 27	42.66	53.66	122.66	3.11	6.50	40.04	39.84	24.5	3.55	3.42	4.75	33	105.66
Ca 28	52.66	58.00	129.00	2.88	6.83	44.37	35.06	28.91	4.30	3.88	10.02	31.5	112.83
Ca 29	62.33	60.33	129.66	3.05	6.50	49.95	53.43	28.83	4.30	3.70	8.94	50.00	113.16

Ca 30	63.33	67.33	137.33	3.05	4.55	51.98	53.05	24.50	5.45	4.17	8.95	39.20	108.58
Ca 31	62.00	62.33	131.33	4.49	9.27	41.71	48.61	53.50	4.52	4.22	7.86	49.50	218.95
Ca 32	63.66	56.00	127.00	3.63	7.83	42.33	50.66	53.33	3.26	3.61	6.77	38.16	141.26
Ca 33	58.00	68.66	141.66	3.06	8.16	65.39	51.83	43.08	3.99	3.39	8.46	48.16	135.57
Ca 34	58.66	56.66	134.66	3.25	6.66	41.05	59.16	49.72	4.11	2.97	7.74	43.00	147.90
Ca 35	61.00	67.33	139.33	4.27	9.50	37.08	53.66	32.98	3.71	3.43	5.96	32.91	121.17
Ca 36	64.00	53.66	125.66	4.08	8.166	32.08	55.33	41.58	2.74	3.52	7.08	40.41	94.27
Ca 37	58.66	81.66	145.66	2.99	7.166	48.20	57.50	24.25	4.29	3.86	7.43	58.33	97.16
Ca 38	57.66	74.00	143.66	3.50	7.00	30.82	37.33	36.41	2.46	3.83	3.64	28.08	82.75
Ca 39	54.66	69.33	138.33	4.27	9.33	34.27	45.33	51.91	3.32	3.23	5.33	45.16	152.44
Ca 40	58.33	74.00	143.00	3.05	7.16	45.10	42.66	42.08	3.51	2.76	6.80	52.75	157.44
Ca 41	66.33	76.33	144.33	6.00	12.00	37.22	50.16	55.05	3.62	2.97	8.76	39.66	174.28
Ca 42	60.66	56.33	126.33	3.27	6.66	31.09	36.33	35.58	3.83	3.08	6.49	37.50	86.14
Ca 43	61.00	51.00	135.00	2.72	5.66	39.83	36.66	32.75	3.73	2.94	6.89	36.16	137.26
Ca 44	60.66	60.66	129.00	5.75	12.66	39.10	57.80	54.06	4.15	3.84	8.48	39.00	216.10
Ca 45	57.66	51.66	122.33	4.50	10.16	49.67	55.66	31.33	2.62	3.73	8.32	41.33	74.42
Ca 46	58.00	68.66	136.66	4.27	11.00	52.72	47.03	40.08	3.33	3.75	5.71	37.58	119.66
Ca 47	49.00	58.00	128.00	5.50	8.55	38.75	39.16	26.61	3.02	3.12	8.48	37.83	102.86
Ca 48	60.66	64.00	133.00	2.94	6.50	44.23	45.66	38.80	3.51	3.50	8.40	54.50	124.35
Ca 49	60.33	55.33	123.33	4.00	8.66	49.50	57.33	41.58	2.66	2.96	5.76	57.08	79.08
Ca 50	62.33	63.66	134.00	3.72	9.50	57.86	55.16	44.75	3.32	2.96	5.76	40.73	135.93
CD(0.05)	6.061	5.012	5.570	0.971	2.261	6.171	6.312	9.272	0.321	0.212	1.031	5.221	32.00
Mean	58.70	64.05	134.69	3.73	8.41	46.08	50.04	47.72	3.51	3.32	7.41	43.65	148.53
SE	± 3.04	± 2.51	± 2.80	± 0.48	± 1.13	± 3.10	± 3.17	± 4.66	± 0.16	± 0.10	± 0.51	± 2.62	± 10.45

minimum was for genotype Ca 43. Ten other varieties also had short fruit bearing period comparable to Ca 43.

The duration of the varieties ranged from 121.00 to 147.33 days. Maximum duration was recorded for genotype Ca13 which was statically on par with 13 other varieties. Ca 24 had the shortest duration among the varieties and was statically on par with eight other varieties.

Number of primary branches per plant varied widely among the genotypes, ranging from 2.11 to 6.80. The highest number was recorded for genotype Ca 8 which was statistically on par with Ca16 and Ca 41. The number of primary branches was the lowest for Ca14, which was statistically on par with 25 other varieties.

Number of secondary branches ranged from 4.55 to 22.16. Maximum was recorded for Ca10 and the minimum for Ca 30. Sparse branching at secondary level was also observed for nineteen other varieties.

The width of plant canopy ranged from 30.05 to 69.55 cm. Ca 20 had the maximum plant canopy width and the only other variety on par with it was Ca 33. Plant canopy width was the lowest for Ca 8 with seven other varieties on par with it.

Plant height ranged from 35.06 to 67.44 cm among the varieties. Ca 24 was the tallest variety and was on par with five other varieties. Ca 28 was the shortest. Other varieties with low plant height included Ca 42, Ca 43, Ca 38, Ca 46 and Ca27.

Among the varieties, number of fruits per plant varied from 22.44 (Ca 25) to 110.66 (Ca 10). The genotype Ca 10 was outstanding with respect to number of fruits per plant as no other variety on par with it. Minimum number of fruits per plant was recorded by Ca 25 which was statistically on par with ten other varieties.

The fruit characters viz., fruit length, fruit girth, fruit weight, and number of seeds per fruit showed wide range of variation among the varieties. Fruit length was maximum for Ca18 (10.58 cm) followed by Ca 25, Ca 28 and Ca 2 which was on par with Ca 18. Ca 38 recorded the lowest fruit length of 3.64 cm. Another variety with short fruit was Ca 27. Highest fruit girth of 4.22 cm was recorded by Ca 31 immediately followed by Ca 30. The genotype Ca 30 had significantly high fruit weight (5.45 g) in comparison with other accessions. Ca19 had the lowest fruit weight of 2.13g. Ca 16 and Ca 38 had low fruit weight similar to Ca 19. Number of seeds per fruit ranged from 28.08 (Ca 38) to 58.33 (Ca 37).

The variation in fruit yield per plant among the accessions was commendable. The fruit yield per plant ranged from 74.01 to 292.88 g. Ca13 was the highest yielder. Accessions Ca 7, Ca 18 and Ca 22 also gave high yield. Several accessions were poor yielding. The lowest yield was recorded for Ca 15 which was on par with 15 other varieties. The high yielding genotypes shown in plate 2.

4.1.2.1 Variability studies

The phenotypic and genotypic variance and coefficients of variation for the 13 characters are presented in Table 5. Fig. 1 shows the phenotypic and genotypic coefficients of variation for the 13 characters studied.

4.1.2.1.1 Phenotypic Coefficient of Variation (PCV)

The highest PCV was observed for number of fruits per plant (43.64) followed by the fruit yield per plant (41.87). Number of secondary branches per plant (39.21) and primary branches per plant (33.61) also had moderate PCV indicating a moderate degree of variation. PCV was very low for duration (5.97) followed by days to 50%flowering (9.97).

4.1.2.1.2 Genotypic Coefficient of Variation (GCV)

Duration and days to 50 per cent flowering had low GCV of 5.42 and 7.68 respectively. The highest value of GCV was observed for number of fruits per plant (41.97) followed by fruit yield per plant (39.70), secondary branches per plant (35.53), primary branches per plant (29.57) and fruit length (21.196).

Ca 13

Ca 7

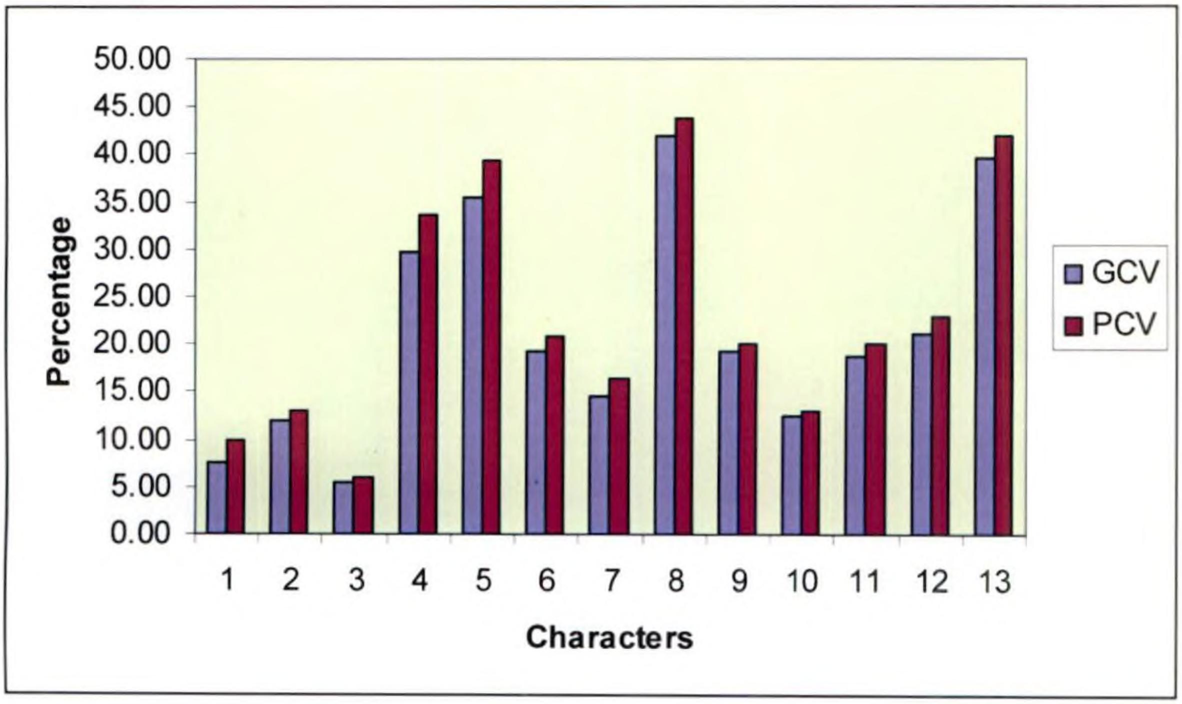
Ca 18

Ca 22

Table 5. Components of variance for the 13 characters in chilli

Sl. No.	Characters	Mean ± SE	σ^2 p	σ^2 g	GCV (%)	PCV (%)
1	Days to 50% flowering	58.70±2.15	34.2797	20.3475	7.68	9.97
2	Fruit bearing period	64.05±1.77	68.8639	59.3344	12.02	12.95
3	Duration	134.69±1.98	65.2596	53.4739	5.42	5.99
4	Primary branches	3.73±0.34	1.5766	1.2196	29.57	33.61
5	Secondary branches	8.41±0.80	10.8973	8.9511	35.53	39.21
6	Plant canopy width (cm)	46.08±2.19	92.6052	78.1522	19.17	20.87
7	Plant height(cm)	50.04±2.24	71.7043	56.5923	14.47	16.29
8	No. of fruits per plant	47.72±3.24	433.8962	401.3112	41.97	43.64
9	Fruit length (cm)	3.51 ±0.58	2.8876	2.4835	21.19	22.85
10	Fruit girth(cm)	3.32 ±0.06	0.1863	0.1691	12.39	13.00
11	Fruit weight(g)	43.69 ±0.36	0.5032	0.4629	19.34	20.17
12	No. of seeds per fruit	7.41 ±1.85	76.4431	66.1170	18.62	20.02
13	Yield per plant (g)	148.53 ±1.22	3869.6170	3478.5560	39.70	41.87

σ^2 p = phenotypic variance, σ^2 g = genotypic variance, GCV=Genotypic coefficient of variation, PCV=Phenotypic coefficient of variation.



1. Days to 50 % flowering
2. Fruit bearing period
3. Duration
4. Primary branches
5. Secondary branches
6. Plant canopy width
7. Plant height
8. Number of fruits per plant
9. Fruit weight
10. Fruit girth
11. Fruit length
12. Number of seeds per fruit
13. Yield per plant

Fig.1.Phenotypic and genotypic coefficients of variation for the various characters in 5 0 chilli genotypes

4.1.2.2 Heritability and Genetic Advance

The estimates of heritability and genetic advance for the various characters are given in Table 6 and Fig. 2. The heritability estimates were high for all the characters except days to 50%flowering (59.36). The heritability estimate was the highest for number of fruits per plant (92.49) followed by fruit weight (91.98), fruit girth (90.80), yield per plant (89.89) and number of seeds per fruit (86.49). Expected genetic gain as percentage of mean was high for number of fruits per plant (83.15) followed by yield (77.55) and secondary branches (66.35). Duration and days to 50% flowering exhibited low genetic gain.

High heritability coupled with high genetic advance was observed for number of fruits per plant, yield per plant and secondary branches.

4.1.3 Correlation studies

The phenotypic, genotypic and environmental correlation coefficients were estimated for all pairs of characters. The results of the correlation analysis are presented under the following subtitles.

a. Correlation between yield and other characters
b. Correlation among the yield component characters

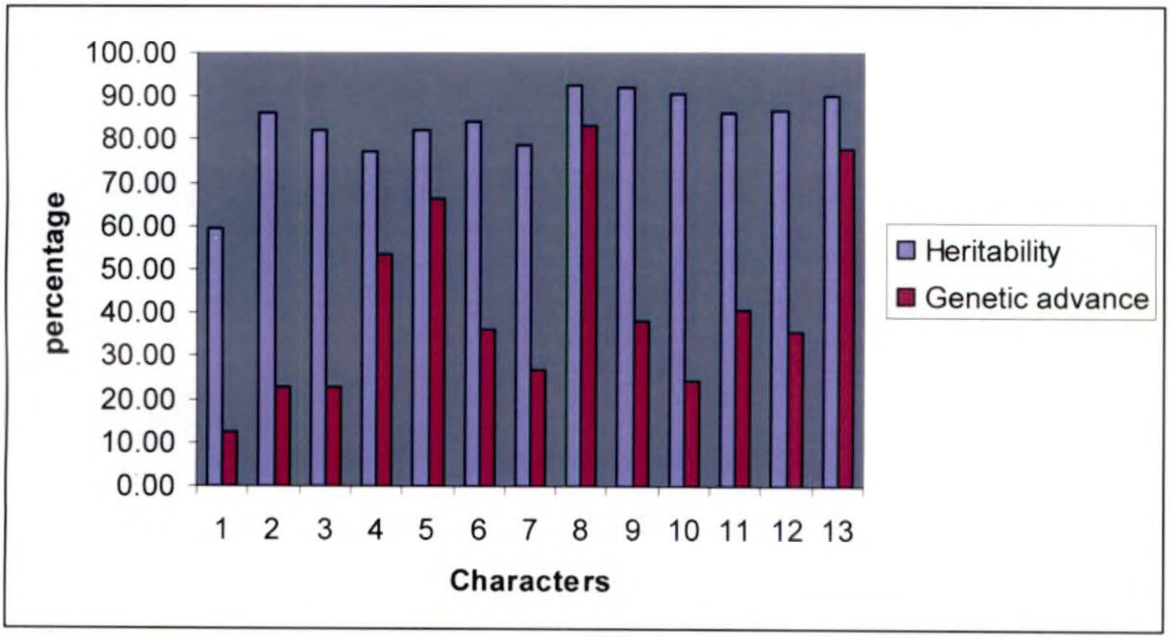
4.1.3. 1 Correlation between yield and other characters

The phenotypic, genotypic and environmental correlation coefficients of yield with other characters were presented in Table 7. Correlation diagram showing genotypic correlation between yield and other characters provided in Fig. 3.

The phenotypic correlation was found to be highly significant and positive for number of fruits per plant (0.7741), duration (0.4846), fruit bearing period (0.4477), plant canopy width (0.3493) and secondary branches (0.3439).

Table 6. Heritability, genetic advance and genetic gain for the 13 characters in chilli

Sl. No.	Characters	Heritability (%)	Genetic advance at 5% selection intensity	Genetic gain(% of mean)
1	Days to 50% flowering	59.36	7.15	12.19
2	Fruit bearing period	86.16	14.72	22.79
3	Duration	81.94	13.63	22.99
4	Primary branches per plant	77.36	2.00	53.57
5	Secondary branches per plant	82.14	5.58	66.35
6	Plant canopy width (cm)	84.39	16.72	36.29
7	Plant height(cm)	78.92	13.76	26.39
8	No. of fruits per plant	92.49	39.68	83.15
9	Fruit weight(g)	91.98	1.34	38.20
10	Fruit girth(cm)	90.80	0.80	24.32
11	Fruit length (cm)	86.01	3.01	40.49
12	No. of seeds per fruit	86.49	15.57	35.67
13	Yield per plant (g)	89.89	15.19	77.55



1. Days to 50 % flowering
2. Fruit bearing period
3. Duration
4. Primary branches
5.Secondary branches
6.Plant canopy width
7.Plant height
8.Number of fruits per plant
9.Fruit weight
10.Fruit girth
11.Fruit length
12.Number of seeds per fruit
13.Yield per plant

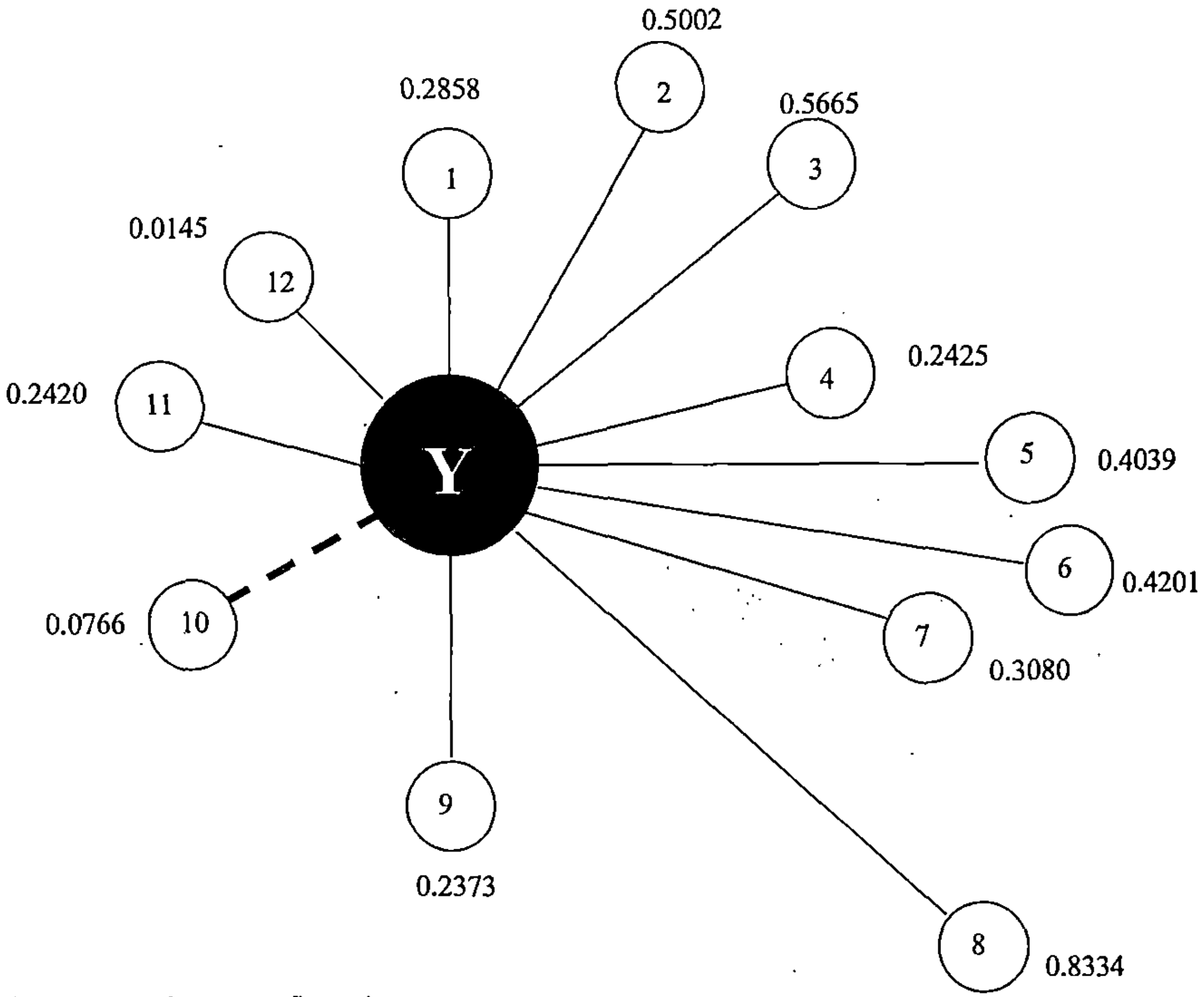
Fig.2.Heritability and genetic advance for the various characters in 50 chilli genotypes

Table 7. Phenotypic, genotypic and environmental correlation coefficients between yield per plant and other characters

Sl. No.	Characters	Correlation coefficient		
		Phenotypic	Genotypic	Environmental
1	Days to 50% flowering	0.2015	0.2858*	-0.0358
2	Fruit bearing period	0.4477**	0.5002**	0.0621
3	Duration	0.4846**	0.5665**	-0.0118
4	Primary branches	0.2016	0.2425	-0.0039
5	Secondary branches	0.3439*	0.4039**	-0.0230
6	Plant canopy width	0.3493**	0.4201**	-0.1328
7	Plant height	0.2577	0.3080	-0.0118
8	No. of fruits per plant	0.7741**	0.8334**	0.1621
9	Fruit length	0.1970	0.2373	-0.2085
10	Fruit girth	-0.0777	-0.0766	-0.0887
11	Fruit weight	0.2052	0.2420	-0.0637
12	No. of seeds per fruit	0.0292	0.0145	0.1405

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

Fig 3. Genotypic correlation of yield with other characters



1. Days to 50 per cent flowering
2. Fruit bearing period
3. Duration
4. Primary branches
5. Secondary branches
6. Plant canopy width
7. Plant height
8. Number of fruits per plant
9. Fruit weight
10. Fruit girth
11. Fruit length
12. Number of seeds per fruit

Positive correlation

Negative correlation

Y: Fruit yield per plant

Number of fruits per plant had the highest significant and positive genotypic correlation with fruit yield per plant (0.8334) followed by duration (0.5665), fruit bearing period (0.5002), plant canopy width (0.4201), secondary branches per plant (0.4039), plant height (0.3080) and days to 50% flowering (0.2858). The genotypic correlations of yield with all the characters except fruit girth were found to be positive. While considering the environmental correlation all the characters were negatively correlated with yield except number of fruits per plant, fruit bearing period and number of seeds per fruit.

4.1.3.2. Correlation among the yield component characters

The phenotypic, genotypic and environmental correlation coefficients among the various yield components were computed and are presented in Tables 8, 9 and 10 respectively.

1. Days to 50% flowering

Phenotypic correlation was significant and positive for plant height (0.3286). No character recorded significant negative correlation. Fruit length (0.3658) and plant height (0.3954) had significant positive genotypic correlation with the character. None of the character showed significant environmental correlation with days to 50 % flowering.

2. Fruit bearing period

Fruit bearing period showed significant and positive phenotypic correlation with duration (0.9247) and number of fruits per plant (0.4499). Genotypic correlation was positive and significant for duration (0.9390), number of fruits per plant (0.4908), secondary branches per plant (0.2912) and plant canopy width (0.2712). None of the characters recorded significant negative correlation with fruit bearing period. Duration (0.8581) was the only character showing significant and positive environmental correlation with fruit bearing period.

3. Duration

Duration recorded significant positive phenotypic correlation with fruit bearing period (0.9247), number of fruits per plant (0.4698), plant canopy width (0.3178). Genotypic correlation was significant and positive with fruit bearing period (0.9390), number of fruits per plant (0.5251) and plant canopy width (0.3415). Duration did not show significant negative correlation with any of the characters. The character recorded significant and positive environmental correlation with fruit bearing period (0.8581).

4. Primary branches per plant

Significant and positive correlations at genotypic and phenotypic levels were observed for secondary branches per plant and number of fruits per plant, the genotypic correlation being 0.8158 and 0.3286 respectively. However, phenotypic correlation was significant and negative for plant canopy width (-0.2731). Plant canopy width (-0.3776) and fruit weight (-0.2797) showed significant negative genotypic correlation with the character. Environmental correlation was significant and positive with number of secondary branches per plant (0.5068).

5. Secondary branches per plant

Phenotypic correlation was positive and significant for primary branches per plant (0.7527) and number of fruits per plant (0.5397). None of the characters showed significant negative correlation with the character at the phenotypic level. The characters that exhibited significant and positive genotypic correlation with the character included primary branches per plant (0.8158), number of fruits per plant (0.6079) and fruit bearing period (0.2912). However the genotypic correlation of fruit weight (-0.3007) with the character was negative and significant. Environmental correlation was significant and positive with primary branches per plant (0.5068).

6. Plant canopy width

Fruit length (0.4094), duration (0.3178), plant height (0.3472) and fruit weight (0.2939) showed significant and positive correlation at phenotypic level. Genotypic correlation was significant and positive for fruit length (0.4674), duration (0.3415), and fruit bearing period (0.2712), plant height (0.3524) and fruit weight (0.3289). Significant negative correlation was observed for primary branches per plant both at phenotypic (-0.2731) and genotypic (-0.3776) levels. Environmental correlation for plant height was significant (0.3283).

7. Plant height

Number of fruits per plant (0.3177), plant canopy width (0.3524), days to 50% flowering (0.3954) and number of seeds per fruit (0.3017) showed positive genotypic correlation with the character. The phenotypic correlations of these characters were also found to be positive and significant. Environmental correlation was found to be positive and significant for plant canopy width (0.3283).

8. Number of fruits per plant

Number of fruits per plant showed significant positive phenotypic correlation with duration (0.4698), fruit bearing period (0.4499), secondary branches per plant (0.5397), primary branches per plant (0.2914) and plant height (0.2844). Phenotypic correlation of fruit girth with the character was negative and significant (-0.3143). Genotypic correlation was positive and significant for fruit bearing period (0.4908), duration (0.5251), primary branches per plant (0.3286), secondary branches per plant (0.6079) and plant height (0.3177). Fruit girth showed significant negative correlation (-0.3459) with the character. The only character exhibiting significant negative environmental correlation with number of fruits per plant was fruit weight (-0.4262).

9. Fruit weight

Significant positive phenotypic correlation was recorded for fruit girth (0.4852), fruit length (0.384), and plant canopy width (0.2939). Genotypic correlation also was significant and positive for fruit length (0.4413), fruit girth (0.4852) and plant canopy width (0.3289). Genotypic correlation was significant and negative for number of primary (-0.2797) and secondary (-0.3007) branches. Number of fruits per plant showed significant and negative environmental correlation (-0.4262) with the character.

10. **Fruit girth**

Fruit weight (0.4852) and fruit length (0.2909) showed significant positive phenotypic correlation with fruit girth. Number of fruits per plant (-0.3143) and number of seeds per fruit (-0.2749) showed significant negative phenotypic correlation. Significant positive genotypic correlation was evident for fruit length (0.3458) and fruit weight (0.5282). Number of fruits per plant (-0.3459) and number of seeds per fruit (-0.3233) showed significant negative genotypic correlation.

11. **Fruit length**

Phenotypic correlation was positive and significant for plant canopy width (0.4094), fruit weight (0.3840) and fruit girth (0.2909) and none of the characters was found to show significant negative correlation with fruit length. Significant genotypic correlation was recorded for plant canopy width (0.4674), fruit weight (0.4143), days to 50% flowering (0.3658) and fruit girth (0.3458). Environmental correlation of fruit length with other characters was not significant.

12. **Number of seeds per fruit**

None of the characters showed significant phenotypic correlation with number of seeds per fruit except fruit girth, which recorded significant negative correlation (-0.2749). Genotypic correlation was significant and positive for plant height (0.3077) and negative for fruit girth (-0.3233).

Table 8. Phenotypic correlation coefficients among the yield component characters

Character	Fruit bearing period	Duration of the crop	Primary branches	Secondary branches	Plant canopy width	Plant height	No of fruits per plant	Fruit weight	Fruit girth	Fruit length	No of seeds per fruit	Yield
Dys to 50 % flowering	0.0989	0.1472	-0.0417	-0.015	-.0.015	0.3286*	0.1937	0.1828	0.1335	0.2379	0.0008	0.2015
Fruit bearing period		0.9247**	0.1753	0.2580	0.2690	0.1362	0.4499**	0.0004	-0.0482	0.0420	0.1328	0.4477
Duration			0.1010	0.1939	0.3178*	0.1040	0.4698**	0.0185	-0.1215	0.0790	0.0785	0.4846
Primary branches				0.7527**	-0.2731*	0.0644	0.2914*	-0.2297	-0.1190	-0.0653	0.0246	0.2016
Secondary branches					0.1053	0.1577	0.5397**	-0.2474	-0.2000	-0.1497	0.1867	0.3439
Plant canopy width(Cm)						0.3472*	0.1768	0.2939*	0.0793	0.4094**	0.0715	0.3493
Plant height							0.2844*	0.0863	-0.0572	0.1756	0.2607	0.2577
No of fruits per plant								-0.2181	-0.3143*	-0.0146	0.1211	0.7741
Fruit weight									0.4852**	0.3840**	-0.0751	0.1970
Fruit girth										0.2909*	-0.2749*	-0.0777
Fruit length											-0.1635	0.2052
No of seeds per fruit												0.0292

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

Table 9. Genotypic correlation coefficients among the yield component characters

Character	Fruit bearing period	Duration of the crop	Primary branches	Secondary branches	Plant canopy width	Plant height	No of fruits per plant	Fruit weight	Fruit girth	Fruit length	No of seeds per fruit	Yield
Dys to 50 % flowering	0.1732	0.2384	-0.1178	-0.0331	0.2070	0.3954*	0.2605	0.2345	0.1511	0.3658**	-0.0472	0.2858*
Fruit bearing period		0.9390**	0.1681	0.2912*	0.2712*	0.1558	0.4908**	0.0023	-0.0542	0.0532	0.1631	0.5002**
Duration			0.1028	0.2346	0.3415*	0.1234	0.5251**	0.0265	-0.1389	0.1029	0.1054	0.5665**
Primary branches				0.8158**	-0.3776**	0.0613	0.3286**	-0.2797*	-0.1418	-0.0596	0.0569	0.2425
Secondary branches					-0.1583	0.1694	0.6079**	-0.3007*	-0.2303	-0.1698	0.2127	0.4039**
Plant canopy width(Cm)						0.3524**	0.2045	0.3289*	0.0965	0.4674**	0.0918	0.4201**
Plant height							0.3177*	0.1079	-0.0721	0.2003	0.3017*	0.3080*
No of fruits per plant								-0.2006	-0.3459**	0.0121	0.1429	0.8334**
Fruit weight									0.5282**	0.4143**	-0.0856	0.2373
Fruit girth										0.3458**	-0.3233*	-0.0766
Fruit length											-0.1988	0.2420
No of seeds per fruit												0.0146

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

Tabel 10. **Environmental correlation among the yield component characters**

Character	Fruit bearing period	Duration of the crop	Primary branches	Secondary branches	Plant canopy width	Plant height	No of fruits per plant	Fruit weight	Fruit girth	Fruit length	No of seeds per fruit	Yield
Dys to 50 % flowering	-0.1053	-0.0703	0.1256	0.0301	0.0159	0.1979	0.0040	0.0527	0.1170	-0.0985	0.1478	-0.0358
Fruit bearing period		0.8581**	0.2149	0.0825	0.2564	0.0453	0.1155	-0.0157	-0.0027	-0.0270	-0.0584	0.0621
Duration			0.0947	0.0077	0.2016	0.0247	0.1090	-0.0375	-0.0131	-0.0457	-0.0655	-0.0118
Primary branches				0.5068**	0.1703	0.0753	0.1036	0.0463	-0.0013	-0.0937	-0.1255	-0.0039
Secondary branches					0.1587	0.1094	0.0853	0.1171	-0.0089	-0.0440	0.0479	-0.0230
Plant canopy width(Cm)						0.3283*	-0.03668	0.0362	-0.0434	0.0755	-0.0474	-0.1328
Plant height								-0.0434	0.0277	0.0613	0.0679	-0.0118
No of fruits per plant								-0.4262	0.0323	-0.2479	-0.0658	0.1621
Fruit weight									0.0291	0.1459	0.0115	-0.2085
Fruit girth										-0.1293	0.1034	-0.0887
Fruit length											0.0579	-0.0637
No of seeds per fruit												0.1495

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

4.1.4 Path Analysis

In path coefficient analysis, the genotypic correlation coefficients of yield with yield contributing characters were partitioned into different components to find the direct and indirect contribution of each character to fruit yield. (Table11). The characters *viz.*, days to 50% flowering, duration, plant canopy width, number of primary branches per plant, number of fruits per plant, fruit length and fruit weight were considered for analysis. Path diagram showing direct and indirect effects of the component characters on yield is provided in Fig. 4.

Highest positive direct effect was observed for number of fruits per plant (0.8151) followed by fruit weight (0.3899). All characters except days to 50% flowering recorded positive direct effect. Though the direct effect of days to 50% flowering on yield was negative, the genotypic correlation was positive. This is due to its positive indirect effect through number of fruits per plant (0.2123) and fruit weight (0.0914).

The direct effect of duration was low but its indirect effect via. number of fruits per plant was high and positive (0.4281) which accounted for its high genotypic correlation with yield. The indirect effects of duration via. other characters, were negligible.

Plant canopy width had positive direct effect and genotypic correlation with yield. The character also exerted high indirect effect on yield through number of fruits per plant (0.1667) and fruit weight (0.1282).

Positive correlation of primary branches per plant can be attributed to its positive direct effect and positive indirect effect on yield via.number of fruits per plant.

Number of fruits per plant had highest direct effect (0.8151) as well as the highest positive correlation (0.8334) with yield and the indirect effects via. other characters were negligible. So the correlation coefficient explained true relationship of number of fruits per plant with yield.

Table 11. Direct and indirect effects of yield components of fruit yield in chilli

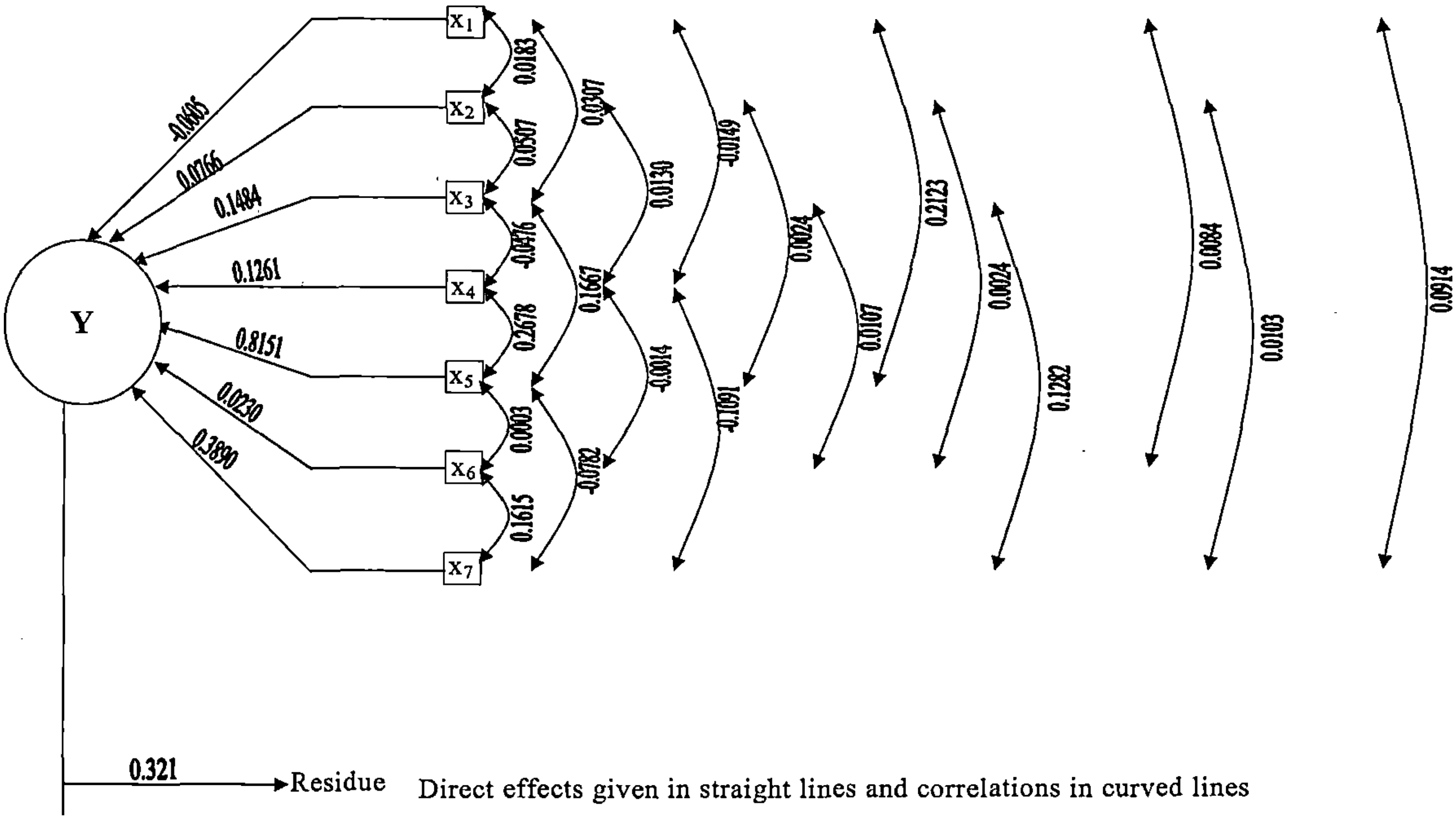
Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	Genotypic correlation with yield
Days to 50% flowering (X_1)	-0.0605	0.0183	0.0307	-0.0149	0.2123	0.0068	0.0914	0.2858*
Duration (X_2)	-0.0144	0.0766	0.0507	0.0130	0.4281	0.0024	0.0103	0.5665**
Plant canopy width (X_3)	-0.0125	0.261	0.1484	-0.0476	0.1667	0.0107	0.1282	0.4201**
Primary branches per plant(X_4)	0.0071	0.0079	-0.0561	0.1261	0.2678	-0.0014	-0.1091	0.2425
No. of fruits per plant (X_5)	-0.0158	0.0402	0.0304	0.0415	0.8151	0.0003	-0.0782	0.8334**
Fruit length (X_6)	-0.0221	0.0079	0.0694	-0.0075	0.0099	0.0230	0.1615	0.2420
Fruit weight (X_7)	-0.0142	0.0020	0.0488	-0.0353	-0.1635	0.0095	0.3899	0.2373

Residue: 0.321

Direct effects-Diagonal elements

Indirect effect-Off diagonal elements

Fig. 4 Path diagram showing direct and indirect effects of the components on yield



Direct effects given in straight lines and correlations in curved lines

Y – Yield per plant
X_1 – Days to 50 % flowering
X_2 – Duration
X_3 - Plant canopy width
X_4 – Primary branches per plant
X_5 – Number of fruits per plant
X_6 – Fruit length
X_7 – Fruit weight

The direct effect of fruit length on yield though low, it excreted high positive indirect via. fruit weight (0.1615).

In the present study, number of fruits per plant had the highest direct effect on yield (0.8151) as well as the highest positive correlation (0.8384). The indirect effect of the character via. other characters was negligible. Plant canopy width also had strong positive correlation with yield (0.4201). The character showed relatively high direct effect as well as positive indirect effect through number of fruits per plant and fruit weight. The study revealed that number of fruits per plant and plant canopy width are important in deciding yield and should be given due consideration in crop improvement programmes.

The residue obtained (R= 0.321) indicated that 68% of the variation was explained by the path coefficient analysis.

4.1.5 Genetic Divergence Analysis

The 50 genotypes were subjected to Mahalanobis D^2 analysis based on the thirteen characters *viz.*, days to 50% flowering, fruit bearing period; duration, primary branches per plant, secondary branches per plant, plant canopy width, plant height, number of fruits per plant, fruit length, fruit girth, fruit weight, number of seeds per fruit and yield per plant. The genotypes were grouped into eight clusters using Tocher's method of clustering. The clustering pattern is presented in Table 12.

The cluster I had the highest number of genotypes (19) followed by cluster IV (10) and cluster III (6). Clusters II and V had five genotypes each. Three genotypes were present in cluster VI. The genotypes Ca 10 (cluster VII) and Ca 20 (cluster VIII) remained as divergent genotypes that cannot be accommodated in any of the clusters and each remained as a separate cluster.

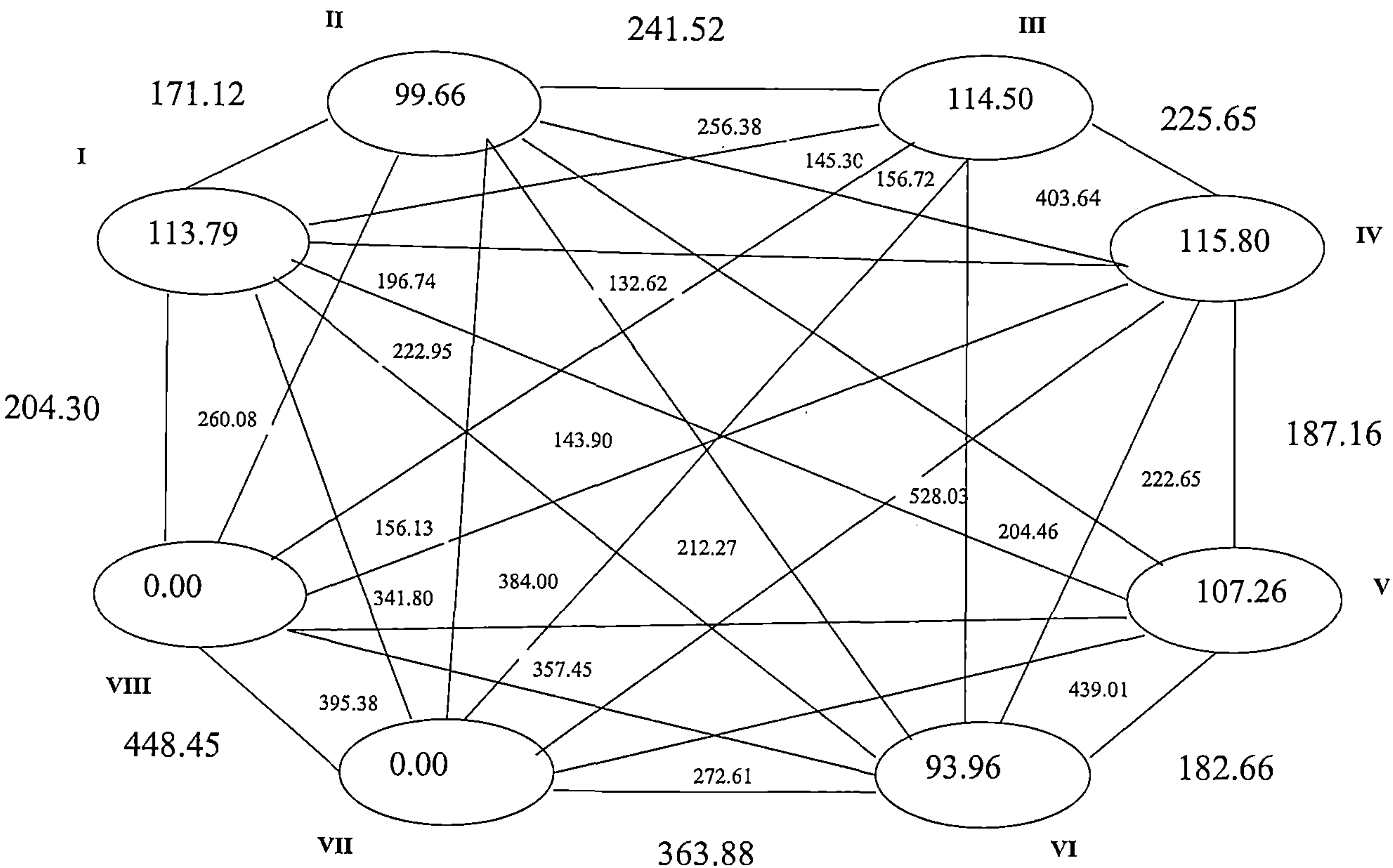


Fig 5. Cluster diagram

Table 12. Clustering pattern of genotypes

Cluster No.	Number of accessions	Accession categories
1	19	Ca 1,Ca 2,Ca 3,Ca 9,Ca 11,Ca 17,Ca 23,Ca 25,Ca 26,Ca 27,Ca 28,Ca 30,Ca 32,Ca 33,Ca 35,Ca 36,Ca 37,Ca 42,Ca48.
2	5	Ca 4, Ca12, Ca16, Ca 39, Ca 41.
3	6	Ca 5, Ca 7, Ca13, Ca 18, Ca 22, Ca 31.
4	10	Ca 6,Ca 14,Ca 21,Ca24,Ca29,Ca34,Ca40,Ca43,Ca44,Ca50
5	5	Ca 19, Ca38, Ca 45, Ca46, Ca47.
6	3	Ca 8,Ca15,Ca49
7	1	Ca10
8	1	Ca20

Table13. Average intra and inter cluster distance values among eight clusters (D^2 values)

Clusters	I	II	III	IV	V	VI	VII	VIII
I	113.79	171.12	256.28	132.62	143.90	222.95	395.38	204.30
II		99.66	241.52	156.72	204.46	212.27	196.74	260.08
III			114.50	225.65	403.64	528.03	348.00	145.3
IV				115.80	187.16	222.65	357.45	156.13
V					107.26	182.66	439.01	341.80
VI						93.96	363.880	412.45
VII							0	448.45
VIII								0

Table 14: Cluster means of the 13 biometric characters

Cluster No	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
I	59.50	62.78	133.40	3.33	7.27	46.01	50.51	37.86	3.61	3.45	8.07	42.19	118.50
II	60.39	72.19	141.86	5.26	11.16	39.91	54.72	66.92	3.05	2.37	6.59	43.65	192.88
III	60.05	70.10	140.60	3.93	9.72	54.32	54.97	77.43	4.05	3.52	8.71	42.54	262.62
IV	54.66	60.03	132.16	3.14	7.00	45.70	54.39	42.89	3.83	3.25	7.07	44.84	149.22
V	54.19	63.46	133.19	4.09	8.64	44.37	46.96	34.63	2.71	3.53	6.60	36.77	94.20
VI	49.88	58.11	126.77	4.45	9.10	37.83	50.31	37.11	2.86	2.87	5.43	57.24	78.17
VII	58.00	72.66	142.00	5.50	22.16	42.74	54.16	110.66	2.62	2.74	5.09	57.67	208.91
VIII	56.00	63.66	137.33	2.44	5.66	69.55	50.66	43.50	4.41	3.14	7.60	45.94	228.33

X_1 = Days to 50% flowering
X_2 = Fruit bearing period
X_3 = Duration
X_4 = Primary branches
X_5 = Secondary branches
X_6 = Plant canopy width (cm)
X_7 = Plant height (cm)
X_8 = Number of fruits per plant
X_9 = Fruit weight (g)
X_{10} = Fruit girth (cm)
X_{11} = Fruit length (cm)
X_{12} = Number of seeds per fruit
X_{13} = Yiled per plant (g)

Table 15. Contribution of different characters towards divergence

Sl. No.	Characters	Contribution % of divergence
1	Days to 50% flowering	1.31
2	Fruit bearing period	6.93
3	Duration	4.08
4	Primary branches per plant	4.48
5	Secondary branches per plant	1.32
6	Plant canopy width (cm)	6.61
7	Plant height(cm)	3.02
8	No. of fruits per plant	14.61
9	Fruit weight(g)	12.16
10	Fruit girth(cm)	15.16
11	Fruit length (cm)	7.75
12	No. of seeds per fruit	8.51
13	Yield per plant (g)	18.75

The average inter and intracluster distances were estimated based on the total D^2 values. The inter and intracluster distances (D) were worked out and presented in Table 13 and Fig. 5. The intra cluster distance varied from 0 (Cluster VII and VIII) to 113.79 (Cluster I). The inter-cluster distances varied from 132.62 (between clusters I and VI) to 528.03 (between Clusters III and VI).

The cluster means for each character is presented in Table 14. The cluster means were high in cluster VII for characters fruit bearing period, duration, number of fruits per plant, primary branches per plant, secondary branches per plant, and number of seeds per fruits. Cluster VIII had high cluster means for plant canopy width and fruit weight. Cluster mean was high for fruit girth in cluster V. Cluster III had the highest cluster mean value for fruit length, yield per plant and plant height. Cluster mean was high for days to 50 per cent flowering in cluster II. Among the thirteen characters considered, fruit yield per plant contributed maximum towards divergence (Table15)

4.1.6 Selection Index

Discriminant function technique was adopted for the construction of selection index for yield.

Selection index (I) for the genotypes was computed based on the thirteen characters, days to 50 % flowering (X_1), fruit bearing period (X_2), duration (X_3), number of primary branches (X_4), number of secondary branches(X_5), plant canopy width (X_6), plant height (X_7), number of fruits per plant (X_8), fruit length (X_9), fruit girth (X_{10}), fruit weight (X_{11}), number of seeds per fruit (X_{12}) and yield per plant (X_{13}).

$$I = 0.52\ X_1 + 0.80\ X_2 + 1.09X_3 + 1.05\ X_4 + 1.12\ X_5 + 1.05\ X_6 + 0.69\ X_7 + 1.78X_8 + 2.55\ X_9 - 3.70X_{10} + 14.72\ X_{11} + 0.74 + 0.67\ X_{13}$$

Accordingly selection index values were worked out and presented in the Table 16. The genotype Ca13 attained the maximum selection index value followed by Ca22 and Ca18. The minimum values were recorded for Ca27 and Ca15.

Table16 selection index values of 50 genotypes of chilli

Accession number	Identity	Selection index value
Ca1	ACS20006	580.84
Ca2	AJIT-3	644.09
Ca3	BC-25	742.18
Ca_4	BC-40-2	785.19
Ca5	CO-4	770.91
Ca6	DCL-352	656.69
Ca7	DCL-524	845.00
Ca8	DSL-1	538.24
Ca9	F112-5-83	656.64
Ca10	DSL-2	838.56
Ca11	G-4	650.29
Ca12	LCA-206	769.11
Ca13	HS-HP154	896.19
Ca14	HS-HP-111	622.74
Ca15	JCA-283	528.42
Ca16	KCS-2013	741.63
Ca17	HDC-75	646.01
Ca18	LCA-235	872.00
Ca19	LCA-305	573.69
Ca20	LCA-334	745.63
Ca21	LCA-353	716.24
Ca22	LCA-357	886.33
Ca23	LCA-760	575.91
Ca24	PC-76	565.41
Ca25	PC-7	586.40
Ca26	SKUV-C-101	557.64
Ca27	SELECTION-11	507.68
Ca28	SELECTION-12	563.58
Ca29	Jwalasakhi	604.72
Ca30	Kattakkada	619.23
Ca31	Palapoor	717.34
Ca32	Manacaud	627.47
Ca33	Kalliyoor	686.27
Ca34	Kuttichall	655.40
Ca35	Poonkulam	591.98
Ca36	Thiruvallam	550.60
Ca37	Vellayani	626.77
Ca38	Srikaryam	534.11
Ca39	Kayankulam	644.53
Ca40	Nedumungadu	665.63
Ca41	Venjarammod	706.64
Ca42	Poonthura	532.89
Ca43	Parsala	575.81
Ca44	Kazhakuttan	704.96
Ca45	Venganoor	532.99
Ca46	Balaramapuram	617.34
Ca47	Ookodu	530.82
Ca48	Vandithadam	617.34
Ca49	Pachaloor	530.82
Ca50	Peringamala	574.22

4.2. Screening for resistance to thrips and mites

The results of the experiment conducted with 50 genotypes for the evaluation of resistance to chilli thrips and yellow mite are presented below. For both thrips and mite, number of insects per leaf and leaf damage intensity were taken as the criteria for evaluation of resistance. Analysis of variance revealed significant differences among the varieties for the number of insects per leaf and leaf damage intensity at 30, 45 and 60 days after transplanting (DAT) due to chilli thrips and yellow mite infestation individually. Pooled analysis done considering population counts and leaf damage at 30, 45 and 60 DAT due to thrips and mite infestation also disclosed significant differences among the varieties.

4.2.1. Evaluation of resistance to chilli thrips

The population of chilli thrips in the experimental field was high which permitted reasonable evaluation of resistance to the pest. Number of thrips per leaf and the damage intensity (30, 45, and 60 DAT) are presented in tables 17 and 18. The thrips counts recorded at 45 and 60 DAT were more than ten per leaf for several varieties.

4.2.1.1. Number of thrips per leaf

The number of thrips per leaf at 30, 45 and 60 DAT ranged from 1.91 to 7.03, 4.61 to 15.55 and 3.38 to 13.89 respectively (Table 17). The genotypes, Ca 14, Ca 41 and Ca 13 recorded the lowest number of thrips per leaf in the first, second and third count respectively.Ca13 and Ca 41 recorded the lowest pooled mean value of 3.47.Ca13 recorded low in the number of thrips per leaf in all the three counts and was on par with the genotypes that recorded the least number of thrips in each of the three counts. Other varieties with lower number of insects per leaf included Ca1,Ca 2,Ca 12,Ca 14,Ca 29, Ca 45,Ca 46,Ca 35 and Ca 50. The genotype, Ca 6 recorded the highest number of thrips per leaf in all the three counts as well as the pooled mean of the three counts. Other varieties with high number of thrips per leaf consistently in all the observations included Ca 4, Ca 21 and Ca 31.

Table 17. Number of chilli thrips per leaf in 50 chilli accessions

Acc.No	Number of chilli thrips per leaf							
	30 DAT		45 DAT		60 DAT		Pooled	
Ca 1	2.16	(1.47)	5.32	(2.04)	4.01	(2.00)	3.71	(1.93)
Ca 2	2.14	(1.46)	5.63	(2.37)	4.19	(2.05)	3.85	(1.96)
Ca 3	3.91	(1.98)	8.53	(2.92)	7.49	(2.74)	6.48	(2.54)
Ca 4	6.04	(2.46)	12.77	(3.57)	11.63	(3.41)	9.91	(3.15)
Ca 5	4.20	(2.05)	10.18	(3.19)	8.17	(2.86)	7.29	(2.70)
Ca 6	7.03	(2.65)	15.55	(3.94)	13.89	(3.73)	11.84	(3.44)
Ca 7	5.06	(2.25)	11.95	(3.46)	10.12	(3.18)	8.78	(2.96)
Ca 8	4.47	(2.11)	10.40	(3.22)	8.64	(2.94)	7.61	(2.76)
Ca 9	2.53	(1.59)	6.11	(2.47)	4.71	(2.17)	4.32	(2.08)
Ca 10	3.75	(1.94)	9.88	(3.14)	7.77	(2.79)	6.88	(2.62)
Ca 11	3.11	(1.76)	7.77	(2.79)	5.85	(2.42)	5.40	(2.32)
Ca 12	2.15	(1.47)	5.82	(2.41)	4.25	(2.06)	3.92	(1.98)
Ca 13	2.03	(1.42)	5.39	(2.32)	3.38	(1.84)	3.47	(1.86)
Ca 14	1.91	(1.38)	5.29	(2.30)	3.72	(1.93)	3.50	(1.87)
Ca 15	3.33	(1.82)	8.16	(2.86)	6.27	(2.50)	5.73	(2.39)
Ca 16	2.39	(1.55)	6.03	(2.46)	4.51	(2.12)	4.17	(2.04)
Ca 17	5.44	(2.33)	12.38	(3.52)	10.39	(3.22)	9.15	(3.03)
Ca 18	5.14	(2.27)	11.72	(3.42)	10.20	(3.19)	8.77	(2.96)
Ca 19	3.78	(1.94)	9.66	(3.11)	7.70	(2.77)	6.81	(2.61)
Ca 20	2.80	(1.67)	6.21	(2.49)	5.32	(2.31)	4.65	(2.16)
Ca 21	6.24	(2.50)	13.93	(3.73)	11.95	(3.46)	10.43	(3.23)
Ca 22	4.35	(2.09)	9.99	(3.16)	8.35	(2.89)	7.35	(2.71)
Ca 23	4.60	(2.15)	11.00	(3.32)	9.08	(3.01)	7.98	(2.83)
Ca 24	3.07	(1.75)	7.97	(2.82)	6.02	(2.45)	5.49	(2.34)
Ca 25	2.34	(1.53)	6.24	(2.50)	4.63	(2.15)	4.24	(2.06)
Ca 26	3.26	(1.81)	9.40	(3.07)	6.78	(2.60)	6.21	(2.49)
Ca 27	2.81	(1.68)	7.74	(2.78)	5.53	(2.35)	5.15	(2.27)
Ca 28	2.32	(1.52)	6.39	(2.53)	4.68	(2.16)	4.29	(2.07)
Ca 29	2.18	(1.48)	5.79	(2.41)	4.19	(2.05)	3.91	(1.98)
Ca 30	5.01	(2.24)	11.89	(3.45)	9.57	(3.09)	8.57	(2.93)
Ca 31	5.64	(2.38)	13.30	(3.65)	11.72	(3.42)	9.92	(3.15)
Ca 32	2.73	(1.65)	6.66	(2.58)	4.93	(2.22)	4.63	(2.15)
Ca 33	3.57	(1.89)	6.90	(2.63)	5.59	(2.36)	5.26	(2.29)

Ca 34	2.56	(1.60)	6.82	(2.61)	4.94	(2.22)	4.60	(2.15)
Ca 35	2.74	(1.65)	6.14	(2.48)	4.83	(2.20)	4.45	(2.11)
Ca 36	4.74	(2.18)	11.32	(3.34)	9.35	(3.06)	8.22	(2.87)
Ca 37	3.11	(1.76)	5.94	(2.44)	4.47	(2.11)	4.43	(2.11)
Ca 38	3.24	(1.80)	7.01	(2.65)	5.76	(2.40)	5.21	(2.28)
Ca 39	5.29	(2.30)	12.39	(3.52)	10.58	(3.25)	9.15	(3.02)
Ca 40	3.24	(1.80)	6.46	(2.54)	4.60	(2.14)	4.67	(2.160
Ca 41	2.41	(1.55)	4.61	(2.15)	3.49	(1.87)	3.45	(1.86)
Ca 42	4.59	(2.14)	10.38	(3.22)	9.00	(3.00)	7.77	(2.79)
Ca 43	3.33	(1.82)	7.81	(2.80)	6.41	(2.53)	5.68	(2.38)
Ca 44	2.95	(1.72)	6.92	(2.63)	5.74	(2.40)	5.05	(2.25)
Ca 45	2.48	(1.58)	5.55	(2.35)	4.21	(2.05)	3.98	(1.99)
Ca 46	2.50	(1.58)	5.95	(2.44)	3.93	(1.98)	4.00	(2.00)
Ca 47	3.08	(1.75)	6.71	(2.59)	4.97	(2.23)	4.80	(2.19)
Ca 48	2.75	(1.66)	6.06	(2.46)	4.13	(2.03)	4.20	(2.05)
Ca 49	3.49	(1.87)	7.89	(2.81)	6.14	(2.48)	5.69	(2.38)
Ca 50	2.56	(1.60)	4.98	(2.23)	3.39	(1.84)	3.58	(1.89)
$F_{49,98}$		0.10**		0.16**		0.15**		0.14**
CD(0.05)		0.291		0.460		0.443		0.362
SE		0.10		0.16		0.15		0.14

Square root transformation
Square root transformation values in parenthesis
** Significant at 1% level

Table 18. Leaf damage intensity of chilli thrips in 50 chilli accessions

Acc.No	Leaf damage intensity of chilli thrips							
	30 DAT		45 DAT		60 DAT		Pooled	
Ca 1	0.73	(0.85)	1.66	(1.29)	1.32	(1.15)	1.21	(1.10)
Ca 2	0.54	(0.73)	1.16	(1.07)	1.08	(1.04)	0.90	(0.95)
Ca 3	0.93	(1.00)	1.66	(1.29)	1.24	(1.11)	1.28	(1.13)
Ca 4	1.74	(1.32)	2.66	(1.63)	2.25	(1.50)	2.20	(1.48)
Ca 5	1.08	(1.03)	2.00	(1.41)	1.33	(1.15)	1.45	(1.20)
Ca 6	2.16	(1.46)	3.16	(1.78)	2.66	(1.63)	2.65	(1.63)
Ca 7	1.15	(1.07)	2.33	(1.53)	1.74	(1.32)	1.71	(1.31)
Ca 8	1.56	(1.25)	2.33	(1.53)	2.08	(1.44)	1.98	1.41)
Ca 9	0.97	(0.99)	1.47	(1.21)	1.23	(1.11)	1.22	(1.10)
Ca 10	0.87	(0.93)	2.00	(1.41)	1.24	(1.11)	1.33	(1.15)
Ca 11	0.73	(0.85)	1.10	(1.05)	1.06	(1.03)	0.96	(0.98)
Ca 12	0.70	(0.84)	1.32	(1.15)	1.16	(1.08)	1.05	(1.02)
Ca 13	0.81	(0.90)	1.24	(1.11)	1.08	(1.04)	1.04	(1.02)
Ca 14	0.80	(0.89)	1.41	(1.19)	1.24	(1.11)	1.14	(1.07)
Ca 15	0.82	(0.91)	1.41	(1.19)	1.08	(1.04)	1.10	(1.05)
Ca 16	0.98	(0.99)	1.55	(1.24)	1.24	(1.11)	1.25	(1.12)
Ca 17	1.90	(1.37)	2.48	(1.58)	2.16	(1.47)	2.11	(1.47)
Ca 18	1.16	(1.07)	2.48	(1.58)	1.41	(1.19)	1.64	1.28)
Ca 19	1.24	(1.11)	2.08	(1.44)	1.49	(1.22)	1.59	(1.26)
Ca 20	1.40	(1.18)	2.41	(1.55)	1.65	(1.29)	1.80	(1.34)
Ca 21	1.16	(1.07)	2.00	(1.41)	1.41	(1.19)	1.51	(1.23)
Ca 22	1.55	(1.24)	2.48	(1.58)	1.90	(1.38)	1.96	(1.40)
Ca 23	1.08	(1.03)	2.00	(1.41)	1.33	(1.15)	1.45	(1.20)
Ca 24	1.31	(1.14)	2.16	(1.47)	1.57	(1.25)	1.66	(1.29)
Ca 25	0.99	(0.99)	1.47	(1.21)	1.24	(1.11)	1.23	(1.11)
Ca 26	0.77	(0.88)	1.32	(1.15)	1.08	(1.04)	1.05	(1.02)
Ca 27	1.08	(1.03)	1.66	(1.29)	1.33	(1.15)	1.35	(1.16)
Ca 28	0.99	(0.99)	1.50	(1.22)	1.24	(1.11)	1.24	(1.11)
Ca 29	0.73	(0.85)	1.41	(1.19)	1.08	(1.04)	1.06	(1.03)
Ca 30	0.73	(0.85)	2.75	(1.66)	2.50	(1.58)	1.86	(1.36)
Ca 31	1.33	(1.15)	2.08	(1.44)	1.74	(1.32)	1.71	(1.31)
Ca 32	1.65	(1.28)	2.48	(1.58)	1.98	(1.41)	2.02	(1.42)
Ca 33	0.73	(0.86)	1.43	(1.20)	1.18	(1.09)	1.10	(1.05)
Ca 34	0.73	(0.86)	1.38	(1.18)	1.00	(1.00)	1.02	(1.01)

Ca 35	0.43	(0.86)	1.08	(1.04)	1.18	(1.09)	0.99	(0.99)
Ca 36	0.75	(0.66)	1.00	(1.00)	1.00	(1.00)	0.79	(0.89)
Ca 37	1.74	(0.87)	1.16	(1.07)	1.16	(1.07)	1.01	(1.01)
Ca 38	1.99	(1.32)	2.48	(1.58)	2.07	(1.44)	2.09	(1.45)
Ca 39	1.39	(1.41)	2.57	(1.60)	2.25	(1.50)	2.27	(1.51)
Ca 40	1.65	(0.74)	1.26	(1.12)	0.99	(0.99)	0.90	(0.95)
Ca41	1.65	(1.28)	2.48	(1.58)	1.98	(1.41)	2.02	(1.42)
Ca 42	0.73	(0.86)	1.33	(1.15)	1.08	(1.04)	1.03	(1.02)
Ca 43	0.45	(0.67)	1.08	(1.04)	0.74	(0.86)	0.74	(0.86)
Ca 44	1.31	(1.14)	2.00	(1.41)	1.58	(1.26)	1.62	(1.27)
Ca 45	1.31	(1.14)	1.90	(1.38)	1.57	(1.25)	1.59	(1.26)
Ca 46	0.73	(0.86)	1.24	(1.11)	1.10	(1.05)	1.01	(1.01)
Ca 47	1.08	(1.04)	1.32	(1.150	1.18	(1.09)	1.20	(1.09)
Ca 48	0.73	(0.85)	1.32	(1.15)	1.08	(1.04)	1.03	(1.02)
Ca 49	0.73	(0.86)	1.24	(1.11)	1.10	(1.05)	1.01	(1.01)
Ca 50	0.98	(1.00)	1.41	(1.19))	1.21	(1.10)	1.20	(1.09)
$F_{49, 98}$		5.32**		12.16**		9.07**		4.47**
CD(0.05)		0.241		0.160		0.203		0.170
SE		± 0.84		± 0.58		± 0.57		± 0.66

Square root transformation
Square root transformation values in parenthesis
** Significant at 1% level

4.2.1.2. Damage intensity due to thrips infestation

The damage intensity due to thrips at 30, 45 and 60 DAT ranged from 0.45 to 2.16, 1.00 to 3.16 and 0.74 to 2.66 respectively (Table 18). The genotype, Ca 36 recorded the lowest damage in the damage assessments done at 45 DAT while Ca 43 was found to suffer the lowest leaf damage at 30 and 60 DAT. The pooled mean of the damage intensity values recorded on the three different stages of the crop indicated Ca 43 as the genotype suffering lowest leaf damage. Other genotypes with low leaf damage included Ca 36, Ca 40, Ca 2 and Ca 35 . The genotype Ca 6 was identified as the one exhibiting the most severe leaf damage recording the highest damage intensity values in the damage assessments done at the three different crop stages as well as the pooled mean value of the damage intensity. Ca 4 was another variety with high damage intensity of leaf consistently in all the observations.

4.2.1.3. **Number of mites per leaf**

The number of mites per leaf at 30, 45 and 60 DAT ranged from 0.71 to 4.96, 1.91 to 12.91 and 1.40 to 9.60 respectively(Table 19). The genotype Ca 35 recorded the lowest number of mites per leaf in the first, second and third counts and the lowest pooled mean value of 1.29. Ca 1 recorded the highest number of mites per leaf in all the three counts as well as the pooled mean worked out considering the counts simultaneously. Other varieties with high number of mites per leaf consistently in all the observations included Ca 9, Ca 11 and Ca15.

4.2.1.4. Damage intensity due to mite infestation

The damage intensity due to mites at 30, 45 and 60 DAT ranged from 0.47 to 1.99, 1.08 to 2.74 and 0.77 to 2.49 respectively (Table 20). The genotype, Ca 38 and Ca 6 recorded the lowest damage in the damage assessments done at 30, 45 and 60 DAT. The pooled mean of damage intensity values recorded on the three different stages of the crop also indicated Ca6 and Ca 38 as the genotype suffering low leaf damage due to mite infestation. Ca 1 was identified as the genotype exhibiting the most severe leaf damage recording the highest damage intensity values in the damage assessments done at the

Table 19. Number of yellow mites per leaf in 50 chilli accessions

Acc.No	Number of yellow mites per leaf							
	30 DAT		45 DAT		60 DAT		Pooled	
Ca 1	4.96	(2.23)	12.91	(3.59)	9.60	(3.10)	8.84	(2.97)
Ca 2	1.19	(1.09)	3.16	(1.78)	2.38	(1.54)	2.16	(1.47)
Ca 3	4.18	(2.05)	10.60	(3.26)	7.78	(2.79)	7.27	(2.70)
Ca 4	1.49	(1.22)	3.75	(1.94)	2.88	(1.70)	2.61	(1.62)
Ca 5	2.34	(1.53)	6.65	(2.58)	4.14	(2.03)	4.19	(2.05)
Ca 6	0.80	(0.89)	2.15	(1.47)	1.46	(1.21)	1.41	(1.19)
Ca 7	2.44	(1.56)	6.07	(2.46)	4.43	(2.10)	4.17	(2.04)
Ca 8	1.77	(1.33)	4.84	(2.20)	3.23	(1.80)	3.15	(1.78)
Ca 9	4.12	(2.03)	11.37	(3.37)	8.32	(2.88)	7.63	(2.76)
Ca 10	2.83	(1.68)	7.16	(2.68)	5.13	(2.26	4.88	(2.21)
Ca 11	4.56	(2.14)	12.43	(3.53)	8.92	(2.99	8.31	(2.88)
Ca 12	3.57	(1.89)	10.44	(3.23)	7.03	(2.65)	6.71	(2.59)
Ca 13	3.54	(1.88)	10.78	(3.28)	7.50	(2.74)	6.94	(2.63)
Ca 14	4.02	(2.01)	10.81	(3.29)	7.64	(2.76)	7.21	(2.69)
Ca 15	4.43	(2.10)	12.45	(3.53	8.94	(2.99)	8.26	(2.87)
Ca 16	3.26	(1.81)	9.53	(3.09)	6.44	(2.54)	6.14	(2.480
Ca 17	1.65	(1.29)	4.76	(2.18)	3.13	(1.77)	3.05	(1.75)
Ca 18	1.61	(1.27)	4.50	(2.12)	2.88	(1.70)	2.88	(1.70)
Ca 19	2.32	(1.52)	5.72	(2.39)	4.17	(2.04)	3.94	(1.99)
Ca 20	2.44	(1.56)	6.13	(2.48)	4.56	(2.14)	4.24	(2.06)
Ca 21	2.77	(1.67)	6.69	(2.59)	5.12	(2.26)	4.71	(2.170
Ca 22	2.44	(1.56)	6.44	(2.54)	4.62	(2.15)	4.34	(2.08)
Ca 23	2.58	(1.61)	7.08	(2.66)	5.40	(2.32)	4.83	(2.20)
Ca 24	1.78	(1.33)	5.1 7	(2.27)	3.66	(1.91)	3.39	(1.84)
Ca 25	1.60	(1.27)	4.41	(2.10)	2.88	(1.70)	2.85	(1.69)
Ca 26	2.76	(1.66)	7.38	(2.72)	5.20	(2.28)	4.92	(2.22)
Ca 27	3.56	(1.89)	9.53	(3.09)	6.32	(2.51)	6.23	(2.50)
Ca 28	3.34	(1.83)	10.08	(3.17)	6.78	(2.60)	6.43	(2.54)
Ca 29	2.88	(1.70)	8.94	(2.99)	5.73	(2.39)	5.57	(2.36)
Ca 30	1.35	(1.16)	4.10	(2.02)	2.36	(1.54)	2.48	(1.57)
Ca 31	1.34	(1.16)	3.76	(1.94)	2.51	(1.59)	2.43	(1.56)

Ca 32	1.41	(1.19)	4.10	(2.02)	2.74	(1.65)	2.63	(1.62)
Ca 33	1.05	(1.02)	2.71	(1.65)	1.96	(1.40)	1.84	(1.36)
Ca 34	0.88	(0.94)	2.43	(1.56)	1.65	(1.29)	1.59	(1.26)
Ca 35	0.71	(0.84)	1.91	(1.38)	1.40	(1.18)	1.29	(1.14)
Ca 36	1.31	(1.15)	4.10	(2.02)	2.50	(1.58)	2.51	(1.58)
Ca 37	1.96	(1.40)	6.99	(2.64)	3.75	(1.94)	3.97	(1.99)
Ca 38	2.21	(1.49)	7.67	(2.77)	3.69	(1.92)	4.24	(2.06)
Ca 39	1.06	(1.03)	4.04	(2.01)	1.94	(1.39)	2.18	(1.48)
Ca 40	1.06	(1.03)	3.90	(1.97)	2.02	(1.42)	2.17	(1.47)
Ca 41	1.23	(1.11)	3.87	(1.97)	2.26	(1.50)	2.33	(1.53)
Ca 42	2.11	(1.45)	6.45	(2.54)	3.63	(1.91)	3.87	(1.97)
Ca 43	0.95	(0.97)	3.15	(1.78)	1.70	(1.30)	1.83	(1.35)
Ca 44	1.28	(1.13)	4.13	(2.03)	2.51	(1.58)	2.51	(1.58)
Ca 45	1.54	(1.24)	4.27	(2.07)	2.66	(1.63)	2.71	(1.65)
Ca 46	3.21	(1.79)	9.46	(3.08)	6.54	(2.56)	6.13	(2.48)
Ca 47	2.71	(1.65)	9.38	(3.06)	5.77	(2.40)	5.62	(2.37)
Ca 48	0.83	(0.91)	3.13	(1.77)	1.67	(1.29)	1.75	(1.32)
Ca 49	1.07	(1.03)	3.59	(1.89)	1.92	(1.38)	2.07	(1.44)
Ca 50	3.33	(1.83)	9.77	(3.13)	6.43	(2.54)	6.23	(1.50)
$F_{49,98}$		0.08**		0.09**		0.10**		0.09**
CD(0.05)		0.233		0.274		0.290		0.253
SE		0.08		0.09		0.10		0.09

Square root transformation
Square root transformation values in parenthesis
** Significant at 1 % level

Table 20. Leaf damage intensity of yellow mite in 50 chilli accessions

Acc.No	Leaf damage intensity of yellow mite							
	30 DAT		45 DAT		60 DAT		Pooled	
Ca 1	1.99	(1.41)	2.74	(1.66)	2.49	(1.58)	2.40	(1.55)
Ca 2	0.66	(0.81)	1.17	(1.08)	0.91	(0.96)	0.91	(0.95)
Ca 3	1.99	(1.41)	2.50	(1.57)	2.24	(1.50)	2.24	(1.50)
Ca 4	0.81	(0.90)	1.30	(1.14)	1.06	(1.03)	1.05	(1.03)
Ca 5	1.24	(1.11)	1.70	(1.30)	1.49	(1.22)	1.48	(1.21)
Ca 6	0.47	(0.69)	1.08	(1.03)	0.77	(0.88)	0.76	(0.87)
Ca 7	1.16	(1.07)	1.80	(1.34)	1.49	(1.22)	1.47	(1.21)
Ca 8	0.73	(0.85)	1.17	(1.08)	0.91	(0.96)	0.93	(0.97)
Ca 9	1.65	(1.28)	2.26	(1.50)	1.99	(1.41)	1.96	(1.40)
Ca 10	1.48	(1.21)	2.07	(1.43)	1.82	(1.34)	1.78	(1.34)
Ca 11	1.65	(1.28)	2.23	(1.50)	1.90	(1.37)	1.92	(1.39)
Ca 12	1.79	(1.34)	2.40	(1.54)	2.05	(1.43)	2.08	(1.44)
Ca 13	1.74	(1.32)	2.37	(1.54)	1.99	(1.41)	2.03	(1.42)
Ca 14	1.74	(1.32)	2.24	(1.50)	1.99	(1.41)	1.99	(1.41)
Ca 15	1.17	(1.08)	1.74	(1.32)	1.49	(1.22)	1.46	(1.21)
Ca 16	1.49	(1.22)	1.76	(1.32)	1.74	(1.32)	1.67	(1.29)
Ca 17	0.73	(0.86)	1.24	(1.11)	0.99	(0.99)	0.98	(0.99)
Ca 18	0.61	(0.78)	1.26	(1.12)	0.91	(0.96)	0.91	(0.95)
Ca 19	1.65	(1.28)	2.16	(1.46)	1.90	(1.38)	1.90	(1.38)
Ca 20	0.99	(0.99)	1.49	(1.22)	1.24	(1.11)	1.23	(1.11)
Ca 21	0.57	(0.76)	1.08	(1.03)	0.82	(0.91)	0.82	(0.90)
Ca 22	1.14	(1.06)	1.62	(1.27)	1.39	(1.18)	1.38	(1.18)
Ca 23	0.99	(0.99)	1.41	(1.19)	1.24	(1.11)	1.21	(1.10)
Ca 24	0.99	(0.99)	1.49	(1.22)	1.24	(1.11)	1.23	(1.11)
Ca 25	0.99	(0.99)	1.49	(1.22)	1.24	(1.11)	1.23	(1.11)
Ca 26	1.33	(1.15)	1.99	(1.41)	1.74	(1.32)	1.68	(1.30)
Ca 27	1.33	(1.15)	1.74	(1.32)	1.49	(1.22)	1.52	(1.23)
Ca 28	0.83	(0.91)	1.33	(1.15)	1.08	(1.03)	1.07	(1.03)
Ca 29	1.24	(1.11)	1.74	(1.32)	1.49	(1.22)	1.49	(1.22)
Ca 30	0.73	(0.85)	1.31	(1.14)	0.98	(0.99)	1.00	(1.00)
Ca 31	0.73	(0.85)	1.24	(1.14)	0.98	(0.99)	0.98	(0.99)
Ca 32	0.91	(0.95)	1.49	(1.22)	1.17	(1.08)	1.18	(1.09)
Ca 33	0.86	(0.86)	1.24	(1.11)	0.99	(0.99)	0.98	(0.99)

Ca 34	0.73	(0.86)	1.31	(1.14)	0.98	(0.99)	1.00	(1.00)
Ca 35	0.80	(0.90)	1.31	(1.14)	1.06	(1.03)	1.05	(1.02)
Ca 36	0.66	(0.81)	1.16	(1.07)	0.91	(0.95)	0.90	(0.95)
Ca 37	1.06	(1.03)	1.56	(1.25)	1.31	(1.14)	1.31	(1.14)
Ca 38	0.47	(0.70)	1.08	(1.03)	0.77	(0.88)	0.76	(0.87)
Ca 39	0.73	(0.86)	1.31	(1.14)	0.99	(0.99)	1.00	(1.00)
Ca 40	0.99	(0.99)	1.49	(1.22)	1.24	(1.11)	1.23	(1.11)
Ca 41	0.73	(0.85)	1.12	(1.05)	0.99	(0.99)	0.94	(0.97)
Ca 42	0.73	(0.85)	1.24	(1.11)	0.99	(0.99)	0.98	(0.99)
Ca 43	0.81	(0.90)	1.32	(1.15)	1.08	(1.04)	1.06	(1.03)
Ca 44	0.91	(0.95)	1.41	(1.18)	1.18	(1.08)	1.16	(1.08)
Ca 45	0.66	(0.81)	1.12	(1.05)	0.91	(0.95)	0.89	(0.94)
Ca 46	1.06	(1.03)	1.60	(1.26)	1.31	(1.14)	1.32	(1.15)
Ca 47	0.73	(0.86)	1.26	(1.12)	0.99	(0.99)	0.99	(0.99)
Ca 48	1.91	(1.38)	2.41	(1.55)	2.14	(1.46)	2.16	(1.47)
Ca 49	1.82	(1.35)	2.48	(1.57)	2.15	(1.46)	2.15	(1.47)
Ca 50	0.73	(0.80)	1.24	(1.11)	0.98	(0.99)	0.98	(0.99)
$F_{49, 98}$	7.57**		8.48**		8.88**		4.51**	
CD(0.05)	0.202		0.171		0.180		0.154	
SE	0.73		0.59		0.62		0.65	

Square root transformation
Square root transformation values in parenthesis
** Significant at 1% level

three different crop stages as well as the pooled mean of the damage measurements. Other varieties with high leaf damage intensity consistently in all the observations included Ca12, Ca13, Ca 14, Ca 48 and Ca 49.

4.3. Critical evaluation for confirmation of resistance/tolerance

For the confirmation of resistance/tolerance to chilli thrips, three accessions(Ca 13,Ca 35 and Ca 43) identified as apparently tolerant in the field screening programme including Ca 13 with the lowest number of thrips per leaf and Ca 43 with least leaf damage intensity were grown in pots along with two susceptible ones (Ca 6 and Ca 21). Thrips were collected from field and released at the rate of 50 insects per plant on fifteen days old potted plants. The population counts of thrips were made 60 days after the release of the pests following the procedure adopted in the field screening experiment. Similarly damage intensity assessment was also done and the mean values are presented in table 21.

Table 21. Number of thrips per leaf and damage intensity values of the genotypes in the confirmation trial

Sl. No	Accession	Number of thrips / leaf	Damage intensity
1	Ca13	5.41	0.81
2	Ca 35	6.14	1.20
3	Ca 43	7.75	1.08
4	Ca 6	15.55	3.16
5	Ca 21	13.93	2.50

Ca 13, Ca 35 and Ca 43 recorded considerably low number of thrips per leaf and leaf damage consequent to thrips infestation in comparison with Ca 6 and Ca 21. Thus the results of the trial confirmed the tolerance of Ca 13, Ca 35 and Ca 43 to chilli thrips observed in the field screening trial.

For confirmation of tolerance to yellow mite two apparently tolerant accessions (Ca 6 and Ca 35) along with two susceptible ones (Ca 1 and Ca 9) were subjected to critical evaluation of resistance.

The results of trial conducted for the confirmation of resistance/tolerance to yellow mite is presented in Table 22.

Table 22. Number of mites per leaf and damage intensity values of the genotypes cultivars in the confirmaion trial

Sl. No	Accession	Number of mites / leaf	Damage intensity
1	Ca6	1.80	1.31
2	Ca35	1.66	1.08
3	Ca1	11.26	2.74
4	Ca 9	9.85	1.74

The genotypes Ca 6 and Ca 35 were tolerant to mite in comparison with Ca 1 and Ca 9 as evident from the relatively low number of mites per leaf and leaf damage intensity recorded.

Discussion

5. DISCUSSION

The discussion is based on the results of the experiments conducted to study varietal variation in chilli for yield and resistance to chilli thrips and yellow mite. The experimental results are discussed under different headings.

5.1. Evaluation for yield and yield component characters

The improvement of any crop depends on altering the genetic make up of the existing varieties. The choice of the most suitable breeding method for improvement of yield and its components largely depends on the available variability, heritability of the character, genetic advance under selection and association among characters. There exists great diversity among the genotypes of chilli with respect to various characters. Genetic diversity play an important role in plant breeding because the more diverse the parents, within a reasonable range, the more would be the chances of improving the characters in question. For effective crop improvement, plant breeder requires information on certain genetic parameters like variability, heritability, genetic advance and association among characters. Selection for yield to be efficient, should take in to account yield as well as its components (Evans, 1978).

The present investigation was aimed to study the genetic parameters, degree and pattern of association among the characters and genetic diversity in chilli.

5.1.1 Variability studies

An estimate of the magnitude of variability present in a population is of great importance as it provides basis for effective selection. The observed variability in a population is the total variation arising due to genotypic and environmental effects. But only the genetic component of total variability contributes to gain under selection. So knowledge on the nature and magnitude of genetic variation governing the inheritance of quantitative characters like yield and its components is essential (Allard, 1960).

In the present investigation, analysis of variance revealed highly significant differences among the 50 genotypes of chilli for all the characters considered in the present study *viz.*, days to 50 per cent flowering, fruit bearing period, duration, primary branches per plant, secondary branches per plant, plant canopy width, plant height, number of fruits per plant, fruit length, fruit girth, fruit weight, number of seeds per fruit and yield per plant. The existence of high degree of variability for different characters in chilli was reported by several workers (Vijayalakshmi et al., 1989; Das et al. 1990; Acharya et al., 1992; Rani and singh, 1996).

There is remarkable variation in yield among the varieties evaluated. The yield per plant ranged from 74.01 to 292.88g. Ca 13 gave highest yield. Ca7, Ca18 and Ca22 were also high yielding accessions. The wide range of variation in yield per plant noticed in the present study was supported by the findings of Varalakshmi and Haribabu (1991), Acharya et al. (1992), Bhat and Shah (1996), Singh and Singh (1998), Nayeema et al. (1998), Munshi and Behera (2000) and Wasule et al.(2004).

Substantial variation in number of fruits per plant was observed in the present study, its range being 22.44 to 110.66. Ca 10 had the highest number of fruits. No other variety was on par with it. Various studies on variability in chilli emphasized the existence of high degree of variability for the character. Wide variation in number of fruits per plant observed in the present study is in line with the reports by Acharya et al. (1992), Pitchaimuthu and Pappiah (1992), Singh et al. (1994), Kataria et al. (1997), Singh and Singh (1998) Munshi and Behera (2000), Mishra et al. (2001) and Wasule et al. (2004).

The plant architecture in chilli is mainly decided by plant height, extent of branching and plant canopy width. Chilli varieties are highly variable with respect to these plant characters as evident from the findings of the present study. The range of plant height among varieties was 35.06 to 67.44 cm. Existence of high degree of variability in plant height was also reported by Pitchaimuthu and Pappiah (1992), Kataria et al. (1997) and Wasule et al. (2004). Number of primary and secondary branches was highly variable among the varieties, the range being 2.11 to 6.80 and 4.55 to 22.16 respectively. The genotype Ca10 recorded the highest number of secondary branches and had relatively larger number of primary branches also. Ca10 is identified as a profusely branching genotype. Variation in number of primary branches reported by Ibrahim et al. (2001) and Nandadevi and Hosamani (2003) is in conformity with the present findings. Variation in plant canopy width was also remarkable showing a range from 30.05 to 69.55 cm.

Earliness in flowering and maturity and compactness in fruit bearing period are desirable traits from the agronomic point of view. Hence days to 50 % flowering, duration (days) and fruit bearing period (number of days from first to last harvest) were included in this varietal evaluation programme and the range in mean values in days were 42.66 to 66.33, 122.33 to 147.33 and 51.00 to 81.66 respectively. Wide variation in days to 50 % flowering was reported by Verma et al. (1998), Devi and Arumugham (1999a) and Wasule et al. (2004). Rajputh et al. (1992) reported wide variation in fruit bearing period.

Remarkable variation in fruit characters, viz., fruit length, fruit girth, fruit weight and number of seeds per fruit was evident in the present study. Wide variation in fruit length and girth observed in the study in conformity with the reports by Vijayalakshmi et al. (1989),Acharya et al. (1992) and Wasule et al. (2004). Vijayalakshmi et al. (1989), Varalakshmi and Haribabu (1990), Pitchaimuthu and Pappiah (1992), Kataria et al.(1997), Singh et al.(1994), Singh and Singh(1998), Munshi and Behera (2000), Mishra (2001) and Wasule et al. (2004) reported considerable variation in fruit weight. Vijayalakshmi et al. (1989), Acharya et al. (1992) and Bhatt and Shah (1996) observed wide variation in number of seeds per fruit in chilli.

Variability is also expressed as coefficients of variation. Coefficients of variation, phenotypic (PCV) and genotypic (GCV) are better indices for comparison of characters with different units of measurements. The GCV provides a valid basis for comparing and assessing the range of genetic variability for quantitative characters and PCV measures the extent of total variation. There was a close relationship between genotypic and phenotypic coefficients of variation for almost all the characters (Table 5 and Fig. 1) .The similarity between phenotypic and genotypic coefficients of variation indicated low environmental influence and reflected the reliability of selection based on phenotypic performance. Pitchaimuthu and Pappiah (1992) also reported close association of the phenotypic and genotypic coefficients of variation for several characters in chilli.

In the present study, GCV ranged from 5.42 to 41.97 per cent for different characters. Highest GCV was for number of fruits per plant followed by yield per plant. Crop duration had the lowest GCV.

High GCV for number of fruits per plant in the present study is an agreement with the findings of Rani and Singh (1996), Munshi and Behera (2000), Ibrahim et al. (2001), Manju and Sreelathakumary (2004), Prabhakaran et al. (2004), and Wasule et al. (2004).

High GCV for fruit yield per plant observed in this study is conformity with the reports of Rani and Singh (1996), Ibrahim et al. (2001), Gogoi and Gautam (2002), Manju and Sreelathakumary (2002), Nandadevi and Hosamani (2003), Mini (2003), Prabhakaran et al. (2004) and Wasule et al. (2004).

High values of PCV with correspondingly high values of GCV observed in this present study for number of fruits per plant and fruit yield per plant indicated the presence of high degree of genetic variation and scope for improvement of these characters through selection. Corroborative reports on high PCV and GCV for number of fruits per plant include those of Ibrahim et al. (2001), Manju and Sreelathakumary (2002). High genotypic coefficient of variation for yield was observed by various workers (Rani and Singh,1996; Ibrahim et al. 2001; Gogoi and Gautam, 2002 and Manju and Sreelathakumary (2002).

5.1.2 Heritability and Genetic advance

Variability existing in a population is the sum total of heritable and non-heritable components. Magnitude of heritability indicates the effectiveness with which selection of genotypes can be made based on phenotypic performance (Johnson et al., 1955). Allard (1960) suggested that gain from selection for a particular character depends largely on heritability of the character. Burton (1952) opined that heritability along with GCV would provide a clear idea about the amount of genetic advance expected through selection. High values of heritability indicates that the phenotype of the trait strongly reflects the genotype and suggests the major role of genotypic constitution in the expression of the character. Such traits are considered dependable from the breeding point of view.

In the present study all the characters except days to 50% flowering showed high heritability. Heritability estimates ranged from 59.36 to 92.49 per cent.

Heritability was the highest for number of fruits per plant followed by fruit weight, fruit girth and yield per plant,

High heritability for number of fruits per plant in the present study is in agreement with the findings of Bavaji and Murthy (1982), Shah et al.(1986), Vijayalakshmi et al.(1989), Singh et al. (1994), Sreelathakumary and Rajmony (2002a) and Rathode et al. (2002).

The present study indicated high heritability for fruit length, fruit weight fruit girth and yield per plant. This is in conformity with the repots of Das and Choudhary (1999a), Manju and Sreelathakumary (2002), Sreelathakumary and Rajmony (2004a) and Wasule et al. (2004).

High values of genetic advance as percentage of mean were recorded for fruits per plant, yield per plant and fruit weight in this study. Manju and Sreelathakumary (2002), Sreelathakumary and Rajmony (2004a) also reported high genetic advance for the above characters .The present findings are supported by earlier reports of high genetic advance for number of fruits per plant (Kumar et al., 1993; Rathode et al., 2002; Wasule et al.,2004) and yield per plant (Prabhakar et al., 2004).

High heritability for the branching at primary and secondary level observed in the study is in agreement with the reports of Verma et al. (2004) and Rathode et al. (2002). On the contrary, Gogoi and Gautam (2002) reported low heritability for number of primary branches.

High heritability with high genetic advance for a character is indicative of additive gene action suggesting the possibility of genetic improvement of the character through selection (Panse, 1957). In the present study, high estimates of heritability in conjunction with high genetic advance was observed for number of fruits per plant, yield per plant, primary branches, secondary branches, fruit length and fruit weight. Similar findings were earlier reported for number of fruits per plant (Singh et al. (1981), fruit length (Meshram, 1987), fruit weight (Vijayalakshmi et al .1989), fruit yield per plant (Kumar et al.1993) and number of branches (Bavaji and Murthy, 1982).

The present findings suggested that the yield and fruit characters viz; length, girth and weight of fruits could be significantly improved through selection.

5.1.3. Correlation studies

Yield is a complex character influenced by many characters either in positive or negative direction. So selection for yield should take into account related characters as well. Correlation provides information on the nature and extent of relationship between pairs of characters. Therefore analysis of yield in terms genotypic and phenotypic correlation coefficients of component characters leads to the identification of characters that can form the basis of selection. The genotypic correlations between characters provide a reliable measure of genetic association between characters and helps to differentiate the vital association useful in breeding from non-vital ones (Falconer, 1981).

In the present investigation, fruit yield showed strong positive genotypic correlation with number of fruits per plant (r = 0.8334), duration (r = 0.5665), fruit bearing period (r = 0.5002), plant canopy width (r = 0.4039) and number of secondary branches (r = 0.4039). Other characters positively correlated with yield included plant height and days to 50 % flowering.

The positive association of fruit yield with number of fruits per plant was quite obvious from the study and is consistent with several earlier reports (Wyrzykowska et al., 2000; Mishra et al., 2001; Ibrahim et al., 2001; Nandadevi and Hosamani, 2003 and Sreelathakumary and Rajmony, 2004b).

Positive correlation of duration, days to 50 % flowering and fruit bearing period with yield per plant was noticed in the present study. Positive association of yield and duration was also reported by Nair et al. (1984) and Jose and Khader (2002). However, Gogoi and Gautam (2003) found the correlation of yield with days to 50 % flowering, duration and harvest duration to be negative, though not significant.

Plant height, canopy width and branching are plant characters that manifest vegetative growth. Present study suggested positive association of yield with plant height, number of secondary branches and canopy width. This inference is supported by corroborative reports of positive association of yield with plant height (Ramakumar et al.1981; Ali, 1994; Ahmed et al.; 1997; Ibrahim et al., 2001; Gogoi and Gautam, 2003) and number of secondary branches (Jose and Khader, 2002 Kumar et al., 2003).

The present study did not suggest any association of yield per plant with fruit characters, *viz.*, fruit length, fruit girth and fruit weight. However, this is in contrary to the reports by Sreelathakumary and Rajmony (2004b).

Positive phenotypic and genotypic correlations of fruit yield with number of fruits per plant, duration, fruit bearing period, number of secondary branches and plant canopy width imply that selection for these characters would lead to simultaneous improvement of fruit yield in chilli. High heritability of the above mentioned characters further supports this notion since for highly heritable characters, the phenotypic value of a genotype tend to reflect its genotype worth.

It is noteworthy that the environmental correlation coefficients of all the characters with fruit yield per plant were meagre. In general, the magnitudes of genotypic correlation coefficients were higher than phenotypic correlation coefficients which indicated that the environment had only small effects on the characters studied.

For selection based on yield components to be successful, knowledge of interrelationships among yield components is necessary as it gives more reliable information for effective selection.

Highly significant and positive correlation of number of primary branches with number of secondary branches, plant canopy width and number of fruits per plant was noticed in the study. This is supported by findings of Ahmed et al. (1997). Eventhough number of primary branches is not directly correlated with yield; its influence through characters associated with it appears to be considerable.

In the present study fruit girth was positively correlated with fruit length and fruit weight and negatively correlated with number of fruits per plant. This is in conformity with the findings of Kumar et al. (2003).

Scrutiny of interrelationships among characters with strong positive correlation with yield per plant indicated strong association of fruit bearing period with duration and the independence of plant canopy width and number of secondary branches. Thus it is inferred that selection for high yielding genotypes should take into account number of fruits per plant, number of secondary branches, plant canopy width and length of fruit bearing period. However the fruit characters *viz.*, length, girth and weight of fruits and number of seeds per fruit are not correlated with yield per plant. These are highly heritable characters with enormous variability and are hence amenable to worthwhile improvement through selection without compromising on yield.

5.1.4 Path Analysis

Plant breeders have to deal mostly with correlated characters during crop improvement programmes. Although correlation analysis of yield and its components is useful, it does not give an exact picture of the relative importance of the various yield attributes. Rate of improvement is expected to be rapid if differential emphasis is laid on the component characters during selection. The basis of differential emphasis could be the degree of influence of component characters on the economic character of interest. Path coefficient analysis helps in partitioning the genotypic correlation coefficients into direct and indirect effects of the component characters on yield on the basis of which improvement programme can be devised more effectively.

In the present study, number of fruits per plant had the highest direct effect on yield (0.8151) as well as the highest positive correlation (0.8384). High direct effect of number of fruits per plant on yield per plant was earlier reported by Rao and Chhonkar (1981), Chouvey et al. (1986), Korla and Rastogi (1997) and Sreelathakumary and Rajmony(2004b). The indirect effect of the character via other characters was negligible. Plant canopy width also had strong positive correlation with yield (0.4201). The character showed relatively high direct effect as well as positive indirect effect through number of fruits per plant and fruit weight. The study revealed that number of fruits per plant and plant canopy width are important in deciding yield and should be given due consideration in crop improvement programmes. A low residual effect (R=0.321) was also noticed in the present study.

5.1.5 Genetic Divergence

Breeding of crop plants adopting hybridization as a tool is one of the most important crop improvement methods. The success of hybridization programme is mainly dependent on the genetic diversity of the parents chosen for the purpose. Crosses between genetically diverse parents are likely to produce high heterotic effects. However maximum heterosis generally occurs at an optimal or intermediate level of genetic diversity. Mahalanobis D^2 stastic (Mahalanobis, 1936) is one of the potent techniques of measuring genetic divergence. This technique measures the force of differentiation at the intracluster and intercluster levels and thus provides a basis for selection of genetically divergent parents in breeding programmes.

Following Mahalanobis D^2 statistic, the 50 genotypes were grouped into eight clusters. The genotypes were grouped into eight clusters using Tocher's method of clustering. The clustering pattern is presented in Table 12.

The cluster I had the highest number of genotypes (19) followed by cluster IV (10), cluster III, cluster II and cluster V. Clusters VII and VIII had one genotype each.

The cluster means for each character is presented in Table 14. The cluster means were high in cluster VII for characters fruit bearing period, duration, number of fruits per plant, primary branches per plant, secondary branches per plant, and number of seeds per fruit. Cluster VIII had high cluster means for plant canopy width and fruit weight. Cluster mean was high for fruit girth in cluster V. Cluster III had the highest cluster mean value for fruit length, yield per plant and plant height. Cluster mean was high for days to 50 per cent flowering in cluster II. Among the thirteen characters considered, fruit yield per plant-contributed maximum towards divergence.

The cultivar Ca13 belonging to cluster III identified as the highest yielder. Hybridization of the variety with varietiey from other clusters having high number of fruits per per plant or plant canopy width would be worthwhile. The cultivars Ca 20 (Cluster VIII) and Ca10 (cluster VII) possessed the highest plant canopy width and number of fruit per plant respectively. So the use of any of these varieties as a parent in recombination breeding programme with Ca13 would be a promising proposition.

5.1.6 Selection Index

Selection of genotypes based on a suitable index is highly efficient in any breeding programme. An estimation of discriminant function based on reliable and effective characters is a valuable tool for the practical plant breeder. Superior genotypes can be selected from a collection of germplasm using a selection index employing the discriminant function.

In the present study the selection indices for the genotypes were computed on the basis of 13 characters,namely, days to 50 per cent flowering, duration, fruit bearing period, primary branches per plant, secondary branches per plant, plant canopy width, plant height, number of fruits per plant, fruit length, fruit girth, fruit weight and yield per plant.

Accordingly selection index values were worked out and presented in the Table 16. The genotype Ca13 attained the maximum selection index value followed by Ca 22 and Ca18 and the minimum estimates was recorded for Ca 27 followed by Ca 15.

The efficiency of the technique in identifying high yielding genotypes depends on the inclusion of several important yield associated characters. Accordingly Ca13 was identified as the most superior among the genotypes. Gill et.al. (1977), Singh and Singh (1977) and Sundaram et al. (1979) also used selectionm index for discrimination of chilli genotypes.

5.2 Screening for resistance to thrips and mites

The crop loss in chilli in the event of serious infestation by chilli thrips and yellow mite is tremendous. Wide spread occurrence of these sucking pests is a threat to the chilli cultivation in India. Chemical control is not advisable in view of the residual toxicity problem and consequent health hazards. Host plant resistance is an economic and eco-friendly pest control tactic.

Varieties harboring lesser pest population and/or suffering lesser leaf damage in comparison with others can be considered relatively resistant. Hence a varietal screening programme to identify chilli varieties resistant/tolerant to thrips and mites was under taken.

5.2.1 Evaluation of resistance to chilli thrips

The present study for resistance evaluation was based on population count and intensity of leaf damage consequent to chilli thrips infestation. There were significant differences among the varieties in number of thrips per leaf as well as the leaf damage intensity due to thrips infestation. The genotype that recorded the lowest number of thrips per leaf is Ca 13. The mean value of number of thrips per leaf pooled over counts at 30, 45 and 60 DAT was 3.47. The genotype recorded consistently low number of thrips per leaf in all the three counts. Ca 41 and Ca 14 also recorded low counts of thrips per leaf.Several genotypes including Ca 1, Ca 2 and Ca 35 recorded low number of thrips per leaf.

Several varieties have been found to suffer comparatively low leaf damage. Ca 36 recoded the lowest leaf damage in the damage assessments done at 30 and 45 DAT while Ca 43 was found to suffer the lowest leaf damage at 60 DAT. The pooled mean worked out taking into account damage intensity values recorded on the three different stages of the crop indicated Ca 43 as the genotype suffering lowest leaf damage. Though Ca 43 was found to suffer the lowest leaf damage, the number of thrips per leaf was significantly higher. The leaf damage due to thrips infestation was found to be low for Ca 13 and Ca 35. Considering both thrips population and leaf damage simultaneously, Ca 13 and Ca 35 were identified as the promising sources of resistance to chilli thrips. The trials conducted for the critical evaluation of resistance also confirmed the relative resistance of Ca 13 and Ca 35. The genotype Ca 13 was identified as the highest yielder in the yield evaluation trials. Hence Ca 13 is identified as a variety promising for cultivation in chilli thrips endemic areas in view of its high yielding ability and tolerance to the thrips. The genotype susceptible to chilli thrips shown in Plate 5.

5.2.2 Evaluation of resistance to yellow mite

The genotype that recorded the lowest number of mites per leaf was Ca 35, the mean value of number of mites per leaf pooled over counts at 30, 45, and 60 DAT being 1.29. The genotype also recorded consistently low number of mites per leaf in all the three counts. On the basis of population counts, Ca 35 is identified as the most tolerant genotype to yellow mite, among the 50 varieties evaluated. Several varieties have been found to show low leaf damage intensity. The genotype Ca 6 and Ca 38 recorded the lowest damage in leaf damage assessments done at 30, 45 and 60 DAT while Ca 6 was found to suffer the lowest leaf damage on 30 DAT. When the damage intensity values recorded on the three different stages of the crop were considered Ca 6 and Ca 38 suffered the least damage as evident from the lowest pooled mean value of 0.76. Ca 6 and Ca 35 were the genotype with low population count and low leaf damage due to mite infestation. Hence these varieties were identified as promising sources of resistance to yellow mite. The trials conducted for the critical evaluation of resistance also confirmed the relative resistance of Ca 35 and Ca 6.

5.2.3 Genotypes showing tolerant to both chilli thrips and yellow mite

Ca 35 was the only genotype that showed tolerance to both chilli thrips and yellow mite. The yielding potential of this genotype is however comparatively low. This suggested that the genotype would be useful as a source of resistance to chilli thrips and yellow mite in combination breeding programmes for developing high yielding varieties tolerant to these pests.

Plate 3. A high yielding genotype tolerant to chilli thrips (c_a 13)

Plate 4. A genotype tolerant to chilli thrips and yellow mite (c_a*35)*

Plate 5. A genotype susceptible to chilli thrips (c_a6)

Plate 6. A genotype susceptible to yellow mite (c_a1)

Summary

6.SUMMARY

The present study was undertaken to estimate the genetic variability in a collection of chilli (*Capsicum annuum* L.) genotypes for yield and resistance to chilli thrips and yellow mite and to identify high yielding types tolerant to these pests. The research work was carried out in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 2006-2007.The data for investigation were collected from two field experiments and a pot culture experiment. The objective of first field experiment was to evaluate 50 genotypes of chilli collected from different sources for yield and component characters and the second one aimed at screening of these genotypes for resistance to chilli thrips and yellow mite. The accessions identified as relatively tolerant in the initial screening trial were further evaluated for confirmation of resistance/tolerance to the pests adopting a pot culture experiment.

Fifty genotypes of chilli varieties collected from different sources which included improved varieties and local cultivars were evaluated for yield and yield components in a field experiment in randomised block design with three replications. Observations were recorded on 13 characters *viz.,* days to 50% flowering, fruit bearing period, duration, primary branches per plant, secondary branches per plant, plant canopy width, number of fruits per plant, fruit length, fruit girth, fruit weight, number of seeds per fruit and yield per plant.

Significant differences existed among genotypes for all the characters as revealed by the analysis of variance. The variety Ca 13 recorded the highest yield per plant (292.88g). Ca 15 was the lowest yielder (74.01g). Ca 10 recorded the highest number of fruits per plant (110.66). The variety Ca 20 recorded maximum plant canopy width (69.55cm).

High phenotypic coefficient of variation with correspondingly high genotypic coefficient of variation was observed for number of fruits per plant, fruit yield per plant, secondary branches per plant and primary branches per plant. This indicated the existence of high degree of genetic variation and scope for improvement of these characters through selection.

All the characters considered except days to 50% flowering recorded high estimates of heritability. High heritability coupled with high genetic advance was

observed for number of fruits per plant, yield per plant and secondary branches per plant. There is immense scope for improvement of these characters through selection on account of their high magnitude of heritability and exceptionally high genetic advance.

Fruit yield per plant showed high positive genotypic correlation with number of fruits per plant, duration, length of fruit bearing period, plant canopy width and number of secondary branches. The highest genotypic correlation of yield was with number of fruits per plant.

Path analysis revealed that number of fruits per plant had the highest direct effect on yield. The indirect effect of the character via other characters was negligible. Plant canopy width also showed relatively high direct effect as well as positive indirect effect through number of fruits per plant and fruit weight. The study revealed that number of fruits per plant and plant canopy width are important in deciding yield and should be given due in consideration in crop improvement programmes.

Genetic diversity studies using Mahalanobis D^2 statistic indicated considerable diversity among the 50 varieties of chilli. The genotypes were grouped into eight clusters. Clustering pattern indicated that cluster I is having maximum number of genotypes (19) followed by cluster IV (10). Five genotypes each were present in clusters II and V. Cluster III had three genotypes. Clusters VII and VIII were single genotype clusters. Maximum divergence was observed between clusters III and VI, while it was minimum between clusters I and IV. The intracluster distance was the highest for cluster I.

Selection indices of the 50 genotypes for yield were worked out using yield per plant and component characters viz., days to 50% flowering, fruit bearing period, duration, primary branches per plant, secondary branches per plant, plant canopy width, number of fruits per plant, fruit length, fruit girth, fruit weight and number of seeds per fruit. Maximum index value was obtained for Ca 13 followed by Ca 22 and Ca 18. Low index values were recorded for Ca 27 and Ca 15.

In the field screening programme for resistance to chilli thrips and yellow mite all the 50 genotypes were included. Resistance evaluation was based on the population count and intensity of leaf damage. The genotype that recorded the lowest number of thrips per leaf is Ca 13. Lowest leaf damage intensity was observed for Ca 43. When population and leaf damage were simultaneously considered, Ca13 and Ca 35 were found to be tolerant to chilli thrips. These varieties are thus identified as promising sources of resistance to chilli thrips. Ca 35 was identified as the variety harbouring the lowest number of yellow mites. Leaf damage due to the mite was low for Ca 6. In view of the relatively low population count and leaf damage, Ca 6 and Ca 35 were identified as genotypes tolerant to yellow mite which can hopefully serve as sources of resistance to the pest. Ca 35 was the only genotype that showed tolerance to both chilli thrips and yellow mite. The critical evaluation for resistance to these pests also confirmed the tolerance of Ca 35 to both of these pests. The study identified Ca 13 as a genotype with high yield potential and tolerance to chilli thrips.

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* Original not seen

GENETIC VARIABILITY FOR YIELD AND RESISTANCE TO CHILLI THRIPS (*Scirtothrips dorsalis* H.) AND YELLOW MITE (*Polyphagotarsonemus latus* Banks) IN CHILLI (*Capsicum annuum* L.)

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Abstract of the
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ABSTRACT

The present study aimed at evaluating a collection of chilli (*Capsicum annuum* L.) genotypes for yield and resistance to chilli thrips and yellow mite was carried out in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 2006-2007.

Fifty genotypes of chilli were evaluated for yield and yield components in a field experiment in randomized block design with three replications. Observations were recorded on 13 characters *viz.,* days to 50% flowering, fruit bearing period, duration, primary branches per plant, secondary branches per plant, plant canopy width, number of fruits per plant, fruit length, fruit girth, fruit weight, number of seeds per fruit and yield per plant. Significant differences existed among genotypes for all the characters as revealed by the analysis of variance. The variety Ca 13 recorded the highest yield per plant (292.88g). Ca 15 was the lowest yielder (74.01g). Ca 10 recorded the highest number of fruits per plant (110.66). The variety Ca 20 recorded maximum plant canopy width (69.55cm).

High phenotypic coefficient of variation with correspondingly high genotypic coefficient of variation was observed for number of fruits per plant, fruit yield per plant, secondary branches per plant and primary branches per plant. This indicated the existence of high degree of genetic variation and scope for improvement of these characters through selection.

All the characters considered except days to 50% flowering recorded high estimates of heritability. High heritability coupled with high genetic advance was observed for number of fruits per plant, yield per plant and secondary branches per plant. There is immense scope for improvement of these characters through selection on account of their high magnitude of heritability and exceptionally high genetic advance.

Fruit yield per plant showed high positive genotypic correlation with number of fruits per plant, duration, length of fruit bearing period, plant canopy width and number of secondary branches. The highest genotypic correlation of yield was with number of fruits per plant.

Path analysis revealed that number of fruits per plant had the highest direct effect on yield. The indirect effect of the character via other characters was negligible. Plant canopy width also showed relatively high direct effect as well as positive indirect effect through number of fruits per plant and fruit weight. The study revealed that number of fruits per plant and plant canopy width are important in deciding yield and should be given due consideration in crop improvement programmes.

Genetic diversity studies using Mahalanobis D^2 statistic indicated considerable diversity among the 50 genotypes of chilli. The genotypes were grouped into eight clusters. Clustering pattern indicated that cluster I is having maximum number of genotypes. Maximum divergence was observed between clusters III and VI. The intracluster distance was the highest for cluster I.

Selection indices of the 50 genotypes for yield were worked out using yield per plant and component characters viz., days to 50% flowering, fruit bearing period, duration, primary branches per plant, secondary branches per plant, plant canopy width, number of fruits per plant, fruit length, fruit girth, fruit weight and number of seeds per fruit. Maximum index value was obtained for Ca 13 followed by Ca 22 and Ca 18. Low index values were recorded for Ca 27 and Ca 15.

Evaluation of the genotypes for resistance to chilli thrips and yellow mite was done to identify sources of resistance. Population count and leaf damage intensity were the criteria adopted for evaluation of resistance. The genotype that recorded the lowest number of thrips per leaf is Ca 13. Lowest leaf damage intensity was observed for Ca 43. Simultaneous consideration of population count and damage intensity suggested tolerance of Ca13 and Ca 35 to chilli thrips. These varieties are thus identified as promising sources of resistance to chilli thrips. Ca 35 was identified as the variety harbouring the lowest number of yellow mites. Leaf damage due to the mite was low for Ca 6. In view of the relatively low population count and leaf damage, Ca 6 and Ca 35 were identified as genotypes tolerant to yellow mite which can hopefully serve as sources of resistance to the pest. Ca 35 was the only genotype that showed resistance to both chilli thrips and yellow mite. The critical evaluation of the genotypes for tolerance to the pests also confirmed the tolerance of Ca 35 to both of these pests. The study identified Ca 13 as a genotype with high yield potential and tolerance to chilli thrips.