GENETIC EVALUATION OF YIELD AND ANTHRACNOSE RESISTANCE IN THE SEGREGATING GENERATION OF THREE WAY CROSS HYBRIDS IN CHILLI (*Capsicum annuum* L.)

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DECLARATION

I hereby declare that this thesis entitled **"Genetic evaluation of yield and anthracnose resistance in the segregating generation of three way cross hybrids 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 evaluation of yield and anthracnose resistance in the segregating generation of three way cross hybrids in chilli (*Capsicum annuum* L.)"** is a record of research work done independently by Ms. Vineetha. G (2011-11-162) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associate ship to her.

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Every word of truth

Dedicated forever

at the Lotus feet of

My parents, guide and

Beloved God

CERTIFICATE

We the undersigned members of the advisory committee of Ms. Vineetha.G (2011-11-162) a candidate for the degree of Master of Science in Agriculture agree that this thesis entitled **"Genetic evaluation of yield and anthracnose resistance in the segregating generation of three way cross hybrids in chilli (*Capsicum annuum* L.)"** may be submitted by Ms. Vineetha. G (2011-11-162), in partial fulfillment of the requirement for the degree.

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INDEX

LIST OF TABLES

LIST OF TABLES CONTINUED

LIST OF TABLES CONTINUED

LIST OF FIGURES

LIST OF FIGURES CONTINUED

LIST OF PLATES

Introduction

INTRODUCTION

Chilli is an important spice and vegetable crop of India. It is also an indispensable condiment of every Indian cusine. Apart from being a source of flavor and colour, 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 to a lesser degree the nutritive value (Bosland, 1993). The active principle of pungency in chilli is capsaicin, which is a mixture of 20 capsacinoids. 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 preparations for uniform quality, longer shelf life, taste and flavor. Oleoresin consists of fixed oil, capsaicin, pigments, sugars and resin. It is extracted from milled chillies using organic solvents.

Chilli belongs to the genus *Capsicum* (Family Solanaceae). Chillies are known as capsicum, paprika, pimento, sweet pepper, hot pepper, red pepper and bird pepper. Five species of *Capsicum* are under cultivation, but in India only two species viz., *Capsicum annuum*.L and *C. frutescens* are well known and most of the cultivated varieties belong to the species *C. annuum.*

India accounts for 1.2 million tons of production annually and is the largest producer in terms of international trade, exporting 25 per cent of its total production (FAO, 2003). However, the average productivity of chilli is low (1 ton/ha) as compared to China, Taiwan and Mexico where it yields 3 tons/ha of dry chilli (Peter, 1998). The main reason for the low productivity in India is the cultivation of open pollinated varieties which do not have the genetic capacity to break the yield barriers (Kaur *et al*, 2011). Moreover, the local cultivars are prone to various diseases which account for significant reduction in productivity. Chilli anthracnose, the most important fungal disease, drastically reduces yield, deteriorates the quality of fruit, and hence gives low returns to the farmers. It has been reported that pre-harvest and post-harvest losses account for more than 50 percent in severe cases of anthracnose (Pakdeevaraporn *et al.*, 2005). Many studies have indicated that disease management practices are often inadequate to control the diseases. Moreover, pesticide residue has become the major constraint in an approach to meet the stringent requirements of the importing countries. Hence, most economical way to minimize the crop losses is to cultivate resistant varieties/hybrids.

Breeding varieties have been predominantly based on single crosses where the yield levels of many crops have been improved but the rate of improvement can be accelerated through multiple crosses also. The obvious choice next to single cross is the three way crosses (Vindhiyavarman, 1997). The information on gene action is very essential for deciding the effective selection method in segregating generations. From the triallel analysis of yield and resistance to anthracnose in chilli conducted as a PG project in the department of Plant Breeding and Genetics, College of Agriculture, Vellayani, eight promising three way cross hybrids were obtained with regard to fruit yield, yield attributes and resistance to anthracnose (Haridass, 2007). These can be subjected to selection of superior types in the segregating generations to obtain stable varieties.

In the light of these facts, the present investigation was undertaken with the following objectives

- To identify high yielding anthracnose resistant types through evaluation from among the segregating generation of three way cross hybrids
- To study the performance of different families and the progenies within each family by using compact family block design

Review of Literature

2. REVIEW OF LITERATURE

The literature available on various aspects of the present investigation "Genetic evaluation of yield and anthracnose resistance in the segregating generation (F_4) of three way cross hybrids in chilli" is reviewed hereunder.

2.1 ORIGIN AND DISTRIBUTION

Capsicum is believed to be of new world origin. Mexico is the centre of diversity of *C. annuum* while Guatemala is the secondary centre. The genus *Capsicum* is clearly of South American origin. Columbus in 1493 introduced capsicum into Spain. By the year 1545, cultivation of capsicum spread from the Mediterranean area to England. It reached Central Europe by the end of 16^{th} century. It was the Portuguese who brought capsicum to India from Brazil prior to 1585 for cultivation.

If the genus *Capsicum* is accepted to contain only the pungent taxa, then a clear centre of diversity is to be found ranging from southern Brazil to Bolivia (McLeod *et al.*, 1982; Eshbaugh *et al.*, 1983 and Pickersgill, 1984). If the genus is reconstituted to include other non-pungent taxa, another centre of diversity may be recognized in Central America and Southern Mexico. Ultimately, the definition of the genus *Capsicum* and what species it includes will determine the view of its centre of origin and whether the genus is monophyletic or polyphyletic.

McLeod *et al.*, (1982) have speculatively hypothesized that Bolivia is a nuclear centre of the genus *Capsicum* and that the origin of the domesticated taxa can ultimately be traced back to this area. But this does not imply that each of the domesticated species arose in Bolivia. Clearly, evidence supports a Mexican origin of *C. annuum* while the other domesticated species arose in South America.

Evidence suggests that *C. annuum* originally occurred in Northern Latin America and *C. chinense* in tropical Northern Amazonia

(Pickersgill, 1971). *C. pubescens* and *C. baccatum* appear to be more prevalent in lower South America.

2.2 TAXONOMY

One of the perplexing questions regarding the taxonomy of *Capsicum* is defining the genus. What taxa are ultimately included in *Capsicum* may change if the concept of the genus is broadened to include taxa with non-pungent fruits but with other common morphological and anatomical traits such as the nature of the anther, the structure of nectaries and the presence of giant cells on the inner surface of the fruit (Pickersgill, 1984).

Early works on the taxonomy of the genus *Capsicum* resulted in more than 100 species and botanical varieties. It belongs to the family Solanaceae. In the first edition of 'Species Plantarum', which appeared in 1753, Linnaeus recorded two species of *Capsicum*. Later in 1797, three additional species were added. The five species were *C. anomalum;* *C. pubescens* Ruiz and Pavan; *C. pendulum Willd; C. frutescens L. and C. annuum L; C. annuum and C. frutescens* are the most commonly cultivated types. Recognizing the extent of variability, modern taxonomists have divided *Capsicum* into the following five species.

C. annuum L.:syn. C. purpureum, C. grossum, C. cerasiformae,

C. frutescens L.: syn. C. minimum

C. chinense Jacq.:syn. C. luteum, C. umbilicatum, C. sinense

C. baccatum L.:syn. C. pendulum, C. microcarpum;, C. angulosum

C. pubescens R. and P.

2.3 REPRODUCTIVE BIOLOGY

Both self and cross pollination take place in chilli. Flower opening and anther dehiscence to a large extent depend on the weather conditions. Flower opening in chilli takes place between 5 and 6 AM. Flower remains open for 2 to 3 days. Anther dehiscence takes place from

9 to 11 AM. Maximum fruit setting occurs when pollination is done at the time of opening of flower (Padda and Singh, 1971). Bees and thrips are the pollinating agents.

2.4 GENETIC VARIABILITY

Forty-five genotypes were studied by Singh and Singh (1976) who found high variability for plant height, days to flowering, days to maturity, number of branches, fruit length, fruit thickness, number of fruits per plant and yield per plant.

Arya and Saini (1977) reported high phenotypic and genotypic variances for fruit yield per plant, number of seeds per fruit, number of fruits per plant, fruit size per plant and plant height. Hiremath and Mathapati (1977) evaluated 36 genotypes of chilli and found high phenotypic variance for yield and number of fruits per plant. Elangovan *et al.* (1981) evaluated 30 cultivars of chilli and obtained high phenotypic and genotypic variances for plant height, plant spread, number of seeds per fruit and number of fruits per plant. In a study using 12 varieties of chilli, Ramakumar *et al.* (1981) found high variability for plant height, plant spread, fruit girth, number of seeds per fruit, number of fruits per plant and yield. Twelve cultivars were evaluated by Rajput *et al.* (1981), found wide variation for dry chilli yield and fruiting period. High variability for number of primary and secondary branches, life span and number of seeds has been reported by Nair *et al.* (1984) in a study using 30 genotypes.

Ado *et al.* (1987) studied 16 cultivars and found the characters fruits per plant, branches per plant and fruit weight to be the most variable. Bai *et al.* (1987) reported high variability for fresh fruit yield per plant and low variability for branches per plant and percentage of fruit setting. Gopalakrishnan *et al.* (1987) found high variability for number of primary branches, number of secondary branches, life span and number of seeds in a study involving 38 chilli cultivars.

Adamu and Ado (1988) found high variability for fruits per plant, individual fruit weight and fresh fruit yield per plant in *C. annuum* and *C. frutescens*. Vijayalakshmi *et al.* (1989) reported high genotypic and phenotypic variances for number of flowers, plant height and spread and low genotypic and phenotypic variances for number of primary branches, average fruit weight, fruit length and fruit girth.

In a study using 64 chilli genotypes, Ahmed *et al.* (1990) obtained low range of variability for days to first fruiting, plant height and plant spread. Das *et al.* (1990) observed significant differences among 30 chilli cultivars for six components of fruit yield.

Sahoo *et al.* (1990) studied F_2 progenies of 45 inter varietal crosses and found high variability for seeds per fruit, dry yield per plant, fruits per plant and plant spread. High variability for fruits per plant, yield per plant, fruit length and seeds per fruit was reported by Acharya *et al.* (1992) in a study using 19 chilli cultivars.

Pichaimuthu and Pappiah (1992) found very high variability for number of fruits, fresh and dry fruit weight and plant height in a study involving 14 F_6 families produced from the F_5 generation of the cross ACC 1683 x K2. Singh *et al.* (1994) studied 20 genotypes and found high variability for weight of fresh red ripe fruits per plant.

High variability for all the characters studied especially for fruit yield in 71 chilli genotypes was reported by Nayeema *et al.* (1998). Verma *et al.* (1998) evaluated 119 accessions of chilli and found high degree of variability for plant height, density of branches, days to 50 per cent flowering, number of fruits per plant, fruit length, fruit width, green fruit weight per ten fruits and fruit dry weight per ten fruits.

In a study using 25 genotypes, Das and Chaudhary (1999) reported high phenotypic and genotypic variances for fruit length. Devi and Arumugam (1999) reported moderate variation for plant height, days to first flowering and dry fruit yield per plant and high variation for yield of fresh fruits per plant. Dwivedi and Bhandari (1999) reported high variability for number of seeds per fruit, 1000-seed weight and days to maturity in a study involving 160 sweet pepper lines. High variability for fruit yield has been reported by Jabeen *et al.* (1999) in a study involving 71 cultivars of chilli.

Munshi and Behera (2000) in a study involving 30 genotypes of chilli, found the existence of considerable genetic variability for all the characters studied except fruit girth. Rathod *et al.* (2002) in an analysis of variance of eight yield components in 13 chilli cultivars, found considerable variability among various components.

Acharyya *et al.* (2002), Nandadevi and Hosamani (2003) Prabhudeva (2003) also reported wide range of variation for most of the characters studied in chilli. Ukkund *et al* (2007) reported high range of variation for all the characters observed and was maximum in case of total green chilli yield per plant and minimum for the fruit girth.

Gupta *et al.* (2009) observed wide range of variation for the characters, day to 50% fruits harvest, fruit length, fruit breadth, and number of fruits per plant, fruit weight, fruit yield /plant, plant height, number of branches / plant, capsaicin content and oleoresin content. Singh and Singh (2011) reported high range of variability for number of fruits/plant, weight of fruits per plant and fruit yield.

2.5 COEFFICIENT OF VARIATION

Arya and Saini (1976) studied seven bell pepper cultivars and reported high phenotypic (PCV) and genotypic coefficients of variation (GCV) for number of fruits per plant, fruit size and fruit yield per plant. Arya and Saini (1977) found that GCV ranged from 12.04 for days to flower to 223.33 for rind thickness in chilli. In a study involving 36 cultivars of chilli, Hiremath and Mathapati (1977) found high coefficient of variation for number of branches and number of seeds per fruit.

Singh and Brar (1979) studied variability in 31 varieties of sweet pepper and reported high phenotypic and genotypic coefficients of variation for number of fruits and fruit yield. Rajput *et al.* (1981) observed similar results for fruits per plant and fruit yield of chilli.

In a study on 45 F_1 and F_2 hybrids from a 10 x 10 diallel cross, Rao and Chhonkar (1981) observed low to medium phenotypic and genotypic coefficients of variation for several characters. Nair *et al.* (1984) found high GCV among 25 cultivars for number of fruits (121.28), weight of fruit and total yield. Gopalakrishnan *et al.* (1985) observed great difference between PCV and GCV for number of branches per plant indicating greater influence of environment.

Number of fruits per plant is the most important yield attributing character in capsicum. High amount of heritability was noticed by several workers (Achalshah *et al.*, 1986; Amarchandra *et al.*, 1990; Rani *et al.*, 1996; Kataria *et al.*, 1997; Munshi and Behera, 2000 and Verma *et al.*, 2004). High GCV for fruit length (42.17), main stem length (44.61), fruit weight (29.70), fruits per plant (35.28) and fruit yield per plant (32.31) was reported by Gopalakrishnan *et al.* (1987) in a study involving 38 lines of chilli. In a study on F_2 generation of an inter-varietal cross, Ghai and Thakur (1987) found GCV to be ranging from 8.24 for number of fruits to 41.27 for fruit weight per plant and reported low PCV and GCV for fruit yield per plant

Sahoo *et al.* (1989) reported high values for GCV for dry yield per plant, plant spread, number of fruits per plant, weight of ten dry fruits and seed number per fruit in 45 crosses of a 10 x 10 diallel. Greater differences between PCV and GCV for plant height, plant spread, number of flowers, number of pods, total yield and total dry pod yield were reported by Vijayalakshmi *et al.* (1989).

High GCV and PCV values were observed for yield by Ahmed *et al.* (1990), Varalakshmi and Haribabu (1991)and Jabeen *et al.* (1999) and for length of fruit also by Nandi (1993), Sharma and Roy (1995), Rani *et al.* (1996), Kataria *et al.* (1997), Choudhary and Das (1998), Sreelathakumary and Rajamony (2002), but extreme low variability for fruit yield per plant and length of fruit was reported by Ghai and Thakur (1987) and Basavaraj (1997).

Ram and Lal (1992) reported very low PCV, GCV, heritability and Genetic advance as percentage of mean for plant height. Pichaimuthu and Pappiah (1992) found close association between the estimates of PCV and GCV for several characters in F_6 generation indicating low influence of environment. High GCV and PCV were observed for fruit length by Choudhary and Das (1998) and Sreelathakumary and Rajamony (2002). Low variability for fruit length was reported by Basavaraj (1997).

Devi and Arumugam (1999) found moderate values of PCV and GCV for all the characters studied in F_2 generation, except days to first flower, dry fruit yield per plant and fruit girth for which it was low. Chaim and Paran (2000) in a study on intra specific cross between a bell type 'Major' and small-fruited pungent chilli line 'Perennial' found low GCV for plant height, moderate GCV for fruit length and high GCV for fruit weight and fruit diameter.

In a study with 30 chilli genotypes, Munshi and Behera (2000) obtained GCV ranging from 5.32 per cent for days to first fruit harvest to 54.94 per cent for number of fruits per plant. High degree of PCV and GCV were observed for number of primary branches, fruit length, pericarp thickness, number of fruits per plant and green fruit yield per plant by Nandadevi and Hosamani (2003). Rao (2005) reported moderate values of GCV and PCV for fruit characters such as in Byadagi selections. Giritammanavar (1995) reported a moderate phenotypic and genotypic coefficient of variation in paprika for primary branches. Rao (2005) observed a low range of variation in primary branches in Byadagi genotypes. Smitha and Basavaraj (2006), Sharma *et al.* (2009) and Singh and Singh (2011) reported high values of phenotypic and genotypic coefficients of variation in chilli for primary branches.

Gupta *et al.* (2009) observed highest phenotypic coefficient of variation for the traits incidence of virus, followed by number of fruits/ plant , fruit yield/ plant, fruit weight, fruit length and capsaicin content. Low phenotypic and genotypic coefficients of variation were reported for days to flowering in paprika by Giritammanavar (1995), Bini (2004), Rao (2005) and Sandeep (2007). Kumari *et al.* (2010) reported low values of 8.20 and 8.37 for genotypic and phenotypic coefficients of variation for days to flowering in paprika.

Singh and Singh (2011) reported that high PCV and GCV for three traits *viz.,* number of fruits per plant, weight of fruits per plant and red ripen fruit yield. Moderate PCV and GCV were recorded for plant height and fruit length, where as moderate to low PCV and GCV was observed in number of primary branches/plant.

2.6 HERITABILITY AND GENETIC ADVANCE

In a 10 x 10 diallel, Rao and Chhonkar (1981) found high heritability for number of branches, fruit length, fruit girth, seed content, fruits per plant, fruit yield per plant and fruit weight. Singh *et al.* (1981) studied 35 chilli genotypes and noticed high heritability for mean weight per fruit, fruits per plant and fresh fruit weight per plant. In a study involving 25 genotypes of chilli, Bavaji and Murthy (1982) found high heritability coupled with high genetic advance for number of branches per plant, fruit length, 50 fruit weight and fruits per plant. High heritability with low genetic advance was reported for days to flowering, plant height, plant spread, number of primary branches and life span by Nair *et al.* (1984).

Chaudhary *et al.* (1985) studied 30 chilli lines and found a wide range of heritability from 27.81 per cent (fruit girth) to 99.86 per cent (number of seeds per fruit) and genetic advance from 0.33 (fruit girth) to 98.99 (yield per plant). Shah *et al.* (1986) found high heritability and expected genetic advance for plant height, number of primary branches, fruit length, fruit width and number of fruits per plant in a study using 12 chilli varieties while Singh and Rai (1981) reported low genetic advance for number of fruit per plant. In a population of parents, F_1s, F_2s and backcrosses, Ghai and Thakur (1987) found number of fruits and total yield to possess the lowest values of heritability in narrow sense. The expected genetic advance showed a wide range from 8.82 per cent for number of fruits per plant to 73.81 per cent for fruit weight. High heritability and high expected genetic advance for fruit length and days to first flowering were reported by Meshram (1987).

High heritability and genetic advance were reported for yield per plant, number of fruits per plant and weight of 10 dry fruits by Sahoo *et al.* (1989) and Bhagyalakshmi *et al.* (1990). Varalakshmi and Haribabu (1991) and Kumar *et al.* (1993) found high heritability and genetic advance for fruits per plant and number of seeds per fruit. Singh *et al.* (1994) observed high heritability for fruit length and fruit diameter in a study on 20 chilli varieties. High genetic advance has been reported for fruit yield per plant by Nandi (1993), Sharma and Roy (1995), Rani *et al.* (1996), Warade *et al.* (1996), Kataria *et al.* (1997) and Sreelathakumary and Rajamony (2002). While evaluating 14 F_6 families from the cross AC.1683 x K2, Pichaimuthu and Pappiah (1995) found high heritability and high genetic advance for fruit length, fruit girth and number of fruits per plant.

In a study involving 50 *C. annuum* and *C. frutescens* cultivars, Bhatt and Shah (1996) obtained high heritability and genetic advance for average fruit weight and fruit diameter. High heritability and genetic advance for fruits per plant, fruit weight and length and circumference of fruits has been reported by Ghildiyal *et al.* (1996) in a study involving 24 cultivars. Rani *et al.* (1996) found high heritability coupled with high genetic advance for yield per plant, number of fruits per plant, mean fruit weight and dry matter production. High heritability and genetic advance for fruit length has been reported by Rani and Singh (1996).

Nayeema *et al.* (1998) found high heritability coupled with high genetic advance for fruit yield per plant, number of seeds per fruit, pericarp thickness and average fruit weight. In a study involving 30 genotypes, Das and Chaudhary (1999) found the highest estimates of heritability and genetic advance for yield per plant. Devi and Arumugam (1999) and Jabeen *et al.* (1999) found high heritability and genetic advance for fruit yield per plant, fruit number per plant, seed number per fruit and pericarp thickness.

Chaim and Paran (2000) observed that days to first ripened fruit and total soluble solids had low (narrow sense) heritability, whereas nine other traits studied had moderate to high values. High heritability (broad sense) values for fruit weight, fruit diameter, fruit length and pericarp thickness and low heritability for plant height was also reported. Munshi and Behera (2000) and Sreelathakumary and Rajamony (2002) reported high estimates of heritability and genetic advance for fruit length and number of fruits per plant. These characters could be effectively improved through selection. This could be treated as an indication of additive gene action and the consequent high expected genetic gain for selection from these characters.

Ibrahim *et al.* (2001) observed that the highest heritability was exhibited for plant height followed by fruit length and number of fruits per plant. High heritability coupled with high genetic advance for total yield per plant was reported by Acharyya *et al.* (2002). Rathod *et al.* (2002) found high heritability for days to fifty per cent flowering, plant height, number of primary branches, number of fruits per plant, fruit length, fruit diameter, 100 seed weight, harvest index and fresh red chilli yield per plant. High heritability coupled with high genetic advance was found for number of fruits per plant, fresh red chilli yield per plant and plant height. Sreelathakumary and Rajamony (2002) reported high heritability and genetic advance for number of fruits per plant, fruit weight, fruit length, fruit girth, fruit yield and leaf area.

In a study involving 26 genotypes of chilli, Nandadevi and Hosamani (2003) found high heritability coupled with high genetic advance for fruit length and green fruit yield per plant. Giritammanavar (1995) and Rao (2005) recorded a low heritability and genetic advance for primary branches per plant in paprika whereas high values of heritability coupled with high genetic advance as percentage of mean were obtained for primary branches per plant in chilli (Farhad *et al.*, 2008). Choudhary and Samadia (2004) and Chatterjee (2006) reported high heritability coupled with high genetic advance for days to maturity in chilli.

Genetic variability, heritability, and genetic advance as a percent over mean for twelve characters were assessed by field evaluation of 80 chilli accessions. High estimates of heritability was found for plant height, days to first flowering, per cent fruit set, number of fruits per plant, fruit length and total green fruits per plant by Ukkund *et al.* (2007).

Fruit weight exhibited high heritability coupled with high genetic advance as reported by Bini (2004) and Sarkar *et al.* (2009). Gupta *et al.* (2009) reported high heritability estimates coupled with high expected genetic advance as per cent of mean were observed for number of fruits per plant, fruit yield per plant, fruit length, fruit weight and capsaicin content. Sharma *et al.* (2009) reported high heritability and high genetic advance for average fruit weight, fruit yield per plant, fruit diameter, number of lobes per fruit, days to first harvest, leaf area and ascorbic acid content. Kumari *et al.* (2010) observed high heritability coupled with low genetic advance for days to maturity and high heritability coupled with high genetic advance for fruit weight in paprika.

High value of heritability coupled with high genetic advance was observed for fruits per plant and yield per plant by Bini (2004), Sandeep

(2007), Patil (2007), Ukkund *et al.* (2007), Patel *et al.* (2009), Kumari *et al.* (2010) and Sood *et al.* (2011).

2.7 CORRELATION

Pandian and Sivasubramanian (1978) reported that the total number of fruits harvested per plant had significant positive association with flowers produced during 66 to 86 days. Positive correlation between yield and days to flowering has been reported by Sundaram and Ranganathan (1978).

Several investigators reported positive association of fruit weight and plant height with yield (Depestre *et al.*, 1981, 1989; Khadi, 1983; Warade *et al.*, 1996; Mishra *et al.*, 1998; Nazir *et al.*, 2005; Smitha, 2005; Ibrahim *et al.*, 2001; Mubarak, 2002;Sonia *et al.*, 2006 and Sonia *et al.*, 2007) whereas Pawade *et al.* (1995); Basavaraja (1997) and Arya and Saini (1976) reported negative correlation for the same characters. Rao *et al.* (1981) found yield to be negatively correlated with days to flowering. Bavaji and Murty (1982) found significant positive association of number of fruits and number of branches with yield.

Chaudhary *et al.* (1985) reported positive correlation of yield per plant with fruit girth and weight of ten fruits, which was positively associated with number of seeds per fruit. Gopalakrishnan *et al.* (1985) reported negative correlation of fruit girth with fruit yield per plant and positive correlation of fruit length with yield. Yield was found to be significantly associated with fruit length, number of branches, number of fruits and plant spread in a study conducted by Ghai and Thakur (1987). Jayasankar *et al.* (1987) suggested that number of primary branches, fruit length, fruit girth and number of seeds per fruit could be considered as secondary yield determinants owing to their loose association with yield. Fourteen parents and 24 F_1s were studied by Kaul and Sharma (1989) and reported a positive association of fruit yield with plant height, number of branches per plant, number of seeds per fruit and dry matter of fruit.

Bhagyalakshmi *et al.* (1990) reported negative correlation of yield with days to 50 per cent flowering and days taken for fruit set. In a study involving 30 chilli genotypes, Das *et al.* (1990) found that yield per plant was positively correlated with number of primary and secondary branches per plant and number of seeds per fruit. Rani (1995) observed plant height, plant spread, number of primary branches per plant and number of secondary branches per plant to show significant positive correlation with yield. Positive association of yield and number of fruits per plant was reported by Pawade *et al.* (1995), Basavaraja (1997), Chang (1977), Depestre *et al.* (1981), Ibrahim *et al.* (2001), Mubarak (2002), Sonia *et al.* (2007) and Smitha and Basavaraja (2006)

Fruit length showed positive association with number of fruits per plant (Pawade *et al.*, 1995 and Akhilesh *et al.*, 2001). However, negative association was also reported for the same trait by Basavaraja (1997), Ibrahim *et al.* (2001), and Smitha (2005). Pawade *et al.* (1995) reported positive association of number of fruits per plant with fruit weight, whereas negative association for the same trait was reported by Depestre *et al.* (1989), Basavaraja (1997), Mubarak (2002), Akhilesh *et al.* (2001) and Smitha (2005). Rani (1996) observed positive correlation between fruit seed weight and fruit seed number in chilli.

Ahmed *et al.* (1997b) reported that significant positive correlation existed between fruit number and branch number per plant, plant height and plant spread, plant height and fruit size, plant spread and fruit length, plant spread and average fruit weight, fruit length and fruit thickness, fruit length and average fruit weight, fruit thickness and average fruit weight and fruit thickness and pericarp thickness. In a study involving 25 chilli genotypes, Das and Chaudhary (1999) found yield to show positive correlation with fruit weight, fruits per plant and primary branches per plant. In an F_2 population, Subashri and Natarajan (1999) found positive association of yield with branches per plant, fruits per plant, fruit weight and fruit length.

Aliyu *et al.* (2000) reported significant positive correlation of fruit yield per plant with plant height, fruit number per plant and canopy width. Chaim and Paran (2000) found high genotypic correlation between fruit weight and three characters, fruit diameter, pericarp thickness and pedicel diameter. But fruit weight had a low correlation coefficient with fruit length. Significant negative correlation between capsaicin content and yield was reported by Kohli and Chatterjee (2000). Munshi *et al.* (2000) found that mean fruit weight showed significant negative correlation with number of fruits per plant and positive correlation with fruit length. Munshi *et al.* (2000), Sreelathakumary and Rajamony (2002) found that fruits per plant, fruit length, fruit weight had significant positive correlation with yield.

Ibrahim *et al.* (2001) in a study on 17 genotypes of chilli reported that dry fruit yield had significant positive correlation with number of fruits per plant, number of branches, fruit length, fruit width and plant height. Number of fruits per plant exhibited highly significant positive correlation with number of branches and plant height but negative correlation with fruit length. Negative association of individual fruit weight with number of fruits per plant was reported by Jose (2001) while crop duration was found to be positively correlated with number of branches, number of fruits per plant and fruit yield. Fruit length was found to be associated positively with yield according to reports of Chang (1977) and Smitha (2005). Rathod *et al.* (2002) reported significant positive association of fresh red chilli yield with number of fruits per plant, hundred seed weight and harvest index.

Acharyya *et al.* (2002) reported positive and significant correlation of total fresh yield per plant with total dry yield per plant. Khader and Jose (2002) reported positive correlation of yield with fruit weight, fruits per plant, primary branches per plant, secondary branches per plant, plant height, 100 seed weight, fruit length, fruit girth and crop duration and negative correlation with days to flowering.

Fruit yield was positively correlated with fruits per plant, fruit length, fruit diameter, plant height, capsaicin content and colouring matter but negatively correlated with number of days to flowering (Khurana *et al.*, 2003). Krishnakumar *et al.* (2003) also observed positive association of yield with number of primary and secondary branches, fruits per plant and other characters. Mini (2003) reported negative association of days to first flowering with fruit length. Yield was positively correlated with individual fruit weight, number of fruits per plant and fruit length. Individual fruit weight was negatively associated with number of fruits per plant. Positive association of yield per plant with number of fruits per plant and pedicel length was reported by Nandadevi and Hosamani (2003).

Muthuswamy (2004) reported negative association of days to first flowering with many of the characters studied and its positive association with fruit length. Fruits per plant was positively correlated with harvest index, capsaicin content and oleoresin content. Capsaicin content was positively correlated with number of primary branches, fruit weight, yield, fruit length, number of seeds per fruit, plant height, crop duration and harvest index. Yadwad (2005) observed significant positive association for number of fruits per plant with fruit length, stalk length, fruit surface area, number of seeds per fruit and fruit yield per plant in a study conducted on segregating population of S-32 x LCA-312 cross in chilli and also observed negative association for same character with fruit weight, stalk length, fruit diameter, fruit surface area, fruit volume.

Significant positive correlation existed between days to 50% flowering and plant height and branch number, plant height and fruit number, branch number and fruit number, fruit length and flesh to seed ratio, fruit length and average fruit weight, fruit girth and pungency, flesh to seed ratio with average fruit weight and average seed weight (Ahmed *et al.*, 2006). Fruit weight, pericarp thickness, number of seeds per fruit and 1000 seed weight showed positively significant association with fruit yield (Chatterjee *et al.*, 2007). Emphasis should be given to the genotypes that are having more number of fruits, more width and higher average fruit weight in the selection process due to their high positive effect on yield (Reddy *et al.*, 2008).

Jabeen *et al.* (2009) studied 25 chilli genotypes and observed yield per plant exhibited highly significant correlation with fruits per plant, branches per plant and height. Correlation coefficients at phenotypic levels between yield and yield components indicated that fruit yield per plant had positive and highly significant correlation with number of fruits per-plant and fruit length (Gupta *et al.*, (2009).

Fruits per plant and green fruit length showed highly positive direct effects on fruit yield per plant in a study involving 34 chilli genotypes (Chattopadhyay *et al.*, 2011).

Correlation studies conducted in 94 diverse genotypes of paprika indicated that dry fruit yield per plant showed significant and positive association with plant height, plant spread, fruits per plant, fruit girth, seeds per fruit and capsanthin content (Kumari *et al.*, 2011). Singh and Singh (2011) in a study of 30 diverse chilli genotypes observed significant and positive correlation of fruits per plant, yield per plant and red ripen fruit yield.

2.8 GENETICS AND BREEDING FOR ANTHRACNOSE DISEASE RESISTANCE

Anthracnose is a major disease of chilli. It occurs worldwide wherever chilli is grown under warm temperatures and overhead irrigation or rainfed conditions (AVRDC, 2000). Anthracnose is mainly a problem on mature fruits causing severe losses due to pre- and post- harvest fruit decay. Anthracnose is mainly a problem on mature fruits, causing both pre- and post-harvest fruit decay resulting in severe economic losses (Hadden and Black, 1987, Bosland and Votava, 2000). Two significant causal pathogens found in tropical Asia are *Colletotrichum capsici (*Syd.)

E. J. Butler and Bisby and *C. gloeosporioides* (Chang and Chung, 1985; Manandhar *et al.*, 1995). *C. capsici* generally infects ripe red fruit, while *C. gloeosporioides* infects both green and ripe fruits. Suryawanshi and Deokar (2000), for the first time in India. The disease is both seed borne and air borne and affects seed germination to a greater extent.

2.8.1 Symptomatology

The major symptoms of anthracnose disease are dieback and fruit rot (Singh, 1987a; Rajeswari *et al.*, 2004).

i. Dieback

The fungus causes necrosis of tender twigs from the tip backwards and hence the disease is called dieback. Infection usually begins when the crop is in flower. In diseased plant, flowers dry up. The drying up spreads from the flower stalk to the stem and the branches wither. The entire branch or the entire top of the plant may wither away. Partially affected plants bear fruits, which are few and are of low quality. The dead twigs are water soaked to brown becoming grayish white or straw coloured in advanced stage of the disease. A large number of black dots (acervuli) are seen scattered all over the necrotic surfaces of the affected twigs. Sometimes the necrotic areas are found separated from the healthy areas by a dark brown to black band. Dieback usually appears after the rains have stopped and when there is prolonged deposition of dew on the plants.

ii) Fruit rot

Ripe fruits turning red are affected. Green fruits are not spared once the disease starts in the field. A small, black, circular spot appears on the skin of the fruit and spreads in the direction of the long axis, thus becoming more or less elliptical. As the infection progresses, the spots get either diffused and black, greenish or dirty gray in colour or they are markedly delimited by the thick and sharp black outline enclosing a lighter black or straw coloured area. Badly diseased fruits turn straw coloured or pale white from normal red and numerous black acervuli are found as scattered pattern. When a diseased fruit is cut open the lower surface of the skin is found covered with minute, elevated, spherical, black stromatic masses or sclerotia of the fungus. In advanced stages, the seeds are covered by a mat of fungal hyphae. Such seeds turn rusty in colour. Affected fruits are deformed, white in colour and lose their pungency. In the fruit, the attacked parts turn black and become depressed or wrinkled. Ultimately the diseased fruits shrivel and dry up.

2.8.2 Causal organism and its occurrence

Four species of *Colletotrichum* viz. *C. capsici* (Syd) (Butler &Bisby), *C.gloeosporiodes* (Penz) Sacc., *C.acutatum* Simmonds and *C.cocodes* (Waltr) Hughes have been recorded on chillies (Hadden and Black, 1987; Kaur and Singh, 1990).*C.capsici* (Syd) (Butler &Bisby) is the main causative agent.

The first report on fruit rot of red pepper was in America (Halstead, 1890). In India, it was first registered in Madras Presidency by Sydow (1913) who reported the causal organism as *Vermicularia capsici* Syd. Syn. *Colletotrichum capsici* (Syd) Butler and Bisby. Later it was reported from Bihar (Dastur, 1921) under high humid conditions, Assam (Chowdhury, 1957), Punjab (Rai and Chohan, 1966), Harayana (Bansal and Grover, 1969). This pathogen has also been reported to affect chillies in Uganda (Small, 1924); Ceylon, (Bertur, 1927); USA (Higgins, 1930); and China (Ling and Lin, 1944).

2.8.3 Extent of damage

The pathogen causes yield reduction of 12-34% in Assam (Chowdhury, 1957)10-30% (Rai and Chohan, 1966) and 66-84% (Tind and Jhooty, 1985) in Punjab and 10-35% in Harayana (Bansal and Grover, 1969). In the Philippines, anthracnose incidence ranged from (1-80 per cent).

2.8.4 Susceptible stages of fruit

When fruits of different ages were inoculated with the pathogen, 25 day old ripe chilli fruit was the most susceptible whereas, 5 day old green fruits were not infected at all (Prakasam, 1983). Higher incidence and more severity during ripening and in fully ripened fruits have been observed by Roy *et al.* (1997) and Bhale *et al.* (1999) in chillies.

2.8.5 Epidemiology

The optimum temperature for conidial germination is 30^{O}C. Maximum disease development takes place at 28^{O}C and 95.7 per cent relative humidity. The disease usually breaks out if rainy conditions prevail after the setting of fruits. Greatest disease development occurs at 28^{O}C (Rajeswari *et al.*, 2004).

2.8.6 Genetics of Anthracnose Resistance

According to Park *et al.* (1990 b) resistance to *Colletotrichum capsici* was likely to be controlled by a single dominant gene. Inheritance of resistance to anthracnose caused by *Collectotrichum dematium* f. sp. *capsicum* and *C.gloeosporioides (Glomerella cingulata)* strain G was studied by Park *et al.* (1990a) using a six parent diallel. Detached green and red fruits were inoculated by pricking with a drop of spore suspension and lesion diameter was measured for index of resistance. Resistance to *C. dematium* (small lesions) was partially dominant to susceptibility (big lesions). Both broad and narrow sense heritabilities were high. Resistance of green fruits to *C. gloeosporioides* was found to be partially dominant or over dominant. Broad sense heritability was high but narrow sense heritability was relatively low.

Ahmed *et al.* (1991) evaluated 6 generations of a cross between susceptible capsicum cultivar 'Kolascai E-14' and resistant genotype 'Perennial' for their reaction to *C. capsici* and came to the conclusion that resistance to anthracnose was controlled by polygenes with a predominantly additive type of gene action and that the level of resistance could be improved through simple selection. In a cross between 83-168 and cultivar KAU cluster and their progenies in F_1, F_2 and BC_1, the segregation of resistance to susceptibility appeared to be 3:1 in the F_2 and 1:1 with BC_1 (F_1x KAU cluster) which indicated that one dominant gene was responsible for the resistance in breeding line 83-168 (Quing *et al.*, 2002). In a generation mean analysis of crosses (Jwalamukhi x Ujwala) and (Jwalasakhi x Ujwala), Ajith (2004) reported the presence of negatively significant dominance x dominance components for anthracnose resistance.

2.8.7 Breeding for Anthracnose Resistance

Ullasa *et al.* (1981) evaluated 298 genotypes and found that sixteen genotypes were resistant and six moderately resistant to *C. capsici*. Among the 23 cultivars of chilli studied by Pearson *et al.* (1984) the level of natural anthracnose infection rates ranged from zero to 17.2 per cent. Among the 21 capsicum cultivars studied, Chang and Chung (1985) found that the cultivars Kumchang No.2, Bulamhouse, Pakistan and Hongilpum were resistant to fruit rot. Singh (1987b) observed that the chilli varieties K.Surkh, CH 107, Chamatkar, Saten Yellow and G 4 were moderately resistant to fruit rot. Sen (1989) reported variety Pant C-1 to be resistant to anthracnose.

Basak (1997) screened 10 cultivars of chilli against three major fruit rotting pathogens, *Colletotrichum capsici, C. gloeosporioides* and *Fusarium pallidoroseum*. Flood irrigation was given before spray inoculation to ensure high humidity. None of the cultivars was found to be immune. Cultivars C-011 and C-045 were susceptible to *G. cingulata* and *C. capsici,* C-123 to *C. capsici* and Chittagong local and Bogra local were susceptible to *F. pallidoroseum* and highly susceptible to *G. cingulata* and *C. capsici*. The remaining cultivars were moderately resistant. Forty genotypes were studied by Jeyalakshmi and Seetharaman (1998) and found only one genotype CA 87-4 to be resistant to anthracnose.

Roy *et al.* (1998) evaluated 24 chilli genotypes for incidence of fruit rot based on percentage of fruits infected and found that none of the genotypes could be rated as resistant. However, six were moderately resistant (DC 1, DC 2, DC 3, DC 4, DC 14 and DC 24). Variety Phule Sai (GCH-8) was reported to be moderately resistant to anthracnose (Jadhav *et al.*, 2000).

Hegde and Anahosur (2001) screened 52 genotypes against fruit rot and found the cultivars LCA-301, LCA-324, K-1 and Byadagi Kaddi to be resistant. Variety Jiangshu No.4 was found to be resistant to fruit rot by Liu *et al.* (2001). Hybrid Xingla No.2 was reported to be resistant to fruit rot (Xiao *et al.*, 2001).

In an evaluation of chilli *(Capsicum annuum* L.) germplasm with ninety three genotypes for yield and resistance to anthracnose disease, three resistant donors Sin 1, Sin 2 and Sin 3 and five moderately resistant lines Arka Lohit, CC 4, KDC 1, Pepper Hot and Ujwala were chosen as potential parents to produce F_1 hybrids with lesser anthracnose incidence and reasonably good fruit yield (Rani *et al.*, 2007)

Susheela (2012) evaluated the existing methods of screening for resistance to chilli anthracnose. In fruit puncture method, conidia of *Colletotrichum capsici* germinated and differentiated into appresoria on fruit surfaces in both green and ripened red fruits. From the study on percentage incidence of anthracnose affected fruits under field conditions employing the spray inoculation were found to be the ideal method to identify resistant hybrids.

2.9 BIOCHEMICAL BASIS OF ANTHRACNOSE RESISTANCE

2.9.1 Capsaicin

Another important typical and unique attribute of capsicum is pungency. They are odourless, colourless and non nutrient compounds. The capsaicinoids are produced in the glands on the placenta of the fruits (Fujiwake *et al.*, 1982). About 90 percent of capsaicin is concentrated in the placenta (Sumathykutty and Mathew, 1984). Indira (1994) classified genotypes with capsaicin in the range 1.0 – 1.5 per cent as highly pungent, 0.25 – 0.75 per cent as medium pungent and 0.11 – 0.25 percent as less pungent.

According to Govindarajan *et al.* (1977), the group paprika contains less than 0.1% of capsaicinoids, the best grade of Spanish paprika having 0 to 0.003% and for the pungent grade, a maximum of 0.5%. But the pungency level of chillies varies from 0.1% to 1.4%. Seeds are not the sources of pungency, but they occasionally absorb capsaicin because of their proximity to the placenta (Jurenitsch *et al.*, 1979).

Pungency was partially dominant over non-pungency and epistasis also occurred (Ahmed *et al.*, 1984). The diseased chilli fruits contained 50 per cent depleted quantities of capsaicin (67.40mg per 100g) the pungency principle for which the condiment is valued. Govindarajan (1985) has reported that cultivar is the most important factor that determines the amount of capsaicinoid and the value of capsaicinoids vary from less than 0.1 per cent to over 1 per cent. Generally there is a decrease in pungency from chillies to paprika and a parallel increase in colour, pigment concentration and an increase in size and fleshy nature of pericarp.

Ahmed *et al.* (1987) tabulated the capsaicin content at three different stages *viz.*, green, ripe and sundried fruits of 12 *C. annuum* varieties. They reported that capsaicin content increased in the order green fruit, ripe fruit and sundried fruit. The capsaicin content ranged from 1.0 to 107.2 mg per 100 g fruit at ripe stage. They opined that fruit size and stage of maturity influenced the amount of capsaicinoind present in chilli fruit. The capsaicin content was found to be inversely related to fruit diameter, length and thickness. The percentage of capsaicin was maximum (1.6%) in resistant variety while minimum (1.2%) in susceptible variety of chilli in Guwahati (Azad, 1991).

Mini (1997) evaluated different capsicum species for capsaicin content. Seasonal change had no significant effect on the pattern of capsacinoid accumulation. Mini (1997) analysed nine chilli genotypes harvested during three different maturity stages *viz.*, turning stage, full ripe and withering stage and observed that chilli fruits were least pungent at turning stage and the pungency showed an increasing trend as the harvesting was progressed from turning to full ripe and withering stage. But the fruits harvested at full ripe and withering stage were on par in pungency in varieties Ujjwala and Kt-Pl 19.

Estarwada *et al.* (1997) studied changes in capsaicin content with fruit development in *C. annuum* and observed that capsaicinoid increases with fruit development. The capsaicinoid concentration of developing fruits (20 to 100 days after flowering were determined by Minami *et al.* (1998) and observed that capsaicin content was highest between 20 and 40 days after flowering.

The surface imparting characteristic luster to the chilli fruits was observed to be depleted in diseased fruits, which affected the marketability of the produce (Jeyalakshmi *et al,* 1999). Dabrowska *et al.* (2000) reported that the content of capsaicin depends mainly on genotypes.

Mathur *et al.* (2000) reported that Tezpur cultivar (*C. frutescence*) containing highest amount of capsaicin and dihydrocapsaicin (4.28 & 1.42%) contributing to pungency. Jha *et al.* (2001) reported that all the cultivars followed a uniform pattern of capsaicin accumulation with progressive fruit development.

Gnayfeed *et al.* (2001) conducted a work to investigate changes in capsaicin as a function of ripening in *C. annuum.* The results indicated that capsaicin was at a low level in mature green fruits and the onset of climacteric ripening caused their content to grow. Capsaicinoid content reached their maximum at the colour break or red stage and then decreased. Jha *et al.* (2001) investigated the capsaicin content in developing fruits of ten *C. annuum* cultivars and recorded the highest capsaicin level at mature stage than at immature stage, intermediate stage and ripened stags in all cultivars.

The biosynthesis of capsaicin content commenced during the early phase of fruit growth. 15 days after flowering the biosynthesis was non significant and at 30 days after flowering it became significant. During the later stages of fruits growth, the capsaicin content started declining (Sathiamurty *et al.*, 2002).

Robi (2003) opined that capsaicin content in hot chilli increased from turning to withering stage. On evaluation of 30 genotypes for biochemical constituents, a range of 0.33mg/100mg to 0.49mg/100mg of capsaicin was observed by Kumar *et al.* (2003).

Muthuswamy (2004) obtained epistatic interaction for this trait. Dhall and Hundal (2005) reported that capsaicin content of red ripe fruits is controlled by both additive and non additive effects with partial dominance on the inheritance of this quality trait.

Prasath *et al.* (2007) analysed 27 chilli accessions and reported that extreme capsaicin levels are 0.10 and 1.26 %, showing a mean value of 0.36 %. Six genotypes exhibited high capsaicin per cent (>1) and low capsaicin value was seen for 3 genotypes (< 0.20). Jyothi *et al.* (2008) observed a range of 0.256 to 0.528 for capsaicin content in different genotypes of paprika.

The wide range of variation in capsaicin reported by several workers

Author	Capsaicin content (%)	Species
Pradeepkumar (1990)	0.42 - 2.54	*Capsicum annuum*
Rani (1996)	0.11 - 1.81	*C. annuum*
Mini (1997)	1.10 - 2.20	*C.species*
Cherian (2000)	0.82 – 1.85	*C. chinense*
Sreelathakumary (2000)	0.65 – 1.06	*C. annuum*
Manju (2001)	1.20 – 3.74	*C. chinense*
Robi (2003)	1.32 – 3.18	*C. chinense (rainy season)*
	1.58 – 3.58	*C. chinense (summer season)*

The capsaicin content of chilli cultivars increased significantly with maturity stage. The per cent increase in ripe chilli cultivar over green stage ranged between 21.28 to 77.78 per cent. The maximum increase in capsaicin content was noticed in Byadagi Kaddi and minimum in Pusa Jwala (Khyadagi, 2009). High heritability estimates coupled with high expected genetic advance per cent of mean was observed for capsaicin content (Gupta *et al.*, 2009). The capsaicin content of ripe fruit was estimated to be high with a mean value of 0.15% in chilli cultivars (Chattopadhyay *et al.*, 2011).

2.9.2 Oleoresin

Pradeepkumar (1990) reported an oleoresin range from 18.7 per cent in *C. annuum* to 31.7 per cent in *C.chinense.* In *C. annuum* Papalkar *et al.* (1991) observed a range of 6.27 to 8.67 per cent. Cherian (2000) observed a range of 4.92 to 25.75 per cent in *C. chinense.*

Sreelathakumary (2000) obtained an oleoresin range of 12.4 per cent in *C. annuum* to 23.35 per cent in *C. chinense*. In an LxT (14x3) analysis. Mini and Vahab (2002) found significant differences among genotypes for oleoresin recovery and interaction of stage of harvest was significant for oleoresin recovery. Maximum recovery observed in winter season, harvested at full ripe, withering or turning stage. In rainy season oleoresin was high in fruits at withering stage.

A study conducted in 25 accessions of bird pepper *C. frutescens* indicated that the oleoresin content was more in red ripe stages than in mature green fruits (Sheela *et al.*, 2001). The oleoresin content ranged from 4.5 to 14.25 per cent in mature green stage to 8.75 to 24.45 per cent in red ripe stage. Rajinder *et al.* (2001) observed the importance of non additive gene action for oleoresin content.

Manju (2001) observed a range of 4.92 per cent to 24.25 per cent of oleoresin. Robi (2003) reported a range of 7.53 to 19.43 and 9.03 to 21.53 per cent in rainy and summer seasons respectively at fruit ripe stage and at withering stage 8.57 to 20.5 and 11.07 to 22.3 per cent in rainy and summer seasons respectively.

Presence of non additive gene action for oleoresin content was identified by Singh and Hundal (2001) while Muthuswamy (2004) observed additive, dominance and epistatic interaction.

Biochemical evaluation of twenty-three paprika genotypes by Jyothi *et al.* (2008) revealed considerable variability among the cultivars with respect to oleoresin recovery. It varied from 6.91 to 13.82 per cent. Similar results are given by Gupta *et al.* (2009).

The oleoresin content of chilli cultivars increased significantly with maturity stage. The per cent increase in dry chillies over ripe was ranging from 6.43 to 96.75 percent .The oleoresin content of chilli cultivars varied significantly between the cultivars, maturity stages and interaction between maturity stage and cultivars (Robi, 2003 and

Khyadagi, 2009).The oleoresin content of ripe fruit varied from 8.89% to 37.00%, the maximum being in 'AC-588' and the minimum in 'BCC-12 (Chattopadhyay *et al.*, 2011).

Materials & Methods

3. MATERIALS AND METHODS

The study was undertaken at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 2011-2013 for the genetic evaluation of yield and anthracnose resistance in the segregating generation (F_4) of three way cross hybrids in chilli (*Capsicum annuum* L.). The details of materials used and methods adopted are presented below.

3.1 MATERIALS

Six chilli varieties/ types (Jwalamukhi, Jwalasakhi, Samkranthi local, Vellayani Athulya, Kidangoor local and Ujwala) were used to develop 60 three way cross hybrids in a previous PG project and eight promising three way cross hybrids were obtained with regard to fruit yield, yield attributes and resistance to anthracnose which were used as the material for the present study.

The eight promising three way cross hybrids selected for the study are the following

Family	Three way cross hybrid
Family 1	(Jwalamukhi x Kidangoor local) x Jwalasakhi
Family 2	(Jwalamukhi x Ujwala) x Vellayani Athulya
Family 3	(Jwalasakhi x Vellayani Athulya) x Kidangoor local
Family 4	(Jwalamukhi x Ujwala) x Kidangoor local
Family 5	(Samkranthi local x Vellayani Athulya) x Kidangoor local
Family 6	(Vellayani Athulya x Jwalasakhi) x Samkranthi local
Family 7	(Vellayani Athulya x Ujwala) x Jwalamukhi
Family 8	(Kidangoor local x Ujwala) x Jwalasakhi.

3.2 METHODS

The present project was conducted as two separate experiments, *viz*. pot culture and field experiments.

3.2.1 Pot culture experiment

The pot culture experiment was mainly aimed at screening for anthracnose resistance along with selection for high yield. The experiment was laid out in Completely Randomized Design with three replications involving 8 families and 8 progenies. Disease pressure was created in the progenies by spraying spore suspension of the pathogen at 35 and 50 days after transplanting (DAT). For preparing spore suspension (10^8 /ml) isolation of pathogen in pure culture was carried out by using Potato Dextrose agar (PDA) medium.

Procedure: The diseased fruits were washed in running tap water and the diseased portions along with some healthy part were cut out and surface sterilized with 0.1 HgCl2. The tissues were washed in three changes of sterile distilled water. PDA melted and transferred to @ 20 ml/ petridishes and kept for solidification. Transferred the surface sterilized bits using a sterile foreceps into the PDA media in petridishes. The dishes were incubated for three days at room temperature (28 ± 2°c) and examined for the fungal growth around the bits were cut by using an inoculation needle and transferred to PDA slants. Two to three times of sub culturing was done and tested the purity of the culture.

The fungus was tested for its pathogenicity on detached fruits kept in petridishes. The fruits were given pinpricks before inoculation. Seven days old culture bits of the fungus grown in PDA were placed on the injured portion and covered with moist cotton wool, soaked in sterile water alone on the pinpricked area. The fruits were observed for development of symptoms and the pathogen was reisolated and maintained in PDA slants for preparing the spore suspension. Wet mount of the pathogen was prepared in lacto phenol cotton blue. Spore load was measured from one plate by using haemocytometer and was directly sprayed to the experimental plants in pots using atomizer.

After artificial inoculation with the spore suspension, scoring for anthracnose disease intensity was done by using the standard procedure by Mayee and Datar, 1986; Sulochana *et al.* 1992 (Table 1). Two progenies from each family were screened out and six superior progenies identified as resistant were used for the field experiment.

3.2.2 Field experiment

Compact Family Block Design with four replications consisting of eight families, six progenies within each family and 10 plants/ progeny was employed .

3.2.3 Biometric observations

In each progeny within a family, the biometrical observations were recorded from five plants selected at random and mean taken.

a. Days to first flowering

Number of days from sowing to the blooming of first flower in each plant was recorded

b. Number of primary branches

Branches arising from the main stem were counted and recorded as the number of primary branches

c. Number of fruits/ plant

The total number of fruits harvested from each plant was counted and recorded.

d. Average green fruit weight (g)

Weight of six fruits from each plant was recorded and the mean single fruit weight calculated in grams.

e. Fruit length (cm)

Length of fruits from the base of the peduncle to the tip of the fruit selected from the observational plants was recorded, the mean worked out and expressed in centimeter.

f. Fruit girth (cm)

The girth of those fruits used for recording length was measured at the broadest part of the fruit and the mean calculated and expressed in centimeter.

g. Number of seeds/ fruit

Seeds were extracted from each fruits, the total number counted and mean recorded

h. Hundred seed weight (g)

Seeds extracted from the fruits of every five selected plants in the respective family were dried and the weight of 100 fully developed seeds was recorded in grams

i. Plant height (cm)

Plant height was measured from the base of the plant to the tip of the longest branch after the last harvest of fruits.

j. Duration of the crop (days)

Number of days from sowing to the last harvest of fruits was considered as the duration of the crop.

3.2.4 Biochemical traits

a. Capsaicin content (%)

The capsaicin content of fruits of the selected plants was estimated by Folin- Dennis method. The pungent principle in chilli reacted with Folin- Dennis reagent to give a bluish complex, which was estimated calorimetrically (Mathew *et al.*, 1971).

Reagents used included Folin – Dennis reagent and aqueous sodium carbonate solution (25%). For preparation of Folin – Dennis reagent, a solution containing 750ml distilled water, 100g sodium tungstate, 20g phosphomolybdic acid and 50ml phosphoric acid were refluxed for two hours. It was cooled and diluted to 100ml with distilled water.

Procedure

Fruits harvested at red ripe stage were dried in a hot air oven at 50°C and powdered finely. Five hundred milligrams of each sample were transferred into test tubes into which 10ml acetone was added and kept overnight. From this 1ml aliquots were pipetted out into 100ml conical flasks and 25ml of Folin- Dennis reagent was added and allowed to stand for 30 minutes. Twenty five milliliters of freshly prepared sodium carbonate solution was added to it and shaken vigorously. The volume was made up to 100ml with distilled water and optical density read after 30 minutes at 725nm against reagent blank using a UV spectrophotometer. The reagent blank contained 1ml acetone, 25ml Folin -Dennis reagent and 25ml aqueous sodium carbonate solution.

To determine the per cent value for pure capsaicin, a stock solution of standard capsaicin (200mgi $^{-1}$) was prepared by dissolving 20mg capsaicin in 100ml acetone. From this stock solution, a series of solutions of different concentrations were prepared and their optical densities measured at 725nm using a UV spectrophotometer. A standard graph was prepared from which capsaicin content in the sample was found out.

b. Oleoresin content (%)

Oleoresin was extracted in Soxhlet apparatus using the solvent acetone (Sadasivam and Manikam, 1992)

Procedure

Chilli fruits at red ripe stage were dried in a hot air oven at 50°C and powdered finely. Two grams of chilli powder was packed in a filter paper and placed in a Soxhlet apparatus. Two hundred milliliters of acetone was taken in the round bottom flask of the apparatus and heated in a water bath kept at boiling point of acetone. After complete extraction, the solvent was evaporated to dryness under vacuum.

Yield of oleoresin on dry weight basis was calculated as

$$\text{Oleoresin (\%)} = \frac{\text{Weight of oleoresin}}{\text{Weight of the sample}} \times 100$$

3.2.5 Incidence of anthracnose

a. Per cent disease incidence

The observational plants per progeny in each family were observed at 45 and 60 DAT for characteristic symptoms of anthracnose on the fruits. Per cent disease incidence in each observational plant was calculated using the formula

$$\text{Per cent disease incidence} = \frac{\text{Number of fruits affected by anthracnose in a plant}}{\text{Total number of fruits in that plant}} \times 100$$

b.Disease intensity (%)

The following rating scale was used for calculating disease intensity

Table 1: Anthracnose rating scale (Plate 1; Plate 2)

Sl No	Per cent fruit area affected	Grade	Rating Scale
1	0	Highly resistant	0
2	1-11	Moderately resistant	1
3	10-21	Slightly resistant	2
4	20-41	Slightly susceptible	3
5	40-61	Moderately susceptible	4
6	>60	Severely susceptible	5

Disease intensity (DI) was calculated using the formula

$$DI = \frac{\text{Sum of all scores for fruits in a plant}}{\text{Total number of fruits in that plant x Maximum score given}} \times 100$$

Disease intensity was calculated at the following stages of the crop

i.45 days after transplanting (45DAT)

ii. 60 days after transplanting (60 DAT)

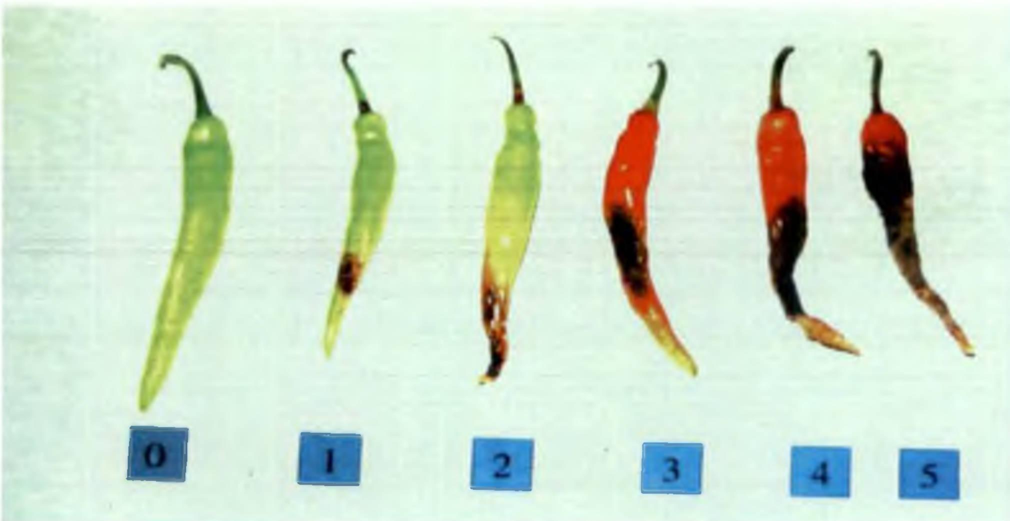

Plate 1. Rating scale of anthracnose disease

Plate 2. Typical symptom of anthracnose disease

3.3 Statistical analysis

The data collected were subjected to statistical analysis

3.3.1 Analysis of Variance

Analysis of variance was carried out for all the traits to find out whether there is any difference among the families and the progenies within the family, (Table 2)

Analysis of variance for families

Source	df	SS	MS	F
Replication	r-1	SSR	MSR	
Families	f-1	SSF	MSF	
Error	(r-1) (f-1)	SSE	MSE	

Analysis of variance for progenies within the family

Source	df	SS	MS	F
Replication	r-1	SSR	MSR	
Progenies	p-1	SSP	MSP	
Error	(r-1) (p-1)	SSE	MSE	

Pooled analysis of variance Table 3)

Source	df	SS	MS	F
Replication	r-1	SSR	MSR	
Families	f-1	SSF	MSF	
Error	(r-1) (f-1)	SSE	MSE	
Progenies within family		SSP	MSP	
1	p-1	SSP_1	MSP_1	
2	p-1	SSP_2	MSP_2	
3	p-1	SSP_3	MSP_3	
4	p-1	SSP_4	MSP_4	
5	p-1	SSP_5	MSP_5	
6	p-1	SSP_6	MSP_6	
7	p-1	SSP_7	MSP_7	
8	p-1	SSP_8	MSP_8	
Pooled error	f(r-1) (p-1)	SSE	MSE	

Where, r = No of replications f = No of treatment

$SSP_{i\,(1to\,8)}$ = Sum of squares of i^{th} progeny

$MSP_{i\,(1to\,8)}$ = Mean sum of squares of i^{th} progeny

p = No of progenies SSR = Replication sum of squares

MSF = Family mean square SSF = Family sum of square

When the treatments differed significantly by the 'F' test, the pair wise comparison of the treatment mean were made by using critical difference as,

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

Where t α is the students't' table value for α (5% or 1 %) level of significance corresponding to the error degree of freedom.

3.3.2 Components of Variance

Based on the initial analysis homogenous group of progenies within each family were identified. These groups of progenies within the family were used for the estimation of genetic components. The mean squares between treatments consisted of variances attributable to genotype, environment and phenotype (Singh and Chaudhary, 1985)

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

(i) Genotypic variance, $\sigma^2{}_g = \frac{\text{MST-MSE}}{r}$

(ii) Environmental variance , $\sigma^2{}_e = \text{MSE}$

(iii) Phenotypic variance, $\sigma^2{}_p = \sigma^2{}_g + \sigma^2{}_e$

3.3.3 Coefficient of Variation

It is a unit of measurement used for comparison of variation of different characters measured in different units. Genotypic and phenotypic coefficients of variation were worked out using the estimates of $\sigma^2 g$ and $\sigma^2 p$ and expressed in percentage (Burton, 1952) for each trait.

(i) Phenotypic coefficient of variation (PCV) = $\frac{\sigma p}{\text{Mean}} \times 100$

(ii) Genotypic coefficient of variation (GCV) = $\frac{\sigma g}{\text{Mean}} \times 100$

3.3.4 Heritability

For each trait heritability (broad sense) was estimated as the ratio of genotypic variance to phenotypic variance and expressed as percentage (Jain, 1982).

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

Heritability percent was categorized as suggested by Johnson *et al.*, (1955) *viz.*, low (0- 30), moderate (30-60) and high (above 60).

3.3.5 Genetic advance

Genetic advance which measures the change in mean genotypic level of the population brought about by selection depends upon standardized selection differential, heritability and phenotypic standard deviation (Allard, 1960)

Genetic advance as percentage of mean was estimated as per the method suggested by Lush (1940) and Johnson *et al.*, (1955) for each trait as,

Genetic advance, GA = $\frac{kh^2\sigma p}{\text{mean}} \times 100$, where 'k' is the standardized selection differential (k = 2.06) at 5% selection intensity and $\bar{x}$ is the mean of the character over all accessions. Genetic advance was categorized into low (below 10%), moderate (10-20 %) and high (above 20 percent)

3.3.6 Correlation analysis

Phenotypic, genotypic and environmental correlation coefficients were worked out for two characters *Xi* and *Xj* as

$$\text{Genotypic correlation } (rg_{ij}) = \frac{\sigma^2 g_{ij}}{\sigma g_i \times \sigma g_j}$$

$$\text{Phenotypic correlation } (rp_{ij}) = \frac{\sigma^2 p_{ij}}{\sigma p_i \times \sigma p_j}$$

Environmental correlation (re_{ij}) = $\frac{\sigma^2 e_{ij}}{\sigma e_i \times \sigma e_j}$

Where σgj, σpij and σeij denote the genotypic, phenotypic, and error covariance between two traits Xi and Xj respectively

Results

4. RESULTS

Evaluation of the progenies in the F_4 segregating generation was conducted as two separate experiments and the data collected were tabulated and subjected to statistical analysis. The results obtained are presented below.

4.1 POT CULTURE EXPERIMENT

The pot culture experiment (Plate 3) was conducted mainly to screen the progenies for anthracnose disease resistance. The analysis of variance for the nine characters studied was used to compare the performance of progenies among the eight different families.

4.1.1 Mean Performance of the Progenies within each Family

Mean performance of eight progenies within each family are given in Tables 4.1-4.8 (Plates 4, 5 and 6)

4.1.1.1: Family 1

a. Days to first flowering.

The minimum number of days to first flowering (51.33 days) was in the progenies 5 and 8 was on par with progeny 1 (53.33 days). Progeny 2 took maximum number of days to first flowering (54.75 days) which was on par with the progenies 2 and 7 (54.66 days).

b. Number of fruits per plant

The maximum number of fruits was obtained in progeny 1 (93) which was on par with progenies 5 (79.33) and 7 (78.33). Progeny 4 produced minimum number of fruits (47.33) and was significantly different from all others.

c. Average green fruit weight (g)

Average green fruit weight was maximum in the progeny 1 (4.95g) which was significantly superior, followed by progenies 7 (4.05g) and 5 (3.95g). The minimum fruit weight was obtained in the progeny 8(2.49g) and was significantly different from others.

Plate 3. Pot culture experiment

d. Length of fruit (cm)

Fruit length was maximum in progeny 1(5.55cm) and was significantly superior to all others. Minimum length of fruit was observed in progeny 6 (3.23cm).

e. Girth of fruit (cm)

Mean values for fruit girth ranged from 3.47cm to 4.31cm. Maximum girth observed in progeny 2 (4.31cm) was on par with five other progenies. The minimum fruit girth was observed in progeny 6 (3.47g).

f. Plant height (cm)

The maximum plant height was noticed in progeny 8 (56.33cm) and was on par with progenies 6 (55.66cm), 1 (52cm) and 7 (50.33cm). Plant height was minimum in progeny 2 (31cm).

g. Fruit yield per plant (g)

The fruit yield per plant was highest in progeny 1 (460.35g) and was significantly superior to all others. The lowest fruit yield was obtained in progeny 4 (114.63g).

h. Duration of the crop (days)

Crop duration ranged from 123.66 to 149.33days. Progeny 4 had the shortest duration of 123.66 days and was on par with progeny 1(130.33days). Maximum duration was observed in progenies 2, 6 and 7 (149.33days).

i. Anthracnose disease incidence and intensity at 45 DAT (%)

Incidence and intensity of anthracnose disease at 45 DAT were noticed only in progeny 3 (2.76% and 3.24%) and all other progenies in family 1 were disease free.

j. Anthracnose disease incidence and intensity at 60 DAT (%)

No disease incidence and intensity were noticed in progenies 1, 5, 6 and 7 at 60 DAT while progenies 2, 3, 4, and 8 exhibited disease incidence and intensity, the highest incidence and intensity being in progeny 4 (20.06 % and 20.10% respectively).

Table 4.1 Mean performance of each progeny for different characters: Family 1

Progeny	Days to first flowering	No of fruits per plant	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Plant height (cm)	Fruit yield per plant (g)	Duration of the crop (days)	Anthracnose disease incidence (%)		Disease intensity (%)	
									45DAT	60DAT	45DAT	60DAT
1	53.33	93.00	4.95	5.55	4.14	52.00	460.35	130.33	0	0	0	0
2	54.66	62.00	3.06	4.99	4.31	31.00	189.42	149.33	0	9.5	0	6.34
3	54.33	76.66	2.95	4.87	3.73	32.66	310.47	147.33	2.76	9.83	3.24	4.9
4	54.75	47.33	2.84	3.53	3.57	39.00	114.63	123.66	0	20.06	0	20.10
5	51.33	79.33	3.95	5.10	3.69	37.66	313.35	142.00	0	0	0	0
6	60.00	66.00	2.96	3.23	3.47	55.66	195.23	149.33	0	0	0	0
7	54.66	78.33	4.05	5.11	4.08	50.33	231.07	149.33	0	0	0	0
8	51.33	56.33	2.49	4.36	4.05	56.33	140.65	136.00	0	10.59	0	9.98
CD(0.05)	3.080	22.660	0.289	0.312	0.640	8.776	71.593	11.914				
SE	1.0274	7.559	0.0964	0.147	0.136	2.927	23.879	5.619				

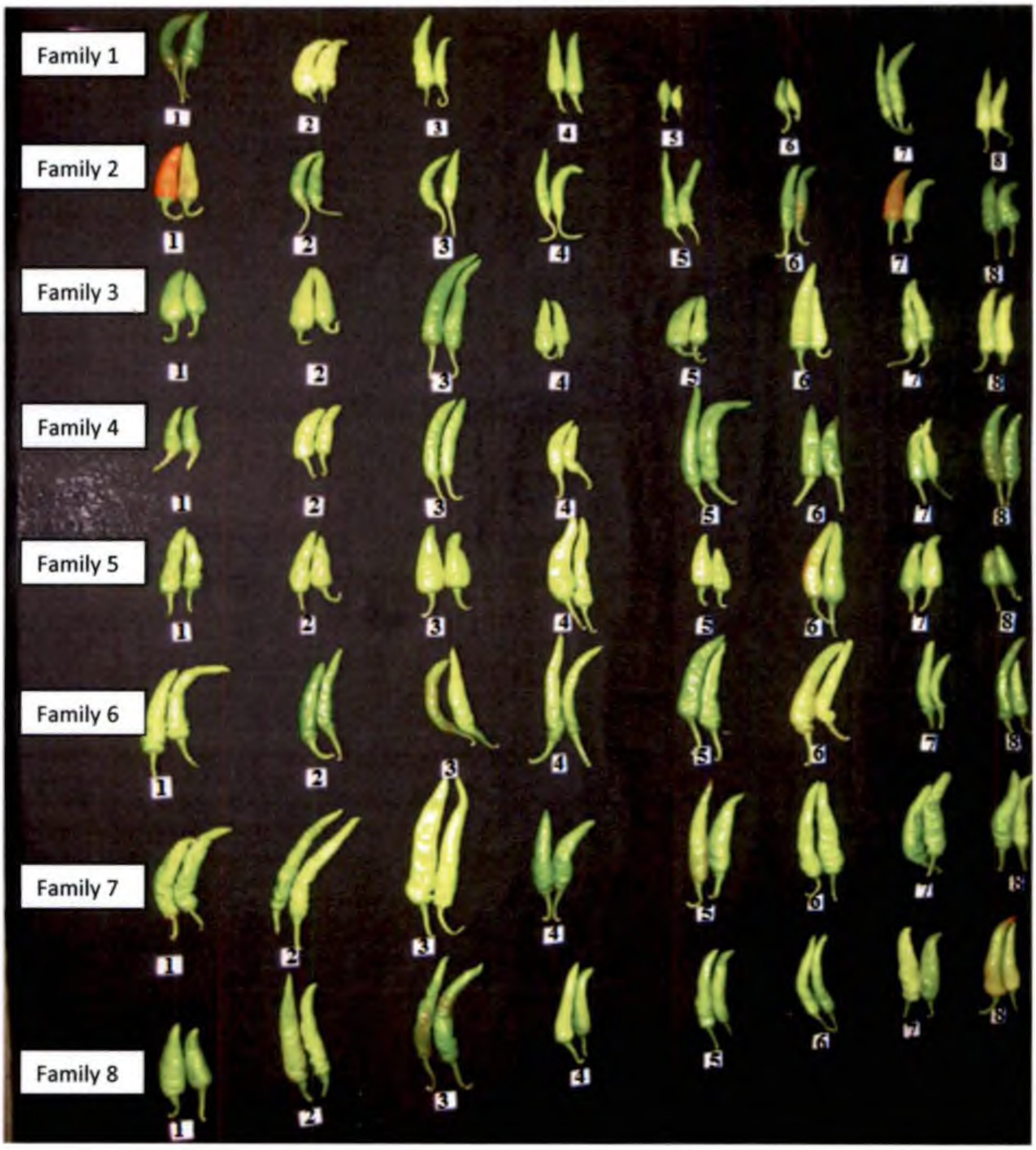

Plate 4. Variability in chilli fruits between families and progenies

4.1.1.2 Family 2

a. Days to first flowering

The earliest flowering progeny was 5 (52.33 days) and was on par with progenies 8 (53.33 days) and 3 (53.66 days) while progeny 6 took maximum number of days for flowering (60.33 days).

b. Number of fruits per plant

Among the eight progenies maximum number of fruits was produced by progeny 3 (131.33) and was significantly superior to all others followed by progeny 6 (97). Minimum number of fruits was observed in progeny 1 (45) and was on par with progeny 4 (48).

c. Average green fruit weight (g)

Average green fruit weight in the eight progenies ranged from 2.33g to 3.32g. The maximum value for the character was noticed in progeny 3 (3.32g) and was on par with progenies 6 (3.23g) and 8 (3.20g). Minimum green fruit weight was observed in progeny 4 (2.33g).

d. Length of fruit (cm)

The longest fruits were produced by progeny 8 (5.72cm) and was on par with progenies 6 (5.19 cm) and 5 (5.08 cm) while the shortest fruits were observed in progeny 1 (4.33cm).

e. Girth of fruit (cm)

Fruit girth was maximum in progeny 3 (4.38 cm) which was on par with progenies 4, 5, 6, 7 and 8. Minimum girth was observed in progeny 2 (3.30 cm).

f. Plant height (cm)

Among the progenies maximum plant height was noticed in progeny 5 (56cm) and was on par with progeny 3 (51.33cm). Minimum plant height was observed in progeny 7 (34cm).

g. Fruit yield per plant (g)

Fruit yield per plant was ranged from 111.75g to 436.01g. The highest yielder was progeny 3 (436.01g) and was significantly superior

Table 4.2 Mean performance of each progeny for different characters: Family 2

Progeny	Days to first flower ing	No of fruits per plant	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Plant height (cm)	Fruit yield per plant (g)	Duration of the crop(days)	Anthracnose disease incidence (%)		Disease intensity (%)	
									45DAT	60DAT	45DAT	60DAT
1	54.66	45.00	2.5	4.33	3.61	40.00	111.75	132.33	0	16.66	0	5.55
2	59.66	61.66	2.72	4.85	3.30	46.00	168.40	134.00	0	0	0	0
3	53.66	131.33	3.32	4.75	4.38	51.33	436.01	149.00	0	3.51	0	3.70
4	54.00	48.00	2.33	4.89	4.17	48.00	116.18	150.33	0	3.25	0	4.80
5	52.33	77.00	2.4	5.08	4.20	56.00	183.36	137.66	0	0	0	0
6	60.33	97.00	3.23	5.19	4.29	46.00	313.31	145.33	0	0	0	0
7	54.33	79.00	2.54	4.85	4.33	34.00	198.44	150.66	0	0	0	0
8	53.33	90.66	3.20	5.72	4.20	35.33	290.11	149.00	0	0	0	0
CD (0.05)	5.68	43.42	0.382	0.651	0.419	7.309	54.31	9.47				
SE	1.896	14.482	0.127	0.217	0.139	2.438	38.12	3.160				

to all others, followed by progenies 6 (313.31g) and 8 (290.11g), while the lowest yielder was progeny 1 (111.75g).

h. Duration of the crop (days)

Crop duration among the eight progenies ranged from 132.33 days to 150.66 days, the lowest being in progeny 1 and highest in progeny 7. Progeny 1 was on par with progenies 2 (134 days) and 5 (137.66 days).

i. Anthracnose disease incidence and intensity at 45 DAT (%)

Regarding anthracnose disease incidence and intensity at 45 DAT all the progenies in this family were free from disease.

j. Anthracnose disease incidence and intensity 60 DAT (%)

All the progenies except progenies 1, 3 and 4 were free from disease incidence. Progeny 4 had low incidence of disease (3.25 %) where as intensity was low in progeny 3 (3.70%). Progeny 1 had the highest incidence (16.66%) and intensity (5.55%) of anthracnose disease.

4.1.1.3 Family 3

a. Days to first flowering

The earliest flowering progeny was 4 (51.00 days) and was on par with progenies 2 and 6 (52.33 days). Progeny 4 took maximum number of days to first flowering (60.00 days).

b. Number of fruits per plant

Progeny 8 produced maximum number of fruits (108.66) and was significantly superior to others. Progeny 4 had the minimum number of fruits (40).

c. Average green fruit weight (g)

Maximum fruit weight was observed in the progeny 8 (3.32g) and was significantly superior to all others, followed by progeny 5 (3.13g) which was on par with progeny 7 (3.03g). Progeny 4 showed minimum fruit weight of 2.48g.

d. Length of fruit (cm)

Fruit length in the eight progenies ranged from 2.90cm to 5.70cm. The longest fruits were produced by progeny 1 (5.70cm) and was on par with

Table 4.3 Mean performance of each progeny for different characters: Family 3

Progeny	Days to first flowering	No of fruits per plant	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Plant height (cm)	Fruit yield per plant (g)	Duration of the crop(days)	Anthracnose disease incidence (%)		Disease intensity (%)	
									45DAT	60DAT	45DAT	60DAT
1	54.00	54.66	2.49	5.70	4.11	56.33	136.10	126.66	0	2.08	0	2.59
2	52.33	66.00	2.78	3.78	4.19	51.00	183.76	149.00	0	1.85	0	2.08
3	54.33	77.33	2.77	5.41	4.25	49.33	214.34	143.33	0	1.16	0	1.69
4	60.00	40.00	2.48	3.72	3.43	35.00	99.2	134.00	10.13	13.5	9.33	10.59
5	58.33	57.33	2.56	4.90	4.91	55.33	147.45	150.33	0	7.66	0	7.17
6	52.33	86.00	3.13	4.96	3.92	54.00	269.18	150.33	0	4.53	0	3.00
7	53.00	40.33	3.03	2.90	3.61	47.66	122.19	150.33	0	10.5	0	8.23
8	51.00	108.66	3.32	3.86	4.32	56.33	360.75	149.00	1.83	0.92	1.83	1.58
CD (0.05)	3.603	19.044	0.167	1.050	0.364	6.887	91.18	11.128				
SE	1.699	9.687	0.055	0.350	0.121	2.297	30.41	3.711				

progenies 3, 6 and 5 (5.41cm, 4.96cm and 4.90cm respectively). Progeny 7 (2.90cm) produced shortest fruits in the progeny.

e. Girth of fruit (cm)

Fruit girth was maximum in the progeny 5 (4.91cm) and was significantly superior to the others. Minimum girth of fruit was observed in progeny 4 (3.43cm).

f. Plant height (cm)

Plant height ranged from 56.33 to 35.00 cm in family 3. Among the 8 progenies, maximum height was observed in progenies 1 and 8 (56.33cm) which was on par with progenies 5 and 6 (55.33 and 54 cm respectively). Minimum plant height was noticed in progeny 4 (35cm).

g. Fruit yield per plant (g)

Fruit yield per plant showed wide range from 99.20g to 360.75g. The best yielder was progeny 8 (360.75g) followed by progeny 6 (269.18). Lowest yield was noticed in progeny 4 (99.20g).

h. Duration of the crop (days)

The crop duration ranged from 126.66 days to 150.33 days. Progeny 1 had the shortest duration of 126.66 days which was on par with progeny 4 (134 days). The long duration progenies were 5, 6 and 7 (150.33days).

i. Anthracnose disease incidence and intensity at 45DAT (%)

The disease incidence ranged from 0.00 to 10.13 %. There was no disease incidence in progenies 1, 2, 3, 5 and 6 (0.00 %), while progeny 4 had highest incidence (10.13%) and intensity (9.33%). Low disease incidence and intensity were noticed in the progeny 8 (1.83% and 2.01% respectively).

j. Anthracnose disease incidence and intensity at 60DAT (%)

All the progenies in family 3 exhibited disease incidence ranging from 0.92 to 13.50 % and intensity from 1.58 to 10.59%. Progeny 8 showed minimum incidence and intensity (0.92% and 1.58% respectively) while maximum incidence and intensity were observed in the progeny 4

(13.50% and 10.59% respectively) and all others had medium range of infection.

4.1.1.4 Family 4

a. Days to first flowering

In progeny 5 early flowering (55.33 days) was observed which was on par with progenies 8 (55.66 days) and 5 (56.66 days) while late flowering was noticed in progeny 1 (61.66days).

b. Number of fruits per plant

In this family maximum number of fruits were produced by progeny 6 (115) and was on par with progeny 7 (95.33). Minimum fruit production was observed in progeny 4 (47.33).

c. Average green fruit weight (g)

Maximum and minimum fruit weight were observed in progenies 6 (4.37g) and 5 (2.82g) respectively among the 8 progenies. Progeny 7 (4.06g) was on par with progeny 6 producing high fruit yield.

d. Length of fruit (cm)

Longest and shortest fruits were observed in progenies 7 (6.73cm) and 3 (3.71cm) respectively. Progeny 8 (5.69cm) was on par with progeny 7 producing long fruits.

e. Girth of fruit (cm)

Fruit girth ranged from 3.38cm to 4.23cm. Among the 8 progenies minimum fruit girth was observed in the progeny 4 (3.38cm) and was on par with progenies 3 (3.41cm) and 5 (3.62 cm). Fruit girth was maximum in progeny 2 (4.23cm) and was on par with progeny 8 (4.09cm).

f. Plant height (cm)

Maximum height was observed in the plants of progeny 5 (57.66cm) and was on par with progeny 6 (55cm). In progenies 1 and 3 short plants having a height of 30cm and 33.66cm respectively were observed.

Table 4.4 Mean performance of each progeny for different characters: Family 4

Progeny	Days to first flowering	No of fruits per plant	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Plant height (cm)	Fruit yield per plant (g)	Duration of the crop (days)	Anthracnose disease incidence (%)		Disease intensity (%)	
									45DAT	60DAT	45DAT	60DAT
1	61.66	68.33	3.16	5.21	3.92	30.00	215.92	134.00	0	1.83	0	2.41
2	57.33	57.00	3.00	4.87	4.23	40.00	171.00	150.00	0	0	0	0
3	58.66	68.00	3.32	3.71	3.41	33.66	225.76	148.66	0	1.45	0	1.86
4	55.33	47.33	3.04	4.69	3.38	49.66	143.88	148.66	4.16	5.05	4.47	4.34
5	56.66	60.00	2.82	4.74	3.62	57.66	169.2	150.00	0	2.08	0	2.08
6	59.33	115.00	4.37	5.23	3.98	55.00	502.55	150.33	5.23	0	5.26	0
7	61.33	95.33	4.06	6.73	3.93	42.00	387.03	150.33	1.06	1.25	1.38	1.28
8	55.66	84.00	3.18	5.69	4.09	41.00	267.12	126.66	0	0	0	0
CD (0.05)	7.805	20.186	0.340	0.784	0.281	6.923	77.28	8.134				
SE	2.603	6.733	0.113	0.261	0.093	2.309	25.778	2.713				

g. Fruit yield per plant (g)

Among the 8 progenies highest yielder was progeny 6 (502.55g) and was significantly superior to all others where as progenies 4 and 5 (143.88g and 169.2g respectively) exhibited poor yield.

h. Duration of the crop (days)

Plants having shortest duration were found in progeny 8 (126.66days) and was on par with progeny 1 (134days). Longest duration plants were observed in progenies 6 and 7 (150.33 days).

i. Anthracnose disease incidence and intensity at 45 DAT (%)

Among the 8 progenies, 3 progenies are in disease affected condition and the range of disease incidence was 0.00% to 5.23% and intensity from 0.00% to 5.26%. Maximum disease incidence and intensity were observed in progeny 6 (5.23% and 5.26% respectively). Progeny 7 showed less incidence and intensity of disease (1.06% and 1.38% respectively).

j. Anthracnose disease incidence and intensity at 60 DAT (%)

Three progenies *viz.,* 2, 6 and 8 were free from the disease incidence. Disease incidence and intensity were maximum in progeny 4 (5.05% and 4.34% respectively). Progeny 3 had less disease incidence (1.45%) and 7 had less disease intensity (1.28%).

4.1.1.5 Family 5

a. Days to first flowering

Earliest flowering was observed in progeny 3 (56 days) and was on par with all the other progenies except progeny 8 (65.00days), 4 (64.68days) and 7 (64.33days) which showed late flowering habit.

b. Number of fruits per plant

Maximum number of fruits was produced by progeny 4 (108.66) and was significantly superior to others, followed by progeny 6 (74.66). Fruit production was minimum in progeny 5 (43.66).

c. Average green fruit weight (g)

Table 4.5 Mean performance of each progeny for different characters: Family 5

Progeny	Days to first flowering	No of fruits per plant	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Plant height (cm)	Fruit yield per plant (g)	Duration of the crop (days)	Anthracnose disease incidence (%)		Disease intensity (%)	
									45DAT	60DAT	45DAT	60DAT
1	62.66	71.66	4.95	6.13	4.42	47.00	354.71	149.33	0	0	0	0
2	61.66	48.66	2.75	4.23	3.74	37.66	134.18	149.33	0	7.20	0	5.12
3	56.00	64.66	2.62	5.12	3.86	46.00	170.37	149.33	0	1.42	0	1.38
4	64.66	108.66	2.84	4.73	4.42	44.66	308.59	142.00	0	0	0	0
5	63.00	43.66	2.50	3.52	3.84	50.66	108.98	151.00	0	2.4	0	3.03
6	60.00	74.66	5.15	5.83	4.65	49.66	384.49	151.00	0	1.75	0	1.89
7	64.33	63.00	2.74	5.75	3.97	59.00	172.62	149.33	1.66	0	5.03	0
8	65.00	60.66	2.63	5.54	3.93	50.33	170.95	136.33	4.16	1.04	5.67	1.32
CD (0.05)	7.773	22.695	0.260	0.969	0.510	8.647	69.183	15.197				
SE	2.592	7.570	0.087	0.323	0.170	2.884	23.075	5.068				

Single fruit weight ranged from 2.50g to 5.15g. Maximum fruit weight was observed in progeny 6 (5.15g) and was on par with progeny 1 (4.95g). Progeny 5 produced fruits with minimum weight (2.50g).

d. Length of fruit (cm)

The longest fruits were produced by progeny 1 (6.13cm) and was on par with progenies 6 (5.83), 7 (5.75cm) and 8 (5.54cm). Progeny 5 produced shortest fruits having a length of 3.52cm.

e. Girth of fruit (cm)

Fruit girth ranged from 3.74cm to 4.65cm, maximum girth was found in progeny 6 (4.65cm) and was on par with progenies 1 and 3 (4.42cm). Progeny 2 had minimum fruit girth of 3.74cm.

f. Plant height (cm)

Maximum height was observed in the plants of progeny 7 (59cm) and was on par with progeny 5 (50.66cm). The plants of progeny 2 had minimum height of 37.66cm.

g. Fruit yield per plant (g)

Fruit yield per plant ranged from 108.98g to 384.49g. The highest yielder was progeny 6 (384.49g) which was on par with progeny 1 (354.71g), while the poor yielder was progeny 5 with 108.98g.

h. Duration of the crop (days)

Progenies 5 and 6 exhibited maximum duration (151 days) and was on par with progenies 1, 2, 3 and 7 (149.33days).Plants with short duration type was observed in progeny 8 (136.33days) and was on par with progeny 4 (142 days).

i. Anthracnose disease incidence and intensity at 45DAT (%)

Disease incidence and intensity were observed only in progenies 7 (1.66% and 5.03% respectively) and 8 (4.16% and 5.67% respectively), and the remaining progenies were free from the disease.

j. Anthracnose disease incidence and intensity at 60 DAT (%)

The disease incidence ranged from 0.00 % to 7.20% while intensity ranged from 1.32% to 5.12%. Progeny 2 showed maximum disease incidence (7.20%) and intensity (5.12%). Progeny 8 showed minimum incidence (1.04%) and intensity of the disease (1.32%).

4.1.1.6 Family 6

a. Days to first flowering

The plants in progeny 4 took minimum number of days to first flowering (58.66 days) and were on par with progeny 6 (60days). Late flowering was observed in progeny 2 (63.66 days) and was on par with progeny 8 (63.33 days).

b. Number of fruits per plant

Progeny 1 produced maximum number of fruits (114) and was significantly superior to all others, followed by progeny 3 (80.33) and progeny 4 (69.33). Progeny 8 produced minimum number of fruits (28).

c. Average green fruit weight (g)

Single fruit weight ranged from 2.48 g to 3.30 g. Maximum fruit weight was observed in progeny 4 (3.30g) and was on par with progeny 7 (3.29 g). Progeny 1 produced fruits with minimum weight (2.48 g) and was on par with progeny 2 (2.58g).

d. Length of fruit (cm)

Fruit length was maximum in progeny 1 (8.16 cm) and was significantly superior to all others, followed by progeny 6 (7.28 cm) and was on par with progeny 4 (7.08 cm). Progeny 2 produced small fruits having a length of (3.55 cm).

e. Girth of fruit (cm)

Fruit girth ranged from 3.54 g to 4.58 g. Progeny 5 produced fruits with maximum girth (4.58cm) and was on par with progeny 4 (4.39cm) and progeny 1 (4.21cm). Fruits produced by progeny 7 (3.54cm) had minimum girth and was on par with progeny 8 (3.57cm).

f. Plant height (cm)

Plants with maximum height was observed in progeny 5 (50.33cm) and was significantly superior to all others. Minimum height was observed in progeny 1 (30.66cm) and was on par with progeny 3 (32cm).

Table 4.6 Mean performance of each progeny for different characters: Family 6

Progeny	Days to first flowering	No of fruits per plant	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Plant height (cm)	Fruit yield per plant (g)	Duration of the crop (days)	Anthracnose disease incidence (%)		Disease intensity (%)	
									45DAT	60DAT	45DAT	60DAT
1	63.66	114.00	2.48	8.16	4.21	30.66	282.72	151.00	0	0	0	0
2	61.66	36.66	2.58	3.55	3.77	35.66	94.46	151.00	0	5.51	0	7.77
3	62.66	80.33	3.01	5.79	4.58	32.00	241.79	151.00	0	0	0	4.16
4	58.66	69.33	3.30	7.09	4.39	35.00	228.78	143.66	4.73	5.10	14.2	5.41
5	63.33	46.33	2.64	5.81	3.62	50.33	122.44	151.00	0	0	0	0
6	60.00	38.00	2.83	7.28	3.83	32.33	107.54	136.33	0	4.53	0	3.53
7	62.66	43.33	3.29	6.12	3.54	38.00	116.06	147.33	2.38	9.06	12.14	1.5
8	60.33	28.33	2.61	5.58	3.57	34.00	73.94	149.33	3.00	17.83	9.09	18.25
CD (0.05)	5.653	15.92	0.262	0.545	0.367	11.106	44.557	11.793				
SE	1.880	5.311	0.087	0.181	0.122	3.704	14.861	3.933				

g. Fruit yield per plant (g)

Among the 8 progenies maximum yield was observed in the progeny 1 (282.72g) and was on par with progeny 3 (241.79g). Progeny 8 (73.94g) possessed minimum yield and was on par with progeny 2 (94.46g).

h. Duration of the crop (days)

Plants in the progenies 1, 2, 3, and 5 recorded long duration (151 days) and were on par with progeny 8 (149.33 days).Progeny 6 had plants with short duration (136.33 days) and was on par with progeny 4 (143.66days).

i. Anthracnose disease incidence and intensity at 45 DAT (%)

Disease incidence and intensity were observed only for three progenies such as 4, 7 and 8 while the others were disease free. The disease incidence and intensity were maximum in progeny 4 (4.73% and 14.2% respectively). Progeny 8 showed minimum incidence (3%) and intensity (9.09%) of the disease.

j. Anthracnose disease incidence and intensity at 60 DAT (%)

All the progenies except progenies 1, 3 and 5 were free from disease incidence, progeny 6 showed low incidence of the disease (4.53%) where as intensity was low in progeny 7 (1.5%). Progeny 8 had the highest incidence (17.83%) and intensity (18.25%) of anthracnose disease.

4.1.1.7 Family 7

a. Days to first flowering

Late flowering was noticed in progeny 1 (64.33days) and was on par with progenies 2 and 8 (63.66days) and 7 (64.33days). Progeny 5 (55.33days) took minimum days to flowering and was on par with progenies 1 (58.33days), 3 (60.33days) and 6 (61.00days).

b. Number of fruits per plant

Maximum number of fruits was produced by progeny 8 (97.33) and was on par with progenies 6 (85) and 4 (80.66). Progeny 3 (24.33)

Table 4.7 Mean performance of each progeny for different characters: Family 7

Progeny	Days to first flowering	No of fruits per plant	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Plant height (cm)	Fruit yield per plant (g)	Duration of the crop (days)	Anthracnose disease incidence (%)		Disease intensity (%)	
									45DAT	60DAT	45DAT	60DAT
1	58.33	45.33	3.66	8.58	4.36	31.00	165.90	117.66	0	0	0	0
2	63.66	49.00	4.52	7.99	4.08	36.33	221.48	143.66	0	0	0	0
3	60.33	24.33	3.67	6.76	4.67	31.33	89.29	136.33	0	14.43	0	14.46
4	59.00	80.66	3.48	8.15	4.89	48.33	280.69	130.33	0	0	0	0
5	55.33	42.00	2.74	6.51	3.80	28.33	115.08	126.66	0	2.76	0	2.78
6	61.00	85.00	3.92	8.01	4.76	31.33	333.2	132.33	0	0	0	0
7	64.33	74.33	4.34	7.73	4.68	31.66	322.59	131.33	0	0	0	0
8	63.33	97.33	4.74	7.51	5.23	26.00	461.34	127.66	0	0	0	0
CD(0.05)	7.063	10.34	0.735	0.570	0.601	5.675	54.054	4.053				
SE	2.081	3.450	0.245	0.190	0.200	1.892	18.029	9.143				

produced minimum number of fruits and was significantly different from others.

c. Average green fruit weight (g)

Average green fruit weight ranged from 2.74g to 4.74g. Progeny 8 (4.74g) produced fruits with maximum weight and was on par with progeny 2 (4.52g) and 7 (4.34g). Minimum fruit weight was found in progeny 5 (2.74g) and was significantly different from all others.

d. Length of fruit (cm)

Fruit length was maximum in progeny 1 (8.58cm) and was on par with progenies 4 (8.15cm) and 6 (8.01cm). Progeny 5 produced fruits with minimum length (6.51cm) and was on par with progeny 3 (6.76cm).

e. Girth of fruit (cm)

Fruit girth ranged from 3.80cm to 4.89cm. Maximum girth was observed in progeny 8 (5.23cm) which was on par with progeny 4 (4.89cm). Progeny 5 produced fruits with minimum girth (3.80cm) and was on par with progeny 2 (4.08cm).

f. Plant height (cm)

Maximum height was observed in progeny 4 (48.33cm) and was on par with progeny 2 (36.33cm). Progeny 8 showed minimum height (26cm) and was on par with progeny 5 (28.33cm).

g. Fruit yield per plant (g)

The fruit yield per plant was maximum in progeny 8 (461.34g) and was significantly superior to all others, followed by progeny 6 (333.2g). Minimum fruit yield was obtained from progeny 3 (89.27g) and was on par with progeny 5 (115.08g).

h. Duration of the crop (days)

Maximum duration was observed in progeny 2 (143.66days) and was significantly superior to all others. Progeny 1 (117.66days) exhibited minimum duration and was significantly different from others.

i. Anthracnose disease incidence and intensity at 45 DAT (%)

Regarding anthracnose disease incidence and intensity at 45DAT, all the progenies in this family were free from disease.

j. Anthracnose disease incidence and intensity at 60 DAT (%)

Disease incidence and intensity were observed only in progenies 3 (14.43% and 14.46% respectively), and 5 (2.76% and 2.78% respectively) and the remaining progenies were in disease free condition.

4.1.1.8 Family 8

a. Days to first flowering

Late flowering was observed in progeny 2 (68.66days) and was on par with progeny 1 (64.00days). Progeny 5 possessed earliest flowering (57.66 days) and was on par with progeny 2 (58.66days).

b. Number of fruits per plant

Maximum number of fruits was produced by the progeny 8 (117.33) and was on par with progeny 3 (106.66). Plants in progeny 1 produced minimum number of fruits (41.66) which was on par with progeny 6 (43).

c. Average green fruit weight (g)

Single fruit weight ranged from 2.94g to 4.12g. Fruits produced by progeny 5 had maximum weight (4.12g) and was on par with progenies 3 (3.86g) and 8 (3.82g). Progeny 4 produced fruits with minimum weight (2.94g) and was on par with progeny 6 (3.14g).

d. Length of fruit (cm)

Fruit length was maximum in progeny 2 (7.54cm) and was on par with progeny 8 (6.82cm). Minimum length of fruit was observed in progenies 6 and 7 (5.36cm) and was on par with progeny 4 (5.39cm).

e. Girth of fruit (cm)

Maximum girth was observed in the fruits produced by progeny 2 (4.51cm) and was on par with progeny 1 (4.46cm). The progeny 4 produced fruits with minimum girth (3.48cm) and was on par with progeny 7 (3.56cm).

Table 4.8 Mean performance of each progeny for different characters: Family 8

Progeny	Days to first flowering	No of fruits per plant	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Plant height (cm)	Fruit yield per plant (g)	Duration of the crop (days)	Anthracnose disease incidence (%)		Disease intensity %	
									45DAT	60DAT	45DAT	60DAT
1	64.00	70.66	3.38	6.05	4.46	29.33	238.83	134.00	0	0	0	0
2	58.66	63.33	3.2	7.54	4.51	25.33	202.58	151.00	0.693	2.83	1.08	4.43
3	66.00	106.66	3.86	6.63	4.08	49.66	411.70	151.00	1.58	0	2.31	0
4	61.00	41.66	2.94	5.39	3.48	38.33	122.48	132.33	0	9.5	0	4.76
5	57.66	70.00	4.12	6.71	3.91	41.66	288.4	151.00	0	1.93	0	0.966
6	63.66	43.00	3.14	5.36	3.73	37.66	135.02	138.00	0	6.66	0	8.39
7	60.00	69.66	3.54	5.36	3.56	33.00	246.59	141.66	0	0	0	0
8	62.33	117.33	3.82	6.82	3.81	39.66	448.20	132.33	9.48	0	9.22	0
CD (0.05)	7.503	23.239	0.424	0.82	0.32	15.437	112.02	17.146				
SE	2.502	7.751	0.141	0.275	0.107	5.149	37.364	5.719				

Plate 5. Superior progenies from pot culture experiment

Plate 6 . Anthracnose affected plants from each family in pot culture experiment

Plate 6 (contd.). Anthracnose affected plants from each family in pot culture experiment

f. Plant height (cm)

Maximum height was observed in progeny 3 (49.66cm) and was on par with progeny 5 (41.66cm). Progeny 2 possessed plants with minimum height (25.33cm) and was on par with progeny 1(29.33cm).

g. Fruit yield per plant (g)

Maximum fruit yield was noticed in the progeny 8 (448.20g) and was on par with progeny 3 (411.70g).Minimum fruit yield was noticed in Progeny 4 (122.48g) and was on par with progeny 6 (135.02g).

h. Duration of the crop (days)

Maximum duration was observed in progenies 2, 3 and 5 (151days) and was on par with progeny 7 (141.66days). Progenies 8 and 4 showed minimum duration (132.33days) and were on par with progeny 1 (134days).

i. Anthracnose disease incidence and intensity at 45 DAT (%)

The disease incidence ranged from 0.00% to 9.48% and intensity 0.00% to 9.22%. There was no disease incidence in progenies 1,3,4,5 and 6 (0.00%) while progeny 8 had maximum incidence (9.48%) and intensity (9.22%) of disease. Low disease incidence and intensity were noticed in progeny 2 (0.693% and 1.08% respectively).

j. Anthracnose disease incidence and intensity at 60 DAT (%)

All the progenies except progenies 1, 3, 7 and 8 were free from disease incidence. Progeny 5 had low disease incidence (1.93%) and intensity (0.96%) while progeny 4 possessed maximum incidence (9.50%) where as intensity was maximum in progeny 6 (8.39%).

4.1.2 Performance based on ranking of each progeny in relation to yield characters

Screening of progenies from each family was done by rank performance in relation to yield characters apart from anthracnose disease incidence. Characters which contributed more to yield such as number of fruits, average green fruit weight, length of fruit and girth of

Table 5.1 Performance based on ranking of each progeny in relation to yield characters – Family 1

Progeny	Number of fruits/ plant	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Rank total
1	1	1	1	2	5
2	6	4	4	1	15
3	4	6	5	8	23
4	8	7	7	7	29
5	2	3	3	6	14
6	5	5	8	5	23
7	3	2	2	3	10
8	7	8	6	4	25

Table 5.2 Performance based on ranking of each progeny in relation to yield characters- Family 2

Progeny	Number of fruits/plant	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Rank total
1	8	6	8	7	29
2	6	4	6	8	24
3	1	1	7	1	10
4	7	8	4	6	25
5	5	7	3	5	20
6	2	2	2	3	9
7	4	5	5	2	16
8	3	3	1	4	11

Table 5.3 Performance based on ranking of each progeny in relation to yield characters – Family 3

progeny	Number of fruits	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Rank total
1	6	7	1	5	19
2	4	4	6	4	18
3	3	5	2	3	13
4	8	8	7	8	31
5	5	6	4	1	16
6	2	2	3	6	15
7	7	3	8	7	25
8	1	1	5	2	9

Table 5.4 Performance based on ranking of each progeny in relation to yield characters – Family 4

Progeny	Number of fruits	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Rank total
1	4	4	4	5	17
2	7	7	5	1	20
3	5	3	8	7	17
4	8	6	7	8	29
5	6	8	6	6	26
6	1	1	3	3	8
7	2	2	1	4	9
8	3	5	2	2	12

Table 5.5 Performance based on ranking of each progeny in relation to yield characters – Family 5

progeny	Number of fruits	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Rank total
1	3	2	1	2	8
2	7	7	7	8	29
3	4	4	5	6	19
4	1	3	6	3	13
5	8	8	8	7	31
6	2	1	2	1	6
7	5	5	3	4	17
8	6	8	4	5	23

Table 5.6 Performance based on ranking of each progeny in relation to yield characters – Family 6

Progeny	Number of fruits	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Rank total
1	1	8	1	3	13
2	7	7	8	5	27
3	2	3	6	1	12
4	3	1	3	2	9
5	4	5	5	6	20
6	5	4	2	4	15
7	6	2	4	8	20
8	8	6	7	7	28

Table 5.7 Performance based on ranking of each progeny in relation to yield characters – Family 7

Progeny	Number of fruits	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Rank total
1	6	6	1	6	19
2	5	2	4	7	18
3	8	5	7	5	26
4	3	7	2	2	14
5	7	8	8	8	34
6	2	4	3	3	12
7	4	3	5	4	16
8	1	1	6	1	9

Table 5.8 Performance based on ranking of each progeny in relation to yield characters – Family 8

Progeny	Number of fruits	Average green fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Rank total
1	3	5	5	2	15
2	6	6	1	1	14
3	2	2	4	3	11
4	8	8	6	8	30
5	4	1	3	4	12
6	7	7	8	6	28
7	5	4	7	7	23
8	1	3	2	5	11

fruit were taken for the selection process. A score ranging from one to eight was given for each character and the score of one was given to the progeny which performed the best from among the eight progenies. Highest rank of eight was given to the poor performer among the progenies. Top ranking six progenies in each family based on yield and anthracnose resistance were selected for the field experiment (Tables 5.1 to 5.8; Fig. 1.1 to1.8).

In family 1 progenies such as 1, 5, 7, 2, 3 and 6 showed best performance (Table 5.1) with a rank total of 5, 14, 10, 15, 23 and 23 respectively. Two progenies *viz.,* 4 and 8 were observed as poor performers on the basis of yield traits and anthracnose disease incidence. The best progenies selected from family 2 (Table 5.2) were 3, 6, 8, 7,5 and 2 with rank total of 10,9,11, 16, 20 and 24 respectively. Progenies 1 and 4 showed maximum rank totals indicating their poor performance.

In family 3 the selected high yielders and disease resistant progenies were 3, 6, 8,5,2 and 1 with rank totals of 13,15,9,16,18 and 19 respectively (Table 5.3). The progenies which not perform well were 4 and 7 on the basis yield and anthracnose disease incidence.

Progenies such as 6,7 , 8,3,1 and 2 performed well with ranks of 8,9,12,17,17, and 20 among the 8 progenies for yield traits and anthracnose disease resistance in family 4 (Table 5.4). Progenies 4 and 5 showed maximum rank total denoting their poor performance for yield and susceptibility to anthracnose disease.

In family 5 (Table 5.5),yield traits such as number of fruits, average green fruit weight, length, and girth were high in progenies 1, 4 , 6,7,3 and 8 showed better performance with rank totals of 8,13,6,17,19 and 23respectively. Two progenies such as 2 and 5 showed poor performance for yield characters and had high disease incidence.

In family 6 (Table 5.6), the selected progenies were 1,3, 4,6,5 and 7 with rank totals of 13,12,9,15,20 and 20 based on performance for their high yield characters and less disease incidence.. The eliminated

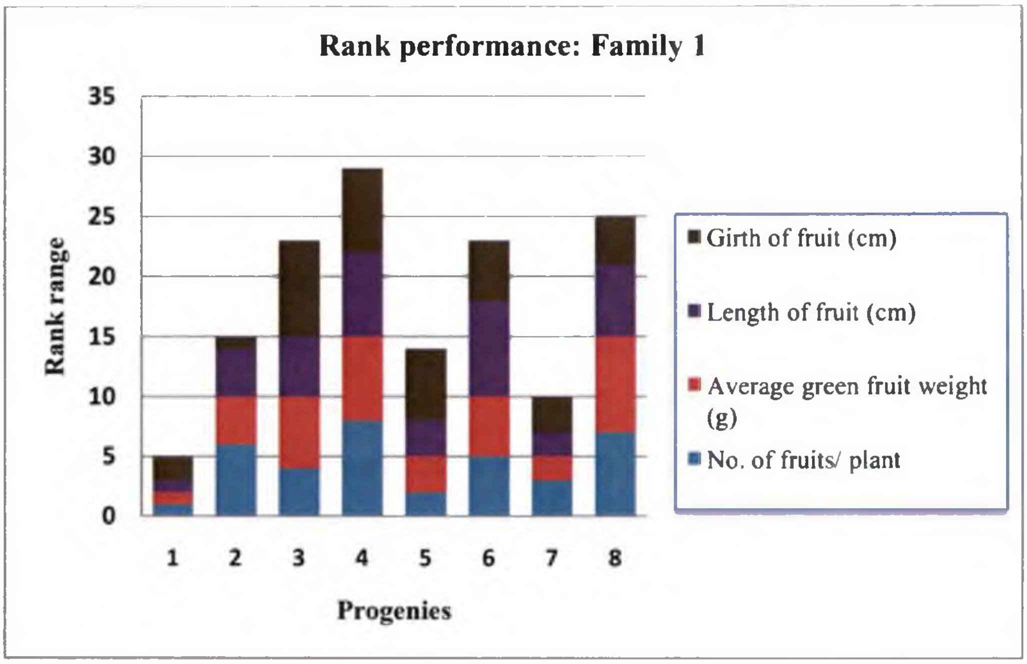

Fig 1.1. Performance based on ranking of each progeny in relation to yield characters – Family 1

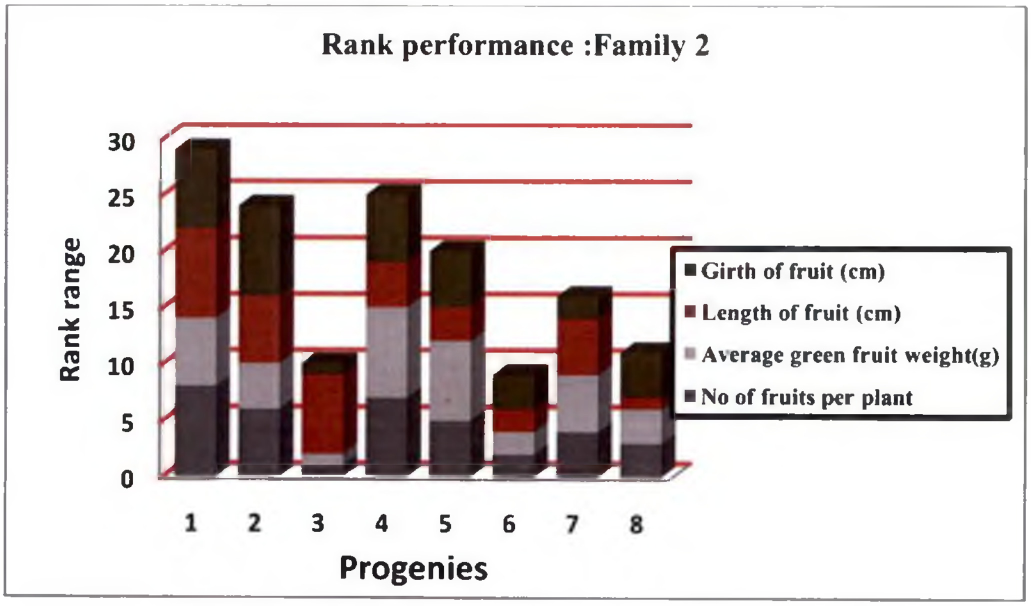

Fig 1.2. Performance based on ranking of each progeny in relation to yield characters – Family

1

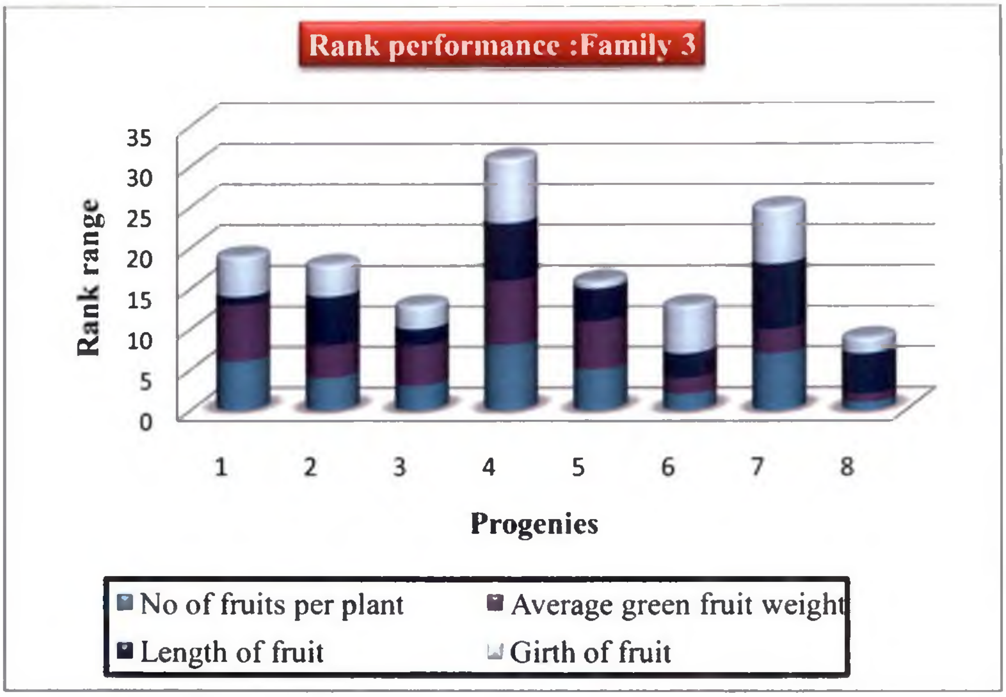

Fig 1.3. Performance based on ranking of each progeny in relation to yield characters – Family 3

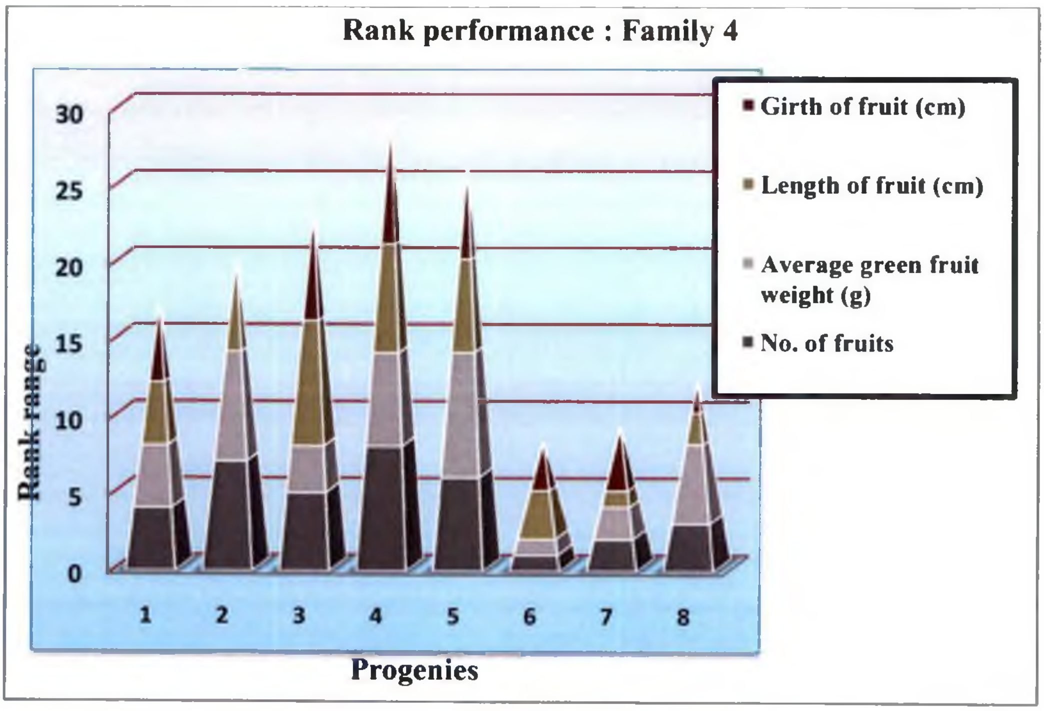

Fig 1.4: Performance based on ranking of each progeny in relation to yield characters – Family 4

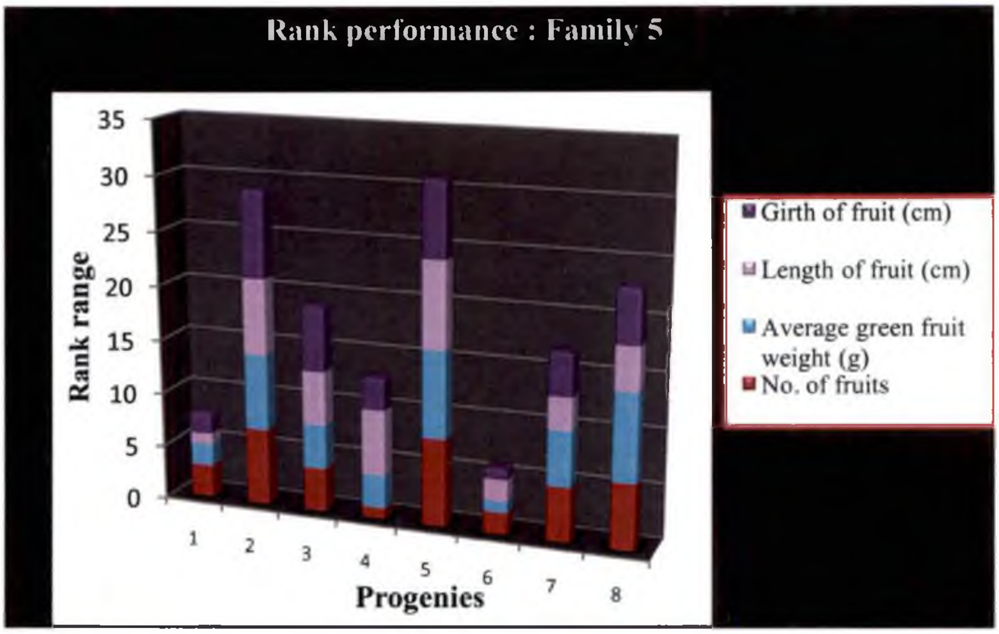

Fig 1.5. Performance based on ranking of each progeny in relation to yield characters – Family 5

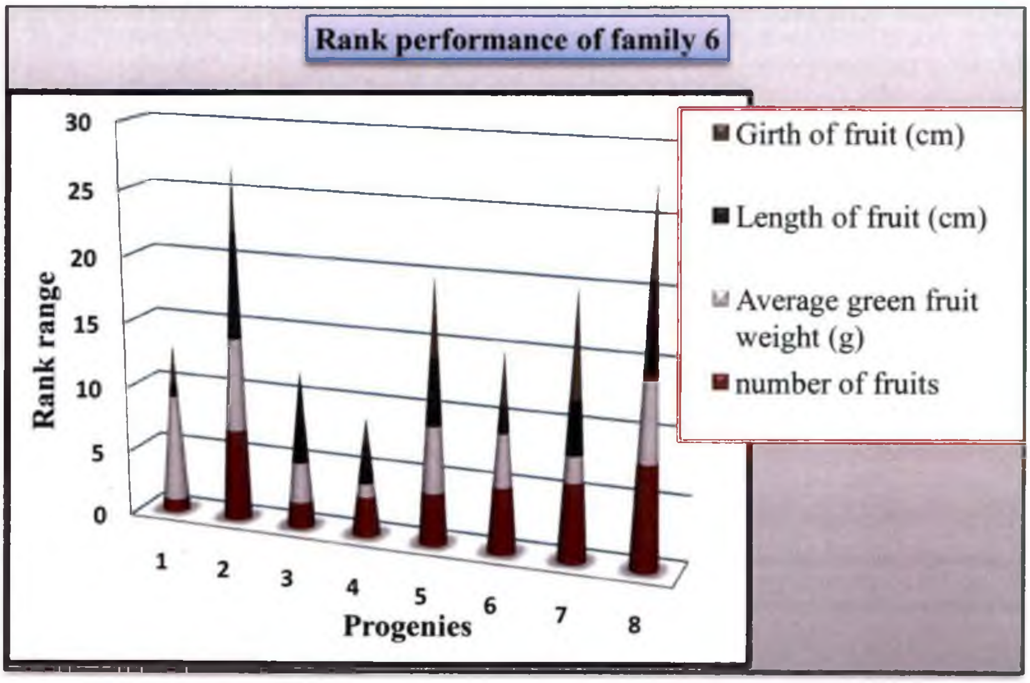

Fig 1.6: Performance based on ranking of each progeny in relation to yield characters – Family 6

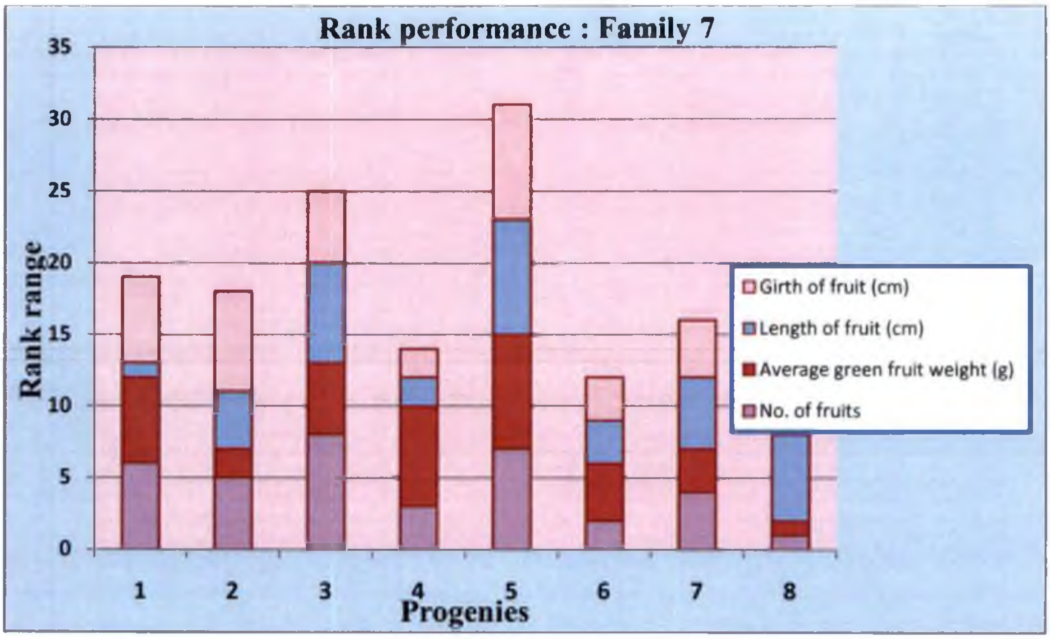

Fig 1.7. Performance based on ranking of each progeny in relation to yield characters – Family 1

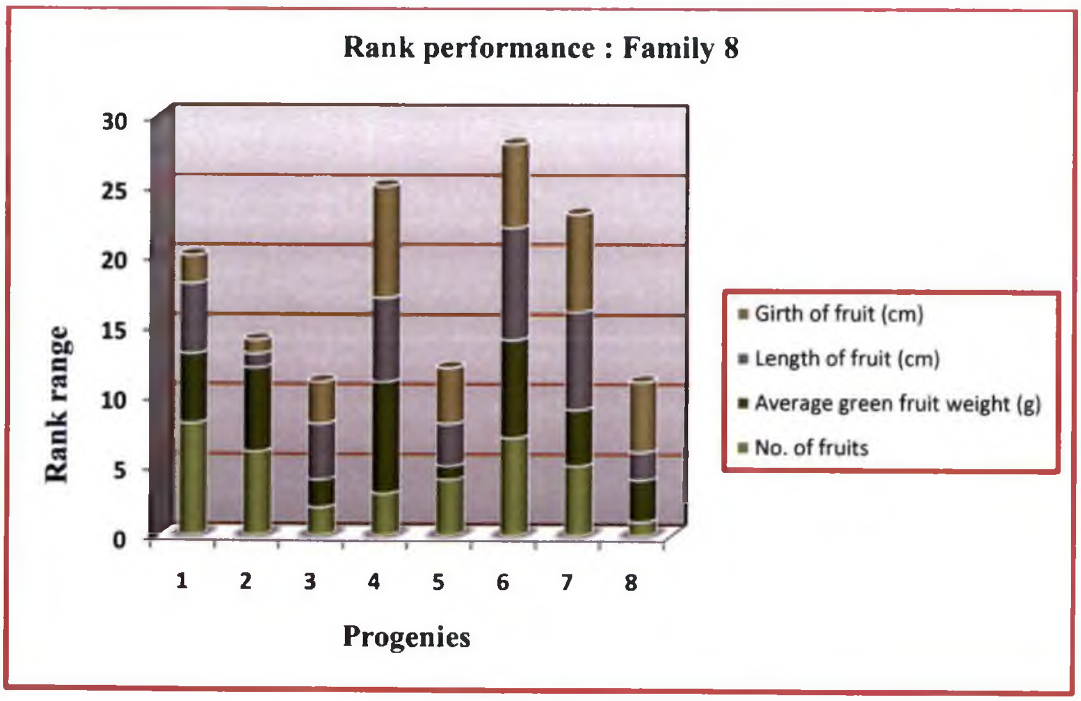

Fig 1.8. Performance based on ranking of each progeny in relation to yield characters – Family 1

progenies were 2 and 8 because of their poor performance and high disease incidence.

The selected progenies in family 7 (Table 5.7) were 4, 6, 8, 7, 2 and 1 with rank totals of 14,12,9, 16, 18 and 19 respectively and they were superior in yield performance and were resistant to disease incidence. The progenies 3 and 5 were screened out based on rank performance of yield characters and high disease incidence.

The progenies *viz.*, 3, 8, 5, 6, 3 and 7 were selected from family 8 (Table 5.8) because of their appreciable performance with top ranks of 11,11,12,14.15 and 23 respectively. The poor yielders and disease susceptible progenies that were screened out were 4 and 6.

4.1.3 Genetic parameters

Genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability % and genetic advance as percent of mean estimated for eight characters are presented in Table 6; Fig 2 and 3. The eight characters was days to first flowering, number of fruits per plant, average green fruit weight, length of fruit, girth of fruit, plant height, fruit yield per plant and duration. Among the eight characters fruit yield per plant (25.10 and 29.05) and length of fruit (20.83 and 22.31) exhibited GCV and PCV. Number of fruits per plant was also possessed high PCV (21.39). Heritability was maximum for length of fruit (87.17%) and followed by average green fruit weight (81.82%) and fruit yield per plant (74.69%). Genetic advance was observed to be maximum for fruit yield per plant (44.70%) followed by length of fruit (40.07%), all the other characters possessed lesser values for genetic advance.

4.1.4 Correlation

Correlation was analysed for eight characters and phenotypic and genotypic correlations coefficient are given in Tables 7 and 8.

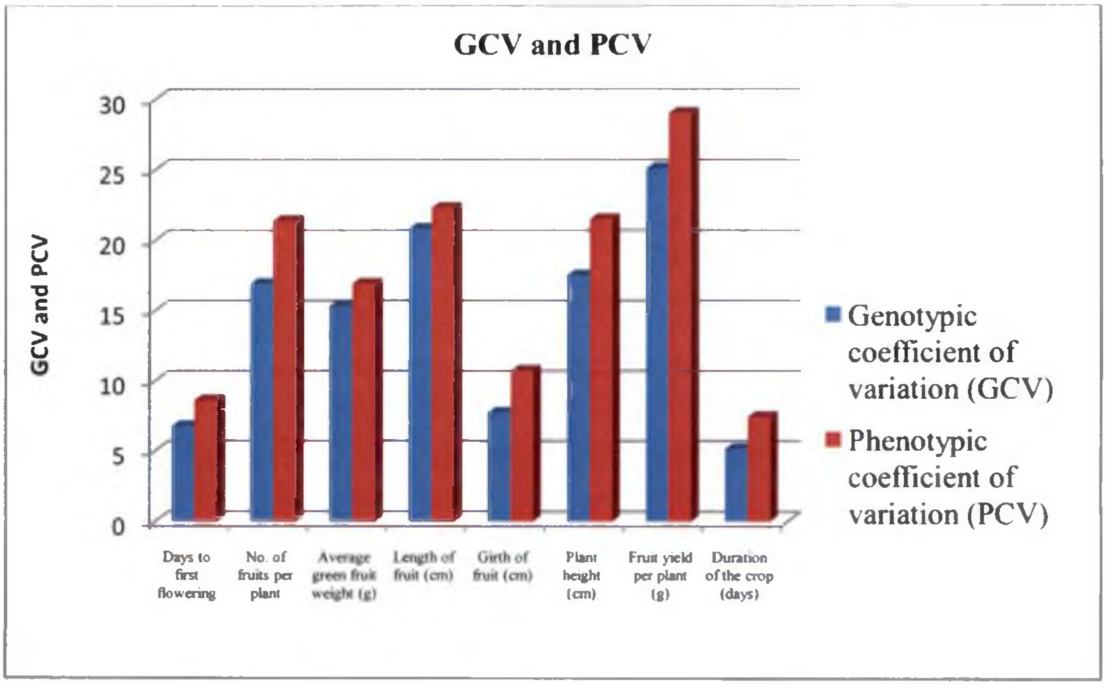

Fig. 2. Genotypic and phenotypic coefficients of variation for different characters

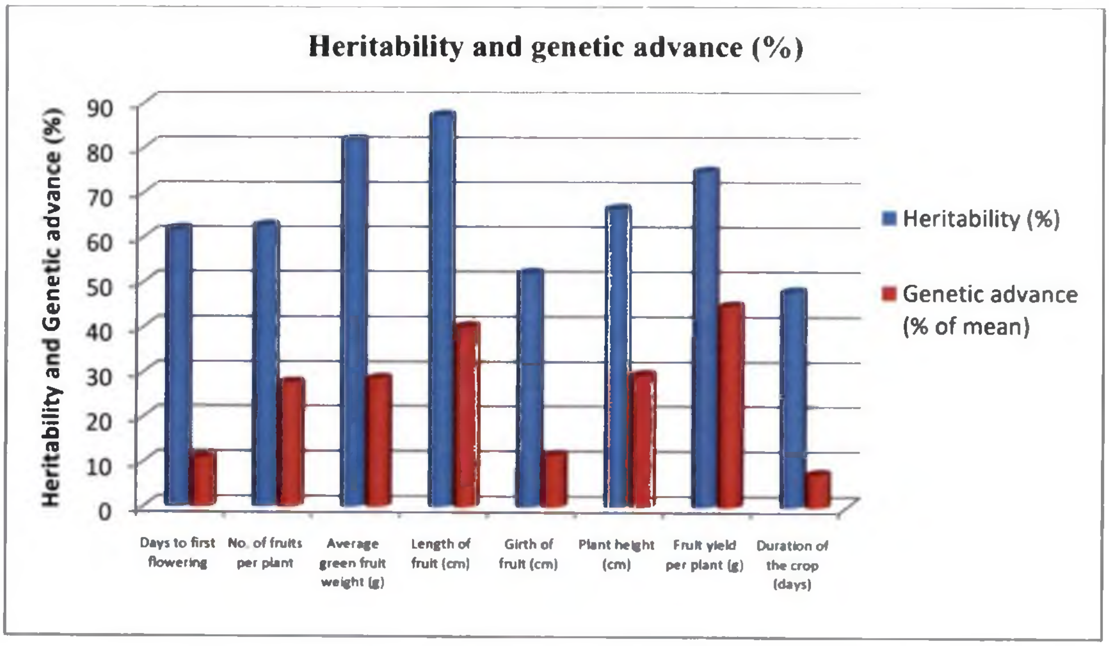

Fig. 3. Heritability and Genetic advance as percentage of mean for different characters

Table 6. Estimation of genetic parameters for various characters in chilli

Sl No.	Character	Genotypic coefficient of variation (GCV)	Phenotypic coefficient of variation (PCV)	Heritability (%)	Genetic advance (% of mean)
1.	Days to first flowering	6.77	8.62	61.67	10.95
2.	No. of fruits per plant	16.93	21.39	62.61	27.60
3.	Average green fruit weight (g)	15.32	16.94	81.82	28.55
4.	Length of fruit (cm)	20.83	22.31	87.17	40.07
5.	Girth of fruit (cm)	7.74	10.73	52.01	11.50
6.	Plant height (cm)	17.52	21.51	66.37	29.40
7	Fruit yield per plant (g)	25.10	29.05	74.69	44.70
8	Duration of the crop (days)	5.15	7.44	47.88	7.34

Table 7 Phenotypic correlation coefficients among yield and yield components

	X1	X2	X3	X4	X5	X6	X7	X8
X1	-	0.0014	0.0019	-0.067	0.0861	0.0530	0.0612	0.2320
X2	-	-	0.0432	-0.549**	-0.0765	0.1111	0.5673**	-0.001
X3	-	-	-	0.3126*	0.1709	-0.1654	0.5342 **	- 0.2182
X4	-	-	-	-	0.1700	-0.4014 **	0.0473	-0.912**
X5	-	-	-	-	-	-0.196	0.1313	0.3096*
X6	-	-	-	-	-	-	0.1728	0.1881
X7	-	-	-	-	-	-	-	-0.1232
X8	-	-	-	-	-	-	-	-

Table 8 Genotypic correlation coefficients among yield and yield components

	X1	X2	X3	X4	X5	X6	X7	X8
X1	-	0.0245	0.533**	0.0039	0.0734	-0.0207	0.095	0.216
X2	-	-	0.0391	-0.131	-0.965 **	0.1158	0.699**	0.069
X3	-	-	-	0.376 **	0.2801	-0.148	0.674**	-0.306*
X4	-	-	-	-	0.2528	-0.554**	0.0782	-0.262
X5	-	-	-	-	-	-0.329*	0.276	-0.541**
X6	-	-	-	-	-	-	0.167	0.356**
X7	-	-	-	-	-	-	-	0.075
X8	-	-	-	-	-	-	-	-

** Significant at 5% level
*Significant at 1% level

X1: Days to first flowering X2: No. of fruits per plant X3: Average green fruit weight (g)
X4: Length of fruit (cm) X5: Girth of fruit cm X6: Plant height (cm)
X7: Fruit yield per plant (g) X8: Duration of crop (days)

In the case of phenotypic correlation fruit yield per plant possessed positive significant correlation with number of fruits per plant and average green fruit weight. Length of fruit was positively and significantly correlated with average green fruit weight and it was also negatively correlated and significant with number of fruits per plant. Plant height possessed significant negative correlation with length of fruit. Duration of crop was significant and negatively correlated with length of fruit and positively correlated with girth of fruit.

Genotypic correlation was observed as to be high for fruit yield per plant with number of fruits and average green fruit weight which were significantly and positively correlated. Fruit length showed positive significant correlation with average green fruit weight. Girth of fruit had significant negative correlation with number of fruits. Average green fruit weight showed significant positive correlation with days to first flowering. Plant height was significantly and negatively correlated with length of fruit and girth of fruit. Duration of crop showed negatively significant correlation with girth of fruit and average green fruit weight it had positive significant correlation with plant height.

4.2. FIELD EXPERIMENT

The field experiment was conducted (Plate7) and the results recorded on yield, yield attributes (Fig. 5.1- 5.8; Plate 8) and anthracnose disease incidence (Plate 9) are presented below.

4.2.1 Days to first flowering

Among the different families (Table 9.1), family 1 exhibited early flowering habit (56.98 days) which was significantly superior to all others. Family 6 took maximum number of days (63.77 days) and was on par with families 2 (63.70 days) and 3 (63.15 days).

In family 1, among the 6 progenies earliest flowering plants were present in progeny 6 (55.05 days) which was on par with progeny 2 (55.30 days). Late flowering was noticed in progeny 5 (59.90 days).

Plate 7. General view of field experiment

Progeny 4 took minimum number of days for first flowering (61.90 days) in family 2 and was on par with progenies 5 (63.00 days) and 6 (63.30 days). Maximum number of days for first flowering was noticed in progeny 3 (65.20 days).

Minimum number of days for first flowering in family 3 was for progeny 6 (61.25 days) which was on par with progenies 3 (61.65days) and 5 (62.65 days) where as late flowering was observed in progenies 1 and 4 (64.70 days).

In family 4, progeny 4 (59.40 days) possessed early flowering nature and was on par with progeny 5 (60.25 days). Progeny 4 (65.95days) exhibited late flowering habit.

Progeny 4 took minimum days for flowering (57.85days) in family 5 and was highly significant than others. Maximum number of days for flowering was observed in progeny 6 (64.25days) and was on par with progeny 1 (63.40 days) and 2 (62.55 days).

In family 6 early flowering was observed in progeny 1 (60.50 days) and was significantly superior to all others, while progeny 2 took 66.70 days for first flowering.

Progeny 3 took minimum days for flowering (58.20 days) in family 7 and was significantly superior to all others followed by progeny 6 (62.10 days) where as maximum number of days for flowering was observed in the progeny 4 (64.55 days).

In family 8 earliest flowering was possessed by progeny 4 (59.80 days) and was on par with progeny 5 (61.50 days). Progeny 6 (63.90days) took maximum number of days for first flowering.

4.2.2 Number of primary branches per plant

Maximum number of branches (Table 9.2) observed in family 1 (6.11) and was on par with Family 2 (4.55). Family 7 possessed less number of branches (3.69). In family 1 number of primary branches was

Table 9.1 Mean performance of each family for different characters: Days to first flowering

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	57.55	55.30	58.30	55.80	59.90	55.05	1.309	56.98
2	64.95	63.90	65.20	61.90	63.00	63.30	1.751	63.71
3	64.70	64.00	61.65	64.70	62.65	61.25	2.015	63.16
4	65.95	63.05	63.10	59.40	60.25	62.20	1.344	62.32
5	63.40	62.55	61.80	57.85	61.65	64.25	2.146	61.92
6	60.50	66.70	64.25	63.20	64.35	63.75	1.549	63.79
7	63.65	62.55	58.20	64.55	62.75	62.10	1.340	62.30
8	63.70	62.45	62.25	59.80	61.50	63.90	2.098	62.27
CD for families (0.05)								1.06

Table 9.2 Mean performance of each family for different characters: Number of primary branches per plant

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	4.95	5.80	5.75	6.30	6.95	6.95	0.751	6.11
2	3.95	4.90	4.35	5.15	4.25	4.70	1.114	4.55
3	3.90	3.60	3.40	5.50	4.65	4.15	1.245	4.20
4	3.75	4.70	4.15	4.40	4.10	4.25	0.626	4.23
5	4.25	3.85	3.55	3.30	4.00	3.40	1.302	3.73
6	3.85	4.50	4.60	3.80	5.15	3.60	1.142	4.25
7	2.90	3.60	4.30	4.00	3.75	3.60	1.543	3.69
8	3.50	3.60	5.00	4.15	3.70	4.30	1.372	4.04
CD for families (0.05)								1.753

maximum in progenies 5 and 6 (6.95) and was on par with progeny 4 (6.30). Minimum number of branches observed in progeny 1 (4.95).

In family 1 number of primary branches was maximum in progenies 5 and 6 (6.95) and was on par with progeny 4 (6.30). Minimum number of branches observed in progeny 1 (4.95).

Progeny 4 possessed maximum number of primary branches (5.15) in family 2 and was on par with progenies 2 (4.90), 6 (4.70), 3 (4.35) and 5 (4.25). Less number of branches observed in progeny 1 (3.95).

Maximum number of primary branches was observed by progeny 4 (5.50) in family 3 and was on par with progeny 6 (4.65). Progeny 3 produced minimum branches (3.40).

In family 4, maximum number of primary branches was observed in progeny 2 (4.70) and was on par with progeny 4 (4.40), 6 (4.25), 3 (4.15) and 5 (4.10). Progeny 1 possessed less number of branches (3.75).

All the progenies in family 5 possessed relatively similar range of primary branches and progeny 1 produced maximum (4.25) and minimum branches observed by progeny 4 (3.30).

Progeny 5 possessed minimum number of branches (5.15) in family 6 and was on par with progenies 2 (4.50) and 3 (4.60). Minimum branches observed by progeny 6 (3.60).

In family 7, maximum number of primary branches observed in progeny 3 (4.30) and minimum in progeny 1 (2.90).

Progeny 3 (5.00) produced more number of primary branches in family 8 and was on par with progeny 6 (4.30), 4 (4.15) and 5 (3.70). Progeny 1 (3.50) possessed less number of branches and was on par with progeny 2 (3.60).

4.2.3 Number of fruits per plant

According to the family mean (Table 9.3) maximum number of fruits was produced by family 8 (80.75) and was on par with family 2 (78.78). Family 5 produced less number of fruits (65.81) was significantly different to all others.

In family 1 maximum number of fruits produced by progeny 1 (92.00) was significantly superior to all others, followed by progeny 6 (81.52).Minimum number of fruits was observed in progeny 2 (57.05) and was significantly different to all others.

Progeny 2 produced more number of fruits (107.10) in family 2 and was significantly superior to all others, followed by progeny 6 (94.82) and 4 (82.90). Minimum fruits produced by progeny 5 (58.25) and was on par with progeny 1 (62.60).

In family 3, fruit production was observed as maximum in progeny 3 (93.15) and was significantly superior to all others, followed by progeny 3 (83.50). Progeny 1 produced less number of fruits (55.90).

Maximum fruit production was observed by progeny 4 (97.78) in family 4, and was significantly superior to all others, followed by progeny 5 (87.40). In Progeny 2 number of fruits was minimum (53.50).

Progeny 3 possessed maximum fruit production (83.65) in family 5 and was significantly superior to all others, followed by progeny 4 (75.00). Less fruit production was observed in progeny 2 (52.85).

Fruit production was maximum by the progeny 1 (110.67) in family 6 and was significantly superior to all others, followed by progeny 3 (83.20). Progeny 2 possessed minimum fruit production (51.57) compared to other progenies.

In family 7 more number of fruits was produced by progeny 6 (96.25) and was on par with progeny 4 (95.90). Progeny 1 (49.65) possessed minimum fruit production (49.65).

Maximum number of fruits was produced by progeny 6 (118.08) in family 8 and was significantly superior to all others, followed by progeny 3 (101.77). Progeny 1 produced minimum number of fruits (53.07) and was significantly different to all others.

Table 9.3 Mean performance of the progenies within the families for number of fruits per plant

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	92.00	57.05	64.42	70.75	64.38	81.52	5.3675	71.69
2	62.60	107.10	67.05	82.90	58.25	94.82	9.0395	78.79
3	55.90	57.70	93.15	83.50	75.20	70.08	5.9203	72.59
4	63.70	53.50	70.23	97.78	87.40	76.45	6.6722	74.84
5	66.88	52.85	83.65	75.00	58.00	58.50	3.6361	65.81
6	110.67	51.57	83.20	60.30	69.33	63.20	14.4183	73.04
7	49.65	55.50	69.15	95.90	55.35	96.25	6.4030	70.30
8	53.075	63.40	101.77	77.65	70.55	118.08	7.8624	80.75
CD for families (0.05)								4.371

Table 9.4 Mean performance of the progenies within the families for average green fruit weight (g)

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	4.165	4.14	3.99	3.70	3.78	3.84	0.257	3.93
2	3.75	3.83	3.76	3.60	3.78	3.71	0.329	3.74
3	4.18	4.55	5.04	4.73	3.89	4.81	0.144	4.53
4	3.90	4.21	4.10	4.80	4.44	4.41	0.134	4.31
5	4.86	5.38	5.40	6.06	4.97	5.10	0.349	5.29
6	4.47	4.24	4.61	3.98	5.04	4.07	0.154	4.40
7	4.20	3.55	4.44	4.58	4.95	4.59	0.094	4.39
8	3.96	4.73	4.67	4.90	4.70	4.75	0.184	4.62
CD for families (0.05)								0.0582

4.2.4 Average green fruit weight

Among the 8 families (Table 9.4) maximum green fruit weight was observed in family 5 (5.29g) and was significantly superior to all others, followed by family 8 (4.62g). Minimum fruit weight was possessed by family 2 (3.74g) compared to the other families.

In family 1, the fruit weight was maximum in progeny 1 (4.16g) and was on par with progeny 2 (4.14g) and 3 (3.99g). Minimum fruit weight was noticed in Progeny 4 (3.70g).

Fruit weight ranged from 3.60g to 3.83g in family 2 and was maximum in progeny 2 (3.83g) and minimum in progeny 4 (3.84g).

Progeny 3 possessed maximum green fruit weight (5.04g) in family 3 and was significantly superior to all others. Followed by progeny 6 (4.81g) and 4 (4.73g). Minimum fruit weight was observed in progeny 5 (3.89g).

In family 4 average green fruit weight was maximum in progeny 4 (4.80g) and was significantly superior to all others, followed by progeny 5 (4.44g) and 6 (4.41g). Minimum fruit weight was observed in progeny 1 (3.90g).

Fruits with maximum average green fruit weight was possessed by progeny 4 (6.06g) in family 5 and was significantly superior to all others, followed by progeny 3 (5.40g) and 2 (5.38g). Minimum fruit weight was observed in progeny 1 (4.86g).

Progeny 5 produced fruits with maximum green fruit weight (5.04g) in family 6 and was significantly superior to all others, followed by progeny 3 (4.61g), 1 (4.47g) and 2 (4.24g). Average green fruit weight was minimum in the progeny 4 (3.98g).

In family 7 maximum green fruit weight observed in the progeny 5 (4.95g) and was highly significant than others, followed by progeny 6 (4.59g), 4 (4.58g). Fruit weight was minimum in progeny 2 (3.55g).

Maximum average green fruit weight was observed by progeny 4 (4.90g) in family 8 and was on par with progeny 6 (4.75g) and 2 (4.73g). Fruits with less weight were observed in progeny 1 (3.96g).

4.2.5 Length of fruit

Among the family means (Table 9.5), longest fruits were produced by family 6 (7.83cm) and was on par with families 7 (7.75cm) and 8 (7.70cm). Smaller fruits were observed in families 3 (5.23cm) and 2 (5.40 cm).

In family 1, fruits with maximum length were observed in progeny 1 (7.33cm) and was significantly superior to all others, followed by progeny 2 (6.38cm). Minimum length was observed in progenies 3 and 5 (5.09cm).

Fruits with maximum length were produced by progeny 2 (6.78cm) in the second family and was significantly superior to all others, followed by progenies 5 (5.49cm) and 6 (5.44cm). Shortest fruits were produced by progeny 3 (4.47cm).

Progeny 4 produced fruits with maximum length (6.24cm) in family 3 and was on par with progenies 6 (5.98cm) and 3 (5.64cm). Length of fruit was minimum in progeny 2 (4.16cm).

In family 4, maximum length of fruit was noticed in progeny 5 (6.91cm) and was on par with progenies 3 (6.58cm), 4 (6.43cm) and 2 (6.19cm). Progeny 1 possessed minimum fruit length (5.03cm) among the others.

Fruit length in the case of family 5 was maximum in progeny 4 (7.42cm) and was on par with progenies 1 (6.61cm) and 3 (6.31cm). Shortest fruits were produced by progeny 6 (5.03cm).

Length of fruit ranged from 6.43 cm to 9.83 cm in family 6 and maximum length observed in progeny 2 (9.83cm) and was significantly superior to all others, followed by progenies 4 (8.34cm) and 1 (8.27cm). Fruits with minimum length were produced by progeny 5 (6.43cm).

Table 9.5 Mean performance of the progenies within the families for length of fruit (cm)

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	7.33	6.38	5.09	5.14	5.09	5.66	0.244	5.74
2	4.97	6.78	4.47	5.23	5.49	5.45	0.444	5.40
3	4.47	4.16	5.64	6.25	4.89	5.98	0.886	5.23
4	5.03	6.19	6.58	6.43	6.91	5.46	0.903	6.10
5	6.61	5.13	6.31	7.42	5.47	5.03	1.514	5.99
6	8.27	9.83	7.59	8.34	6.43	6.51	0.354	7.83
7	6.52	6.21	8.10	8.19	9.47	7.98	0.145	7.74
8	6.55	6.87	8.77	7.85	8.22	7.95	0.412	7.70
CD for families (0.05)								0.319

Table 9.6 Mean performance of the progenies within the families for girth of fruit (cm)

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	4.69	2.96	3.37	3.56	3.46	3.72	0.163	3.63
2	3.45	3.17	3.36	3.64	3.59	4.25	0.307	3.58
3	4.56	3.99	4.59	4.00	4.52	4.94	0.330	4.43
4	3.36	2.97	3.81	3.82	3.80	3.26	0.555	3.50
5	4.48	5.91	3.77	4.82	3.80	4.22	0.893	4.50
6	3.88	3.37	3.78	4.07	4.24	4.15	0.121	3.92
7	3.74	3.97	4.56	4.23	4.21	4.04	0.087	4.13
8	4.64	3.65	4.61	3.73	3.66	4.56	0.205	4.14
CD for families (0.05)								0.245

In family 7, long fruits were produced by progeny 5 (9.47cm) and was highly significant than others, followed by progenies 4 (8.19cm) and 3 (8.10cm). Fruits with minimum length were observed in progeny 2 (6.21 cm)

Fruits which exhibited maximum length were observed in progeny 3 (8.76cm) in the case of family 8 and was significantly superior to all others, followed by progeny 5 (8.22cm). Short fruits were produced by progeny 1 (6.55cm).

4.2.6 Girth of fruit

Mean value of fruit girth was maximum in family 5 (4.50cm) and was on par with family 3 (4.43cm) (Table 9.6). Family 4 possessed minimum fruit girth of 3.50cm compared to the other families.

In family 1 maximum girth was observed by progeny 3 (4.69cm) and was significantly superior to all others, followed by progeny 6 (3.72cm). Fruit girth was minimum in progeny 2 (2.96cm).

Progeny 6 possessed maximum fruit girth (4.25cm) in family 2 and was significantly superior to all others, followed by progeny 4 (3.64cm). Minimum fruit girth was observed in progeny 2 (3.17cm).

Girth of fruit was maximum in progeny 6 (4.94cm) and was significantly superior to all others in the case of family 3, followed by progenies 1 (4.56cm) and 3 (4.59cm). Fruits with minimum girth were observed by progeny 2 (3.99cm).

In family 4, maximum girth was noticed by progeny 4 (3.82cm) and was on par with progenies 3 (3.81cm), 5 (3.80cm) and 1 (3.36cm). Minimum fruit girth was observed by progeny 2 (2.97cm).

Fruit girth ranged from 3.77cm to 5.91cm in family 5, maximum girth was observed by progeny 2 (5.91cm) and was significantly superior to others, followed by progenies 4 (4.82cm) and 1 (4.48cm). Fruits with minimum girth were produced by progeny 3 (3.77cm).

Maximum fruit girth was observed by progeny 5 (4.24cm) in family 6 and was on par with progeny 6 (4.15cm). Girth of fruit was minimum in progeny 2 (3.37cm).

In family 7, fruits produced by progeny 3 had maximum girth (4.56cm) and was significantly superior to all others, followed by progeny 4 (4.23cm) and 5 (4.21cm). Minimum fruit girth was observed in progeny 1 (3.74cm).

Fruits with maximum girth was observed in progeny 1 (4.64cm)in family 8 and was on par with progenies 3 (4.61cm) and 6 (4.57cm). Fruit girth was observed to be minimum in progeny 2 (3.65cm).

4.2.7 Fruit yield per plant

Fruit yield among the different families ranged from 282.58g to 376.54g (Table 9.7) and the maximum was in family 8 (376.54g) and was significantly superior to all others, followed by families 5 (339.56g), 3 (329.30g) and 4 (328.17). Family 1 possessed poor yield (282.58g) compared to others.

In family 1, maximum yield was observed in progeny 1 (383.12g) and was significantly superior to all others, followed by progeny 6 (312.92g). Minimum fruit yield was noticed in progeny 2 (236.07g).

Fruit yield ranged from 219.98g to 411.58g in family 2 and best yielder progeny 2 (411.58g) was significantly superior to all others, followed by progeny 6 (351.80g). Progeny 5 was found to be a poor yielder giving 219.98g.

Progeny 3 was considered as the promising yielder (469.34g) in family 3 and was highly significant than others, followed by progenies 4 (376.88g) and 6 (337.14g). Fruit yield was minimum in progeny 1 (233.15g).

Best yielding progeny was 4 in family 4 (469.89g) and was significantly superior to all others, followed by progeny 5 (388.35g) and 6 (312.76). Progeny 2 possessed poor yield (239.41g) compared to others.

Table 9.7 Mean performance of the progenies within the families for fruit yield per plant (g)

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	383.12	236.07	257.89	262.03	243.45	312.92	29.670	282.58
2	234.76	411.58	254.53	298.66	219.98	351.80	47.563	295.22
3	233.15	266.72	469.34	376.88	292.58	337.14	35.235	329.30
4	248.68	239.41	309.90	469.89	388.35	312.76	39.734	328.17
5	310.81	271.26	428.76	454.13	273.83	298.55	36.055	339.56
6	494.60	209.12	403.40	239.86	350.08	257.62	72.220	325.78
7	208.69	197.28	307.17	439.42	266.37	442.75	29.500	310.28
8	210.40	299.86	474.75	380.91	331.55	561.76	38.388	376.54
CD for families (0.05)								23.330

Table 9.8 Mean performance of the progenies within the families for number of seeds per fruit

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	50.70	46.55	52.75	52.85	55.15	50.10	3.802	51.35
2	38.95	50.00	50.65	49.00	48.95	50.45	3.550	48.00
3	39.25	42.37	56.60	44.90	54.80	47.45	2.955	47.56
4	50.65	53.65	50.40	28.05	31.30	36.80	3.813	41.80
5	32.55	40.60	34.90	44.10	55.97	44.55	2.422	42.11
6	62.15	53.76	35.27	52.22	45.35	44.35	3.987	48.85
7	70.72	65.55	56.60	36.35	52.92	43.75	4.321	54.31
8	64.95	54.10	45.37	60.12	44.45	64.05	4.400	55.50
CD for families (0.05)								1.413

In Family 5, maximum fruit yield was observed in progeny 4 (454.13g) and was on par with progeny 3 (428.76g). The progeny noticed as poor yielder was 2 (271.26g) in this family.

Fruit yield per plant showed wide range from 209.12g to 494.60g in family 6. The best yielding progeny was 1 (494.60g) was significantly superior to others, followed by progeny 3 (403.40g). Lowest yield was noticed in progeny 2 (209.12g).

Among the 6 progenies highest yielder was progeny 6 (442.75g) in family 7 and was on par with progeny 4 (439.42g) while progeny 2 giving 197.28g fruit yield was a poor yielder.

The fruit yield per plant was maximum in progeny 6 (561.76g) in family 8 and was significantly superior to all others, followed by progeny 3 (474.75g). Minimum fruit yield was obtained from the progeny 1 (210.40g).

4.2.8 No. of seeds per fruit

According to the family mean (Table 9.8) maximum number of seeds was observed in family 8 (55.50) and was on par with family 7 (54.31). Progeny 4 possessed minimum no of seeds (41.80) among the others.

In family 1 maximum seeds was observed in the fruits produced by progeny 5 (55.15) and was on par with progeny 3 (52.75) and 4 (52.85). Minimum seeds were found in the fruits of progeny 2 (46.55).

Progeny 2 showed maximum number of seeds in single fruit (50.65) in family 2 and was on par with progenies 2 50.00), 6 50.45). 4 (49.00) and 5 (48.95). Seeds were minimum in progeny 1 (38.95).

Fruits with maximum seeds was observed in progeny 3 (56.60) and was on par with progeny 5 (54.80) in the case of family 3. Progeny 1 possessed minimum seeds (39.25) among the others.

Seeds per fruit were ranged from 28.05 to 53.65 in family 4 and was on par with progenies 3 (50.40) and 1 (50.65). Minimum number of fruits was observed by progeny 4 (28.05).

In family 5 number of seeds was maximum in progeny 5 (55.97) and was significantly superior to all others, followed by progenies 6 (44.55) and 4 (44.10). Progeny 1 showed minimum number of seeds (32.55) compared to others.

Fruits with maximum number of seeds was produced by progeny 1 (62.15) in family 6 and was significantly superior to all others, followed by progenies 2 (53.76) and 4 (52.22). Minimum seeds were observed in progeny 3 (35.27).

Progeny 1 possessed maximum seeds (70.72) in family 7 and was significantly superior to all others, followed by progenies 2 (65.55) and 3 (56.60). Minimum seeds were observed in progeny 4 (35.27).

In family 8 maximum seed per fruit was observed in progeny 1 (64.95) and was on par with progeny 6 (64.05). Fruits possessed minimum seeds was progeny 5 (44.45).

4.2.9 100 seed weight

Mean values of families for 100 seed weight (Table 9.9) was maximum in family 3 (0.58g) and was on par with families 5 (0.57g), 2 (0.53), 1 (0.52g), 5 (0.50g), 8 (0.49g) and 7 (0.38g). Minimum seed weight was observed in family 4 (0.38g).

In family 1, 100 seed weight was maximum in progeny 5 (0.69g) and was on par with progeny 4 (0.58g), 2 (0.53g), 6 (0.50g). Seeds exhibited minimum weight was in progeny 1 (0.39g).

Progeny 4 possessed maximum weight for 100 seeds (0.604g) in family 2 and was on par with progeny 2 (0.583g), 1 (0.575g) and 5 (0.552g). Minimum seed weight was observed by progeny 1 (0.39g).

100 seed weight was maximum in progeny 1 (0.718g) and was on par with progeny (2 0.706g), 6 (0.557g), 4 (0.543g) and 3 (0.501g) in the case of family 3. Seeds showed minimum weight was observed by progeny 6 (0.415g).

In family 4, weight of 100 seeds was maximum in progeny 2 (0.44g) and was on par with progenies 6 (0.41g, 4 (0.40g), 1 (0.37g) and

Table 9.9 Mean performance of the progenies within the families for 100 seed weight (g)

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	0.398	0.535	0.414	0.583	0.699	0.503	0.266	0.522
2	0.575	0.583	0.423	0.604	0.552	0.462	0.244	0.533
3	0.718	0.706	0.501	0.543	0.415	0.557	0.293	0.573
4	0.376	0.441	0.332	0.400	0.362	0.415	0.295	0.388
5	0.388	0.504	0.501	0.684	0.531	0.410	0.260	0.503
6	0.647	0.620	0.458	0.525	0.557	0.612	0.294	0.570
7	0.413	0.382	0.429	0.516	0.386	0.488	0.295	0.435
8	0.393	0.326	0.552	0.514	0.503	0.659	0.265	0.491
CD for families (0.05)								0.167

Table 9.10 Mean performance of the progenies within the families for plant height (cm)

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	44.05	33.60	24.70	55.05	36.05	33.90	3.430	37.89
2	45.00	38.85	40.15	38.00	37.70	38.30	9.926	39.66
3	39.55	40.95	53.55	52.45	55.80	58.55	10.758	50.14
4	49.32	66.70	57.65	44.75	40.05	40.10	7.832	49.76
5	43.05	50.05	47.75	63.55	38.85	50.80	8.822	49.00
6	56.95	50.45	32.60	43.45	35.85	58.80	8.633	46.35
7	36.75	36.95	44.95	45.65	52.45	43.00	6.557	43.29
8	33.30	36.15	39.40	44.65	44.20	37.45	7.436	39.19
CD for families (0.05)								3.950

5 (0.36g). Minimum seed weight for 100 seeds was exhibited by progeny 3 (0.332g).

Maximum seed weight for 100 seeds was observed by progeny 4 (0.68g) in family 5 and was on par with progenies 5 (0.531g), 2 (0.504g) and 3 (0.501g). Seed weight was minimum in progeny 1 (0.388g).

Progeny 1 showed maximum seed weight (0.647g) in family 6 and was on par with progenies 2 (0.62g), 6 (0.61g), 5 (0.55g) and 4 (0.52g). Minimum seeds weight was observed in progeny 3 (0.45g).

In family 7, 100 seed weight was observed as maximum by progeny 4 (0.516g) and was on par with progenies 6 (0.488g), 3 (0.429g) and 1 (0.413g). Seed weight was less in progeny 2 (0.382g)

Seed weight for 100 seeds was maximum in progeny 6 (0.659g) for family 8 and was on par with progenies 3 (0.552g), 4 (0.514g) and 5 (0.503g). Progeny 2 possessed minimum seed weight (0.326g) among others.

4.2.10 Plant height

Among the family means Table (9.10), maximum height was observed in family 3 (50.14cm) and was on par with families 4 (49.76cm), 5 (49.00cm) and 6 (46.35cm). Plant height was observed as minimum in family 1(37.89cm).

In family 1 maximum plant height was observed in progeny 4 55.05cm and was significantly superior to all others, followed by progeny 1 (44.05cm). Minimum height was observed by progeny 3 (24.70cm).

Progeny 6 showed plants with maximum height (45.00cm) in family 2 and was on par with progenies 3 (40.15cm), 2 (38.85cm), 4 and 6 (38cm). Minimum height was noticed in progeny 5 (37cm).

Height of plants was observed as maximum by progeny 6 (58.55cm) in family 3 and was on par with progenies 5 (55.80cm), 3 (53.55cm) and 4 (52.45cm). Minimum height was observed by progeny 1 (39.55cm).

In family 4, maximum plant height was possessed by progeny 2 (66.70cm) and was significantly superior to all others, followed by progenies 3 (57.65cm). Plant height was minimum in progeny 6 (41.10cm).

Progeny which possessed maximum height in family 5 was 4 (63.55cm) and was significantly superior to all others, followed by progenies 6 (50.80cm) and 2 (50.05cm). Minimum height was observed by progeny 5 (38.85cm).

Plants exhibited maximum height was observed in progeny 6 (58.80cm) and was on par with progenies 1 (56.95cm), 2 (50.45cm) in the case of family 6 while short plants were noticed in progeny 3 (32.60cm).

Maximum plant height was observed by progeny 5 (52.45cm) in family 7 and was significantly superior to all others, followed by progenies 4 (45.65cm) and 3 (44.95cm). Height of plant was minimum in progeny 1 (36.75cm).

In family 8, plants with maximum height were observed in progeny 4 (44.65cm) and was on par with progenies 3 (39.40cm) and 6 (37.45cm). Plant height was minimum in progeny 1 (33.30cm).

4.2.11 Duration of the crop

Among the 8 families duration was observed (Table 9.11) as minimum in family 8 (114.59days) and was significantly superior to all others, followed by families 5 (118.05) days and 3 (108.90days). Long duration habit was observed by the progeny 1 (121.50days).

In family 1, crop duration was minimum in progeny 5 (116.35days) and was on par with progeny 1 (119.05days). Maximum duration was noticed in progeny 6 (130.40days).

Among the 6 progenies in family 2 long duration was expressed by progeny 1 (116.90days) and was on par with progenies 2 (119.25days) and 3 (119.75days). Duration was observed as maximum by progeny 6 (130.95days).

Table 9.11 Mean performance of the progenies within the families for duration of crop (days)

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	119.05	122.55	120.25	120.40	116.35	130.40	3.467	121.50
2	116.90	119.25	119.75	118.90	121.00	130.95	2.521	121.29
3	117.35	119.25	119.40	117.15	121.45	118.85	3.381	118.90
4	119.55	121.40	119.45	118.55	121.60	117.60	4.734	119.69
5	117.05	118.95	118.95	115.05	120.65	117.65	3.477	118.05
6	120.85	121.25	121.25	116.70	121.95	116.45	3.307	119.74
7	125.00	125.55	116.50	115.00	116.25	118.40	3.517	119.45
8	114.20	113.30	114.75	118.85	114.95	111.50	3.545	114.59
CD for families (0.05)								1.709

Table 9.12 Mean performance of the progenies within the families for colour of fruit

Family	Progenies					
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6
1	Yellowish green	Yellowish green	Light green	Dark green	Light green	Green
2	Light green	Green	Green	Light green	Green	Dark green
3	Green	Dark green	Green	Light green	Dark green	Light green
4	Light green	Light green	Green	Green	Dark green	Green
5	Green	Light green	Green	Dark green	Green	Light green
6	Green	Green	Light green	Green	Light green	Light green
7	Green	Green	Green	Light green	Green	Green
8	Green	Light green	Light green	Light green	Light green	Yellowish green

Progeny 4 possessed minimum duration (117.15days) in family 3 and was on par with progenies 1 (117.35days), 6 (118.85days), 2 (119.25days) and 3 (119.40days). Maximum duration was exhibited by progeny 5 (121.45days).

All the progenies in family 4 possessed relatively same range of duration and in that minimum were observed by progeny 6 (117.60days) and maximum by progeny 5 (121.60days).

In family 5, plants which showed short duration habit was in progeny 4 (115.05days) and was on par with progenies 2 (117.05days) and 6 (117.65 days). Duration of plants was maximum in progeny 5 (120.65days).

Progeny 6 showed short duration habit (116.45days) and was on par with progenies 4 (116.70days). Crop duration was maximum in progeny 5 (121.95days).

Duration of crop was observed as minimum in progeny 4 (115.00days) in the case of family 7 and was on par with progenies 5 (116.25days), 3 (116.50days) and 6 (118.40days). Progeny 2 was observed as long duration type (125.55days) compared to the others.

Crop duration ranged from 111.50days to 118.85days in family 8 and was on par with progenies 1 (114.25days), 3 (114.75days) and 5 (114.95days). Maximum duration was exhibited by progeny 4 (118.85days).

4.2.12 Colour of fruit

Colour of fruit (Table 9.12) showed variation among the progenies within the families. In family 1 the colour of fruit ranged from yellowish green to dark green, in families 2, 3, 4 and 5 colour variations from light green to dark green. In family 5, the progenies exhibited only two colour gradations as green and light green, in family 7 majority of the progenies were in dark green colour. In family 8 all the progenies possessed light green colour except progenies 6 (yellowish green) and 1(green).

4.2.13 Anthracnose disease incidence and intensity at 30 DAT and 45 DAT

Anthracnose disease incidence was not observed in any of the families at 30 DAT and 45 DAT in the field. Since the disease occurrence was noticed later in the field, the scoring for anthracnose disease was done at 80 DAT.

4.2.14 Anthracnose disease incidence and intensity at 80 DAT

Family 6 possessed maximum disease incidence (Table 9.13) (1.67%) and intensity (3.73%) (Table 9.14). Minimum incidence was in family 4 (0.30%) and intensity in family 3 (0.68%).

In family 1, only two progenies possessed disease incidence. Maximum incidence and intensity of the disease were in progeny 3 (3.37% and 7.47% respectively). Progeny 2 possessed minimum incidence (2.38%) and intensity (6.22%).

Among the 6 progenies in family 2, disease incidence and intensity were maximum in progeny 1 (2.76% and 3.54% respectively). Progeny 5 possessed minimum disease incidence (1.94%) and intensity (2.67%).

In family 3, disease incidence and intensity was relatively less and among the 6 progenies only two progenies possessed disease incidence and intensity, progeny 1 (1.73% and 1.96% respectively) and progeny 2 (2.14 % and 1.81% respectively).

Progeny 1 and 5 showed disease incidence and intensity in family 4 and maximum incidence and intensity were observed in progeny 3 (3.15% and 6.62% respectively). Progeny 1 possessed minimum incidence (1.83%) and intensity (2.15%) and all other progenies showed disease free condition.

All the progenies except one (progeny 1) had disease incidence and intensity in family 5, maximum disease incidence was observed in progeny 2 (2.87%) and intensity by progeny 6 (3.64%). Disease

Plate 9. Field view of anthracnose disease

Table 9.13 Anthracnose disease incidence at 80 DAT

Family	Progenies					
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6
1	0	2.38	3.37	0	0	0
2	2.76	0	2.61	0	1.94	0
3	1.73	1.81	0	0	0	0
4	1.83	0	3.15	0	0	0
5	0	2.87	1.66	1.25	1.92	2.25
6	0	1.78	0	4.29	1.67	2.27
7	0	0	0	0	2.27	0
8	1.17	0	0	0	1.89	0

Table 9.14 Anthracnose disease intensity at 80 DAT

Family	Progenies					
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6
1	0	6.22	7.47	0	0	0
2	3.54	0	3.31	0	2.67	0
3	1.96	2.14	0	0	0	0
4	2.15	0	6.62	0	0	0
5	0	2.25	1.35	1.42	2.04	3.64
6	0	4.61	0	8.35	4.31	5.12
7	0	0	0	0	5.42	0
8	1.51	0	0	0	3.17	0

incidence and intensity were minimum in progenies 4 (1.25%) and 3 (1.35%).

Among the 6 progenies in family 6, four progenies showed disease incidence and intensity and in that maximum disease incidence and intensity were observed by progeny 4 (4.29% and 8.35%). Minimum incidence was observed in progeny 5 (1.67%) and intensity by progeny 5 (4.31%).

In family 7, only one progeny possessed (Progeny 5) disease incidence (2.27%) and intensity (5.42%) and all others were free from the disease.

The plants in progenies 1 and 5 were found to be affected by disease in family 8 and all others progenies were resistant to anthracnose. Among these two progenies maximum incidence and intensity were in progeny 5 (1.89% and 3.17% respectively) while minimum incidence and intensity were observed in progeny 1(1.17% and 1.51 %).

4.2.15 Capsaicin content

According to family means (Table 9.15; Fig 4.1) maximum capsaicin content was observed in family 2 (0.519%) and was on par with families 8 (0.511%) and 1 (0.506%). Minimum capsaicin content was observed in family 4 (0.361%).

In family 1 maximum capsaicin content was observed by progeny 1 (0.711%) and was significantly superior to all others, followed by progenies 6 (0.609%) and 4 (0.597%). Capsaicin content was minimum in progeny 2 (0.258%).

Progeny 4 (0.812%) possessed high amount of capsaicin in family 2, and was significantly superior to all others, followed by progenies 1 (0.620%) and 1 (0.602%). Less amount of capsaicin was observed in progeny 1 (0.174%).

Maximum content of capsaicin was observed by progeny 6 (0.556%) in family 3 and was significantly superior to all others,

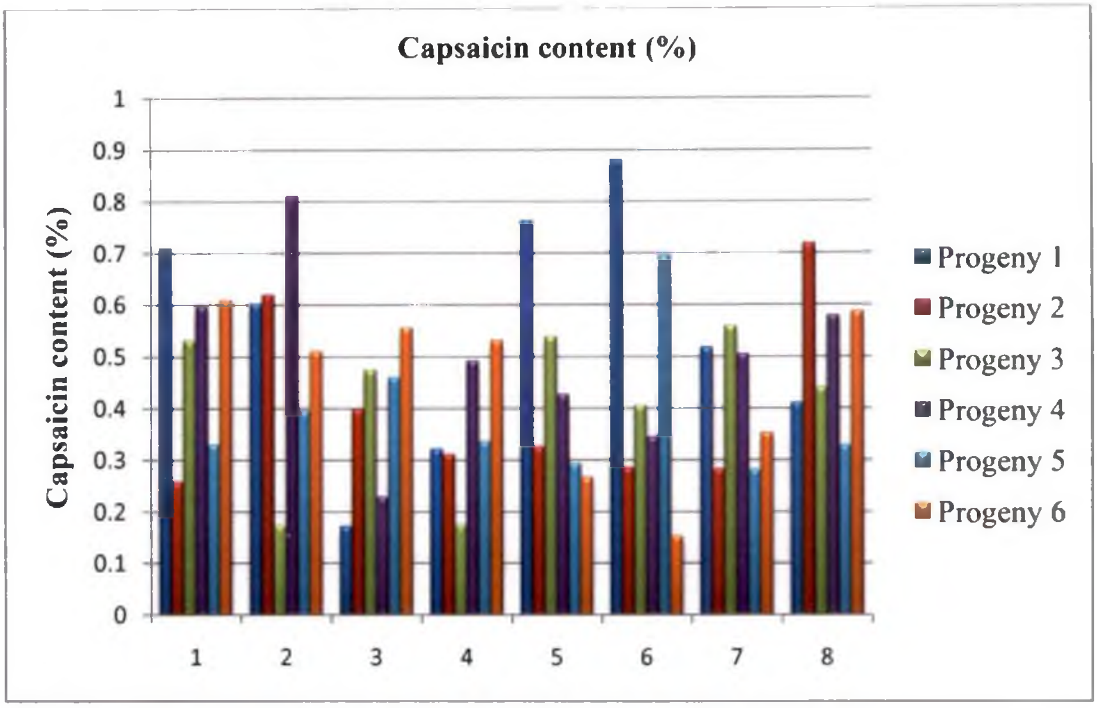

Fig. 4.1. Mean performance of progenies within the families for capsaicin content (%)

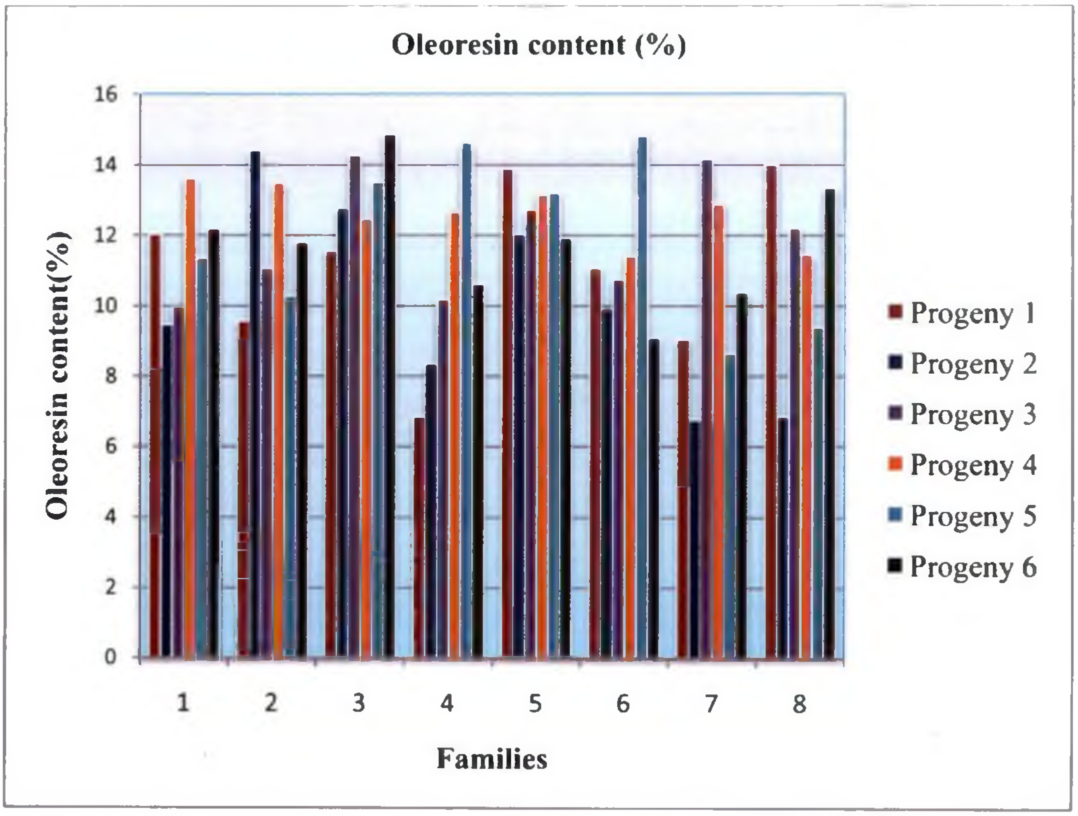

Fig 4.2. Mean performance of progenies within the families for oleoresin content (%)

Table 9.15 Mean performance of the progenies within the families for Capsaicin content (%)

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	0.711	0.258	0.533	0.597	0.330	0.609	0.060	0.506
2	0.602	0.620	0.174	0.812	0.395	0.511	0.062	0.519
3	0.172	0.397	0.475	0.229	0.461	0.556	0.055	0.382
4	0.322	0.311	0.175	0.492	0.336	0.532	0.051	0.361
5	0.763	0.326	0.539	0.427	0.293	0.266	0.051	0.436
6	0.881	0.285	0.405	0.345	0.695	0.153	0.073	0.461
7	0.518	0.282	0.559	0.505	0.281	0.353	0.186	0.416
8	0.411	0.719	0.441	0.579	0.329	0.587	0.057	0.511
CD for families (0.05)								0.030

9.16 Mean performance of the progenies within the families for Oleoresin content %

Family	Progenies						CD for progenies	Family mean
	Progeny 1	Progeny 2	Progeny 3	Progeny 4	Progeny 5	Progeny 6		
1	12.04	9.46	9.96	13.63	11.35	12.18	1.130	11.44
2	9.57	14.40	11.07	13.50	10.28	11.79	1.851	11.77
3	11.56	12.76	14.28	12.46	13.52	14.87	0.764	13.24
4	6.85	8.34	10.18	12.69	14.64	10.62	0.923	10.55
5	13.91	12.02	12.72	13.16	13.22	11.92	1.146	12.82
6	11.07	9.08	10.75	11.42	14.83	9.08	1.046	11.18
7	9.04	6.76	14.15	12.90	8.64	10.36	1.003	10.31
8	14.01	6.85	12.25	9.39	11.46	13.34	1.158	11.22
CD for families (0.05)								0.596

Plate 8. High yielding progenies from field experiment

Plate 8 (Contd.). High yielding progenies selected from field experiment

followed by progenies 3 (0.475%) and 5 (0.461%). Capsaicin content was low in progeny 3 (0.172%).

Percentage of capsaicin was high in progeny 6 (0.532%) in family 4 and was on par with progeny 4 (0.492%). Minimum amount of capsaicin was noticed in progeny 3 (0.175%).

In family 5, high amount of capsaicin was observed in progeny 1 (0.763%) and was significantly superior to all others followed by progenies 3 (0.539%) and 4 (0.427%). Less percentage of capsaicin was possessed by progeny 6 (0.266%).

Capsaicin content in family 6 was ranged from 0.153% to 0.881% and maximum amount of capsaicin was found in progeny 1 (0.881%) and was significantly superior to all others, followed by progeny 5 (0.695%). Percentage of capsaicin was minimum in progeny 6 (0.153%).

Progeny 3 showed high level of capsaicin range (0.559%) in family 7 and was on par with progenies 1 (0.518%) and 4 (0.505%). Level of capsaicin content was minimum in progeny 5 (0.281%).

Capsaicin percentage was observed as maximum by progeny 2 (0.719%) in family 8 and was significantly superior to all others, followed by progenies 6 (0.587%) and 4 (0.579%). Low percentage of capsaicin was observed in progeny 5 (0.329%).

4.2.16 Oleoresin content

Mean values of oleoresin content was ranged from 10.31% to 13.24% among 8 families (Table 9.16; Fig 4.2) and maximum level of oleoresin was observed in family 3 (13.24%) and was on par with family 5 (12.82%). Minimum amount of oleoresin was found in family 7 (10.31%).

In family 1 maximum amount of oleoresin was showed by progeny 4 (13.63%) and was significantly superior to all others, followed by progeny 6 (12.18%) and 1 (12.04%). Oleoresin percentage was minimum in progeny 2 (9.46%).

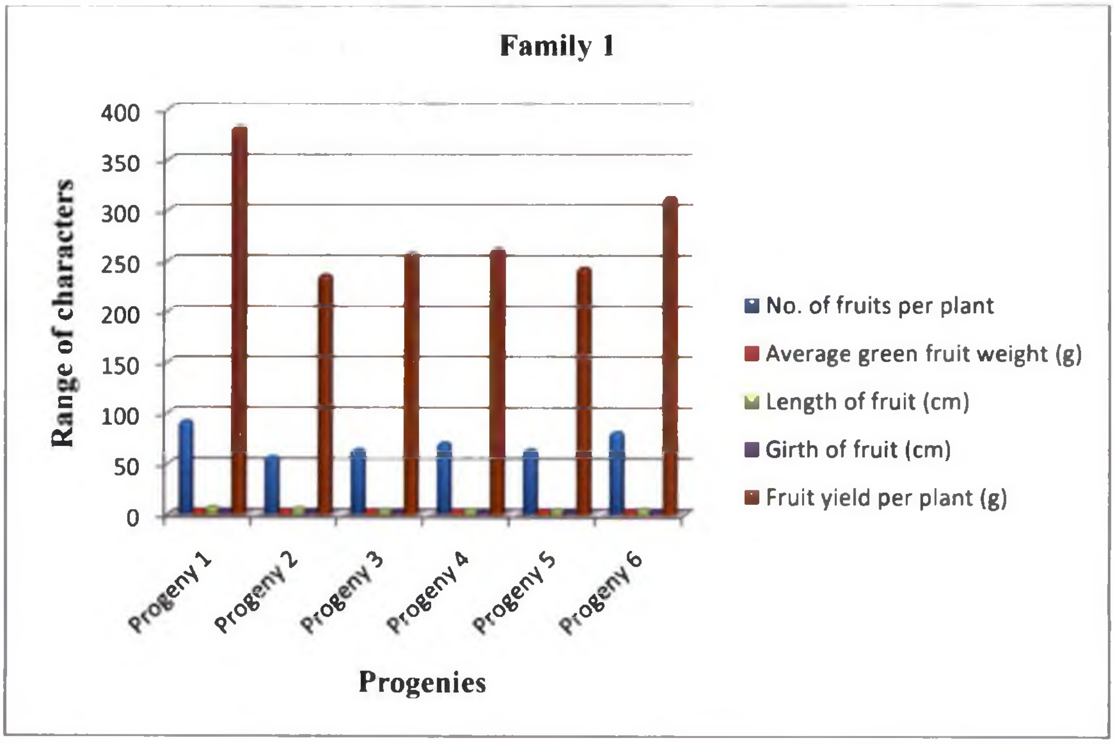

Fig. 5.1. Performance of progenies based on yield attributes: Family 1

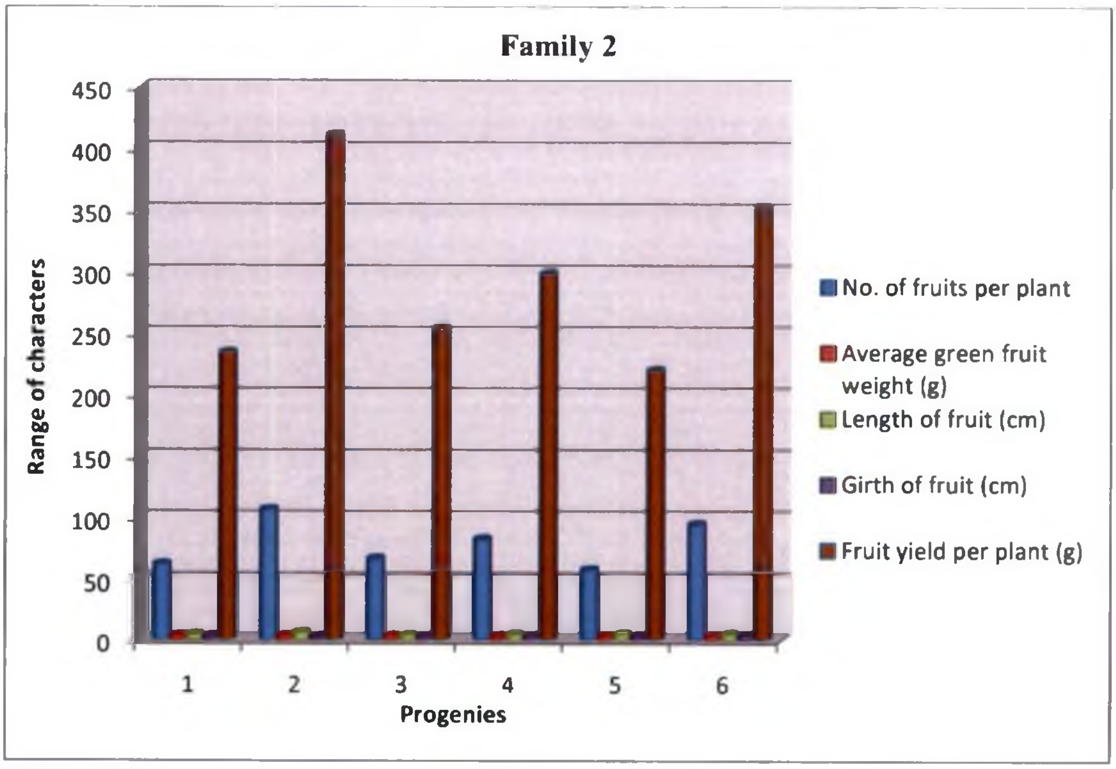

Fig. 5.2. Performance of progenies based on yield attributes- Family 2

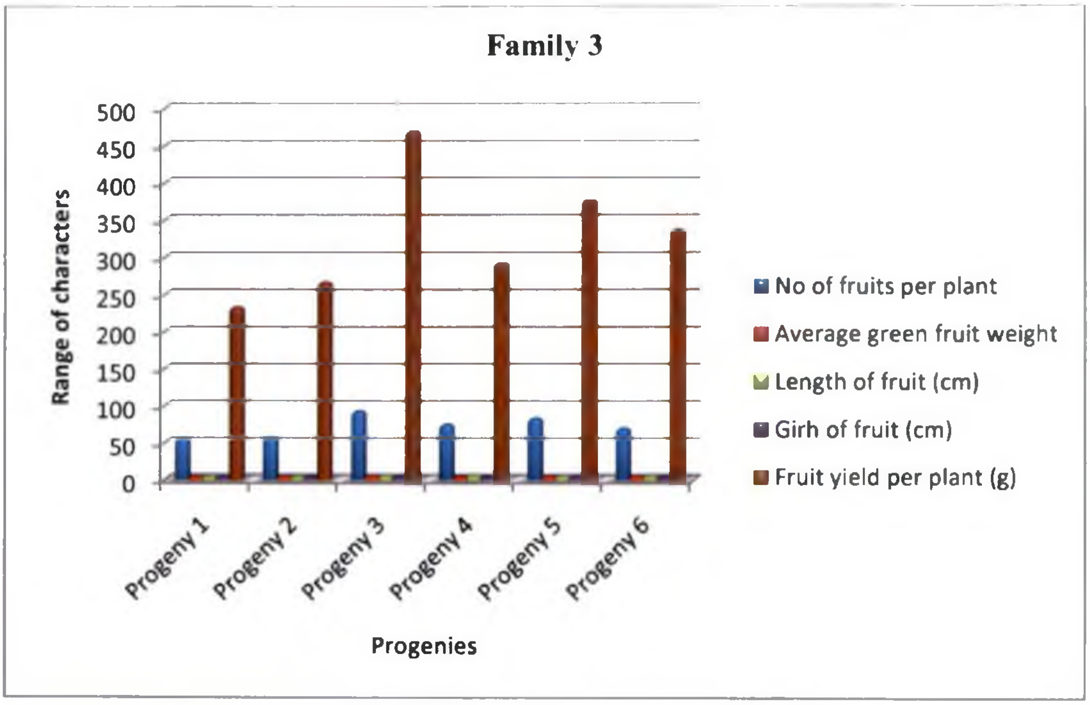

Fig. 5.3. Performance of progenies based on yield attributes- Family 3

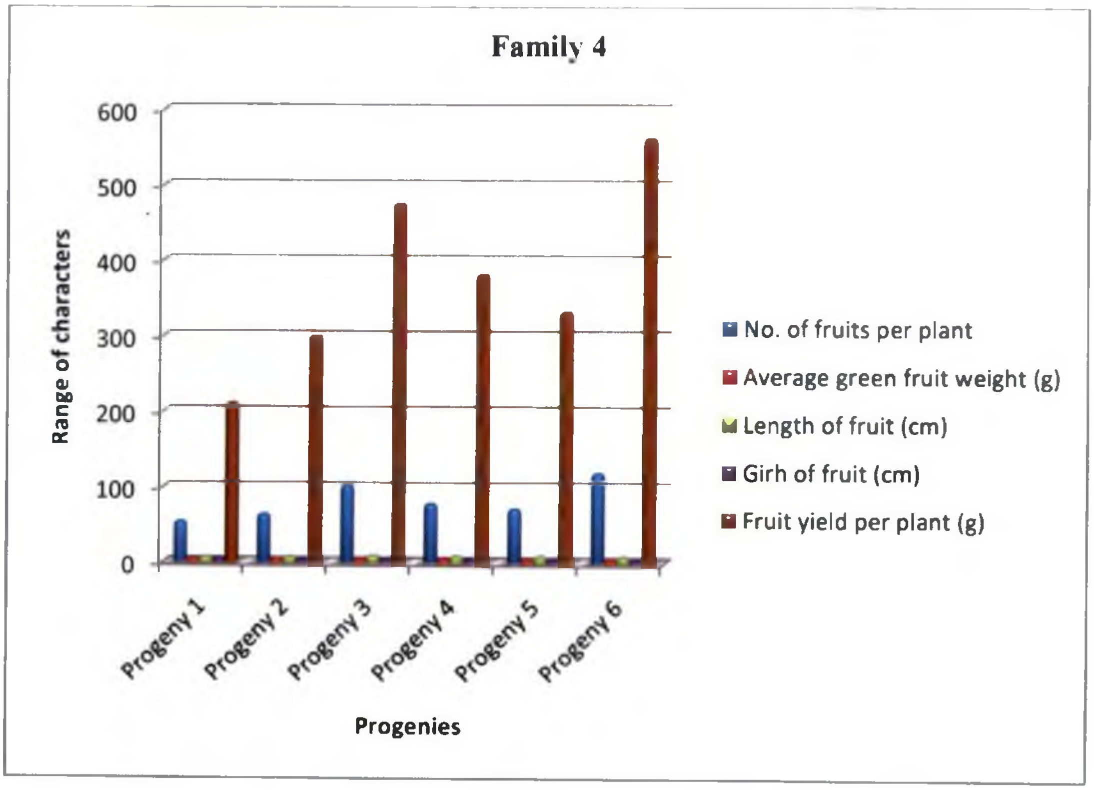

Fig. 5.4. Performance of progenies based on yield attributes- Family 4

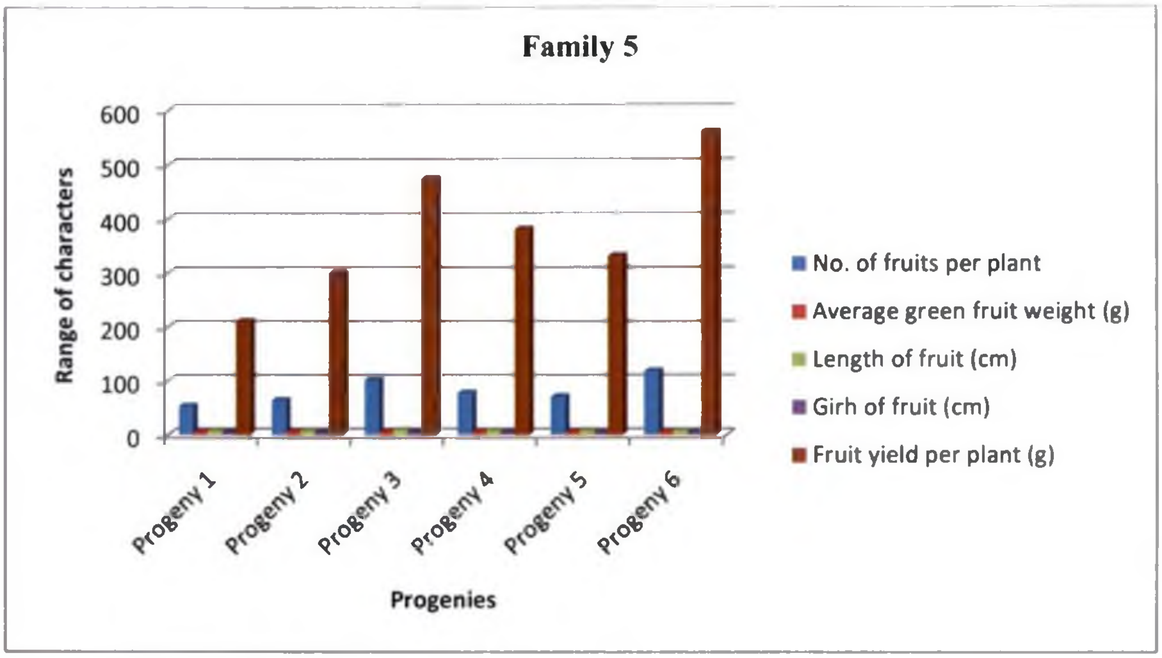

Fig 5.5. Performance of progenies based on yield attributes- Family 5

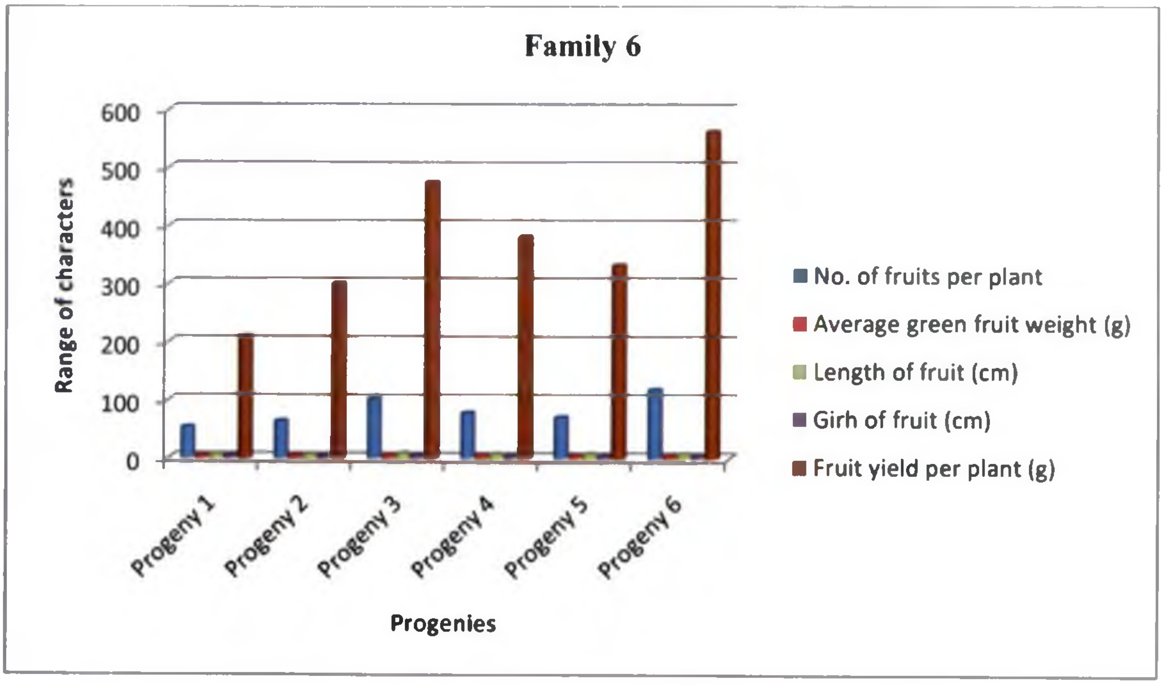

Fig 5.6. Performance of progenies based on yield attributes- Family 6

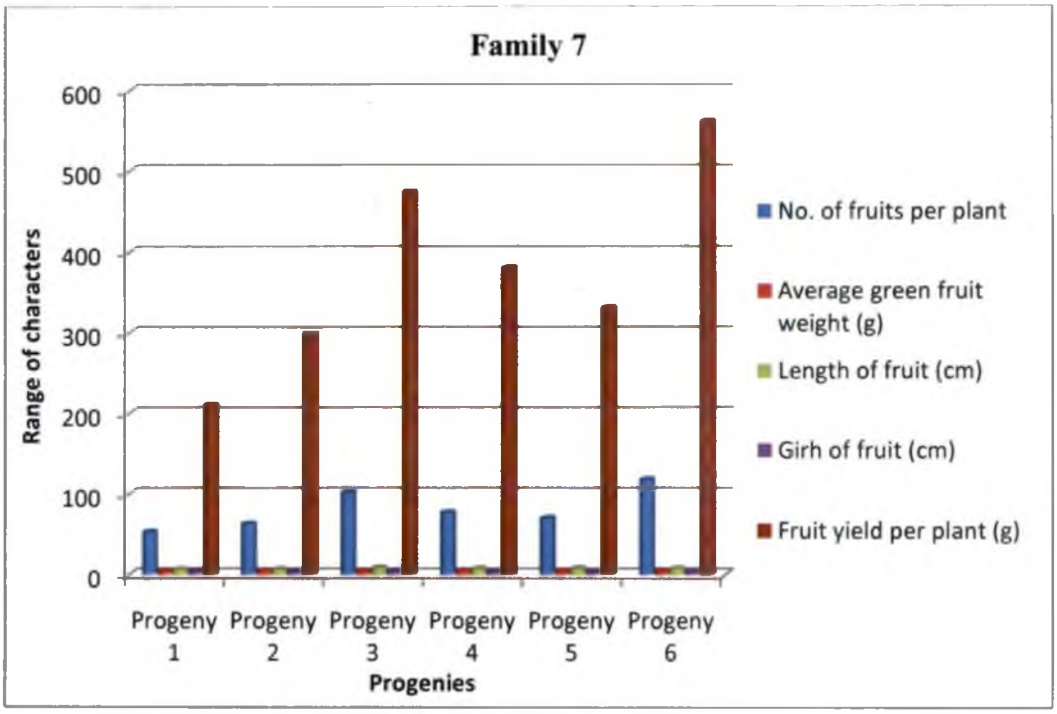

Fig 5.7. Performance of progenies based on yield attributes- Family 7

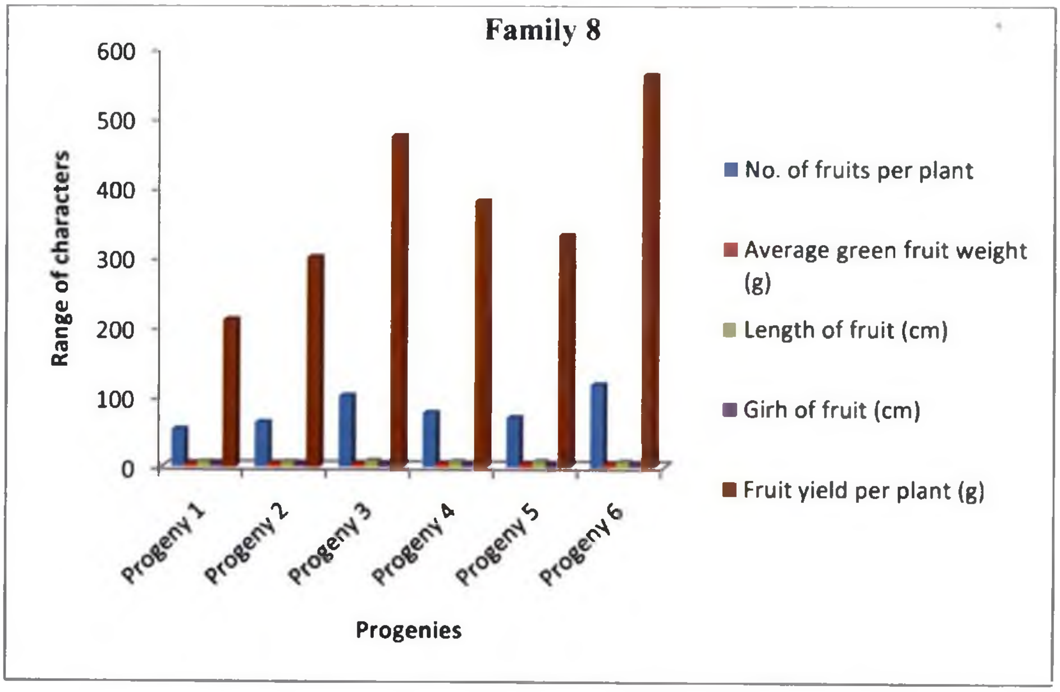

Fig 5.8. Performance of progenies based on yield attributes- Family 8

Progeny 2 possessed high level of oleoresin content (14.40%) in family 2 and was on par with progeny 4 (13.50%). Amount of oleoresin was less in progeny 1 (9.57%).

Maximum range of oleoresin percentage was expressed by progeny 6 (14.87%) in family 3 and was on par with progeny 3 (14.28%). Minimum level of oleoresin was found in progeny 1 (11.56%).

Oleoresin percentage was ranged from 6.85% to 14.64% in family 4 and high percent was observed in progeny 5 (14.64%) and was significantly superior to all others, followed by progeny 4 (12.69%). Low percentage of oleoresin was possessed by progeny 1 (6.85%).

Percentage level of oleoresin was found as maximum in progeny1 (13.91%) and was on par with progenies 5 (13.22%) and 4 (13.16%) in family 5. Minimum oleoresin content was showed by progeny 6 (11.92%).

Maximum percentage of oleoresin was observed by progeny 5 (14.83%) in family 6 and was significantly superior to all others, followed by progeny 4 (11.42%) and 1 (11.07%). Less percentage of oleoresin was found by progeny 2 (9.08%).

In family 7, high amount of oleoresin was observed in progeny 3 (14.15%) and was significantly superior to all others, followed by progeny 4 (12.90%). Minimum percentage was found by progeny 2 (6.76%).

High amount of oleoresin was observed by progeny 1 (14.01%) in family 8 and was on par with progeny 6 (13.34%). Per cent oleoresin was minimum in progeny 2 (6.85%) compared to others.

Discussion

5. DISCUSSION

The salient results gathered in the light of the present investigation are discussed here under

5.1 POT CULTURE EXPERIMENT

5.1.1 Evaluation of yield traits

Knowledge of the extent of variability available in a germplasm is of great importance as it acts as the key factor, which provides a clear practice of genetic advancement that can be achieved through selection. In quantitative characters, phenotypes are unreliable indicators of genotype and so it is desirable to test the genetic value of individuals prior to selection. As the observed variability in a population is the sum total of variation arising due to genotypic and environmental effects, knowledge on the nature and magnitude of genetic variation leading to gain under selection is essential (Allard 1960). Analysis of variance partitions the total phenotypic variation into genotypic and environmental components. This provides information on the breeding value of genotypes involved and also the nature and magnitude of variability in the expression of a particular character.

Analysis of variance revealed remarkable variation for all the traits under study. Among eight families and eight progenies sufficient variation was noticed for days to first flowering and early flowering nature was observed by progenies 5 and 8 in families 1 and 2 , in family progeny 8 in family 3, progeny 5 in families 7 and 8, progeny 4 in families 4 and 6 and progeny 3 in family 5. For number of fruits per plant, progeny 1 in families 1and 6, progeny 3 in family 2, progeny 8 in families 3,7 and 8, progeny 6 in family 4 and progeny 4 in family 5. Average green fruit weight was maximum in progeny 1 in family 1, progenies 3 and 6 in family 2, progeny 8 in family 3, progenies 6 and 7 in family 4, progenies 1 and 6 in family 5, progenies 4 and 7 in family 6, progenies 8 and 2 in family 7 and progenies 5,3 and 8. Longest fruits were produced by the progenies 1(family 1), 8 and 6(Family 2), 1, 3, 6 and 5(Family 3), 7and 8 (Family 4), 1 and 6 (Family 5), progeny 1(Family 6), 1, 4 and 6 (Family 7), 2 and 8 (Family 8). Girth of fruit was maximum in progeny 2 in family 1, progeny 4 in family 2, progeny 5 in family 3, progenies, 4, 3 and 5 in family 4, progeny 6 in family 5, progeny 5 in family 6, progenies 8 and 4 in family 7 and progenies 2 and 1 in family 8. Progenies such as 8 and 6, 5 and 3, 1 and 8, 5 and 6, 7 and 5, progeny 5, 4 and 2, 3 and 5 in families 1,2,3,4,5,6,7 and 8 respectively possessed plants with maximum height. Progenies observed as the superior yielders among the eight families were progeny 1 in family 1, progeny 3 in family 2, progenies 8 and 6 in family 3, progeny 6 in family 4, progenies 6 and 1 in family 5, progenies 1 and 3 in family 6, progeny 8 in family 7 and progenies 8 and 3 in family 8. Crop duration was minimum in progeny 1 in families 2, 3 and 6, progeny 4 in families 1 and 8, progeny 8 in families 4 and 5 and progeny 6 in family 6.

Similar findings showing variations in varietal characters in chilli have been reported earlier. Some of the important works on variability include those of Rani (1996) for fruit weight, fruit length and number of seeds per fruit, Jabeen *et al.* (1999) and Nayeema *et al.* (1998) for fruit yield, Verma *et al.* (1998), Pichaimuthu and Pappiah (1992) for number of fruits per plant and fruit girth, and Devi and Arumugam (1999) for plant height and days to first flowering.

Reports which are contradictory to the present findings were also observed for average green fruit weight; fruit length and fruit girth by Vijayalakshmi *et al.* (1989), fruit length by Munshi and Behera (2000) and plant height by Ahmed *et al.* (1990).

5.1.2 Screening for anthracnose disease resistance

Anthracnose diseases or die back and fruit rot of chilli caused by the fungus *Colletotrichum capsaici* (Syd.). Butler and Bisby is the most destructive fungal disease as it affects the crop during the early stages and continue till the harvest and as well during storage. Anthracnose is noticed in the mature fruits which cause both pre and post harvest fruit decay resulting in severe yield losses (Hadden and Black, 1987, Bosland and Votava,2000). Screening for anthracnose disease was done under artificial condition by inoculating the plants with spore suspension and scoring for disease incidence and intensity were done in the present investigation.

Similar method was employed by Susheela (2012) who found that the spray inoculation method was found to be the ideal one to identify resistant hybrids in chilli. Large scale screening of chilli germplasm for anthracnose was attempted earlier by Ullasa *et al.* (1981), Basak (1997), Chang and Chung (1985), Jeyalakshmi and Seetharaman (1998) and Roy *et al.* (1998), Hedge and Anahosur (2001),.Liu *et al.* (2001) and Xiao *et al.* (2001).

In the present study anthracnose disease incidence was noticed at 45 DAT and 60 DAT. In family 1 progenies 1, 5, 6 and 7 are anthracnose highly resistant and maximum disease was observed in the progenies 4 and 8 while others were moderately resistant. In family 2 progeny 1 and 4 exhibited high anthracnose disease incidence and progenies 1, 3, 4 were highly resistant;. others were moderately resistant. Progeny 8 showed resistant reaction to the disease in family 3 while other progenies except 4 and 7 (highly susceptible) were moderately resistant. Progenies such as 2, 6, and 8 were highly resistant in family 4 and the progenies 4 and 5 were susceptible to the disease. In family 5, progeny 8 was highly resistant and progenies 2 and 5 were highly susceptible. Progenies such as 4 and 6 were found to be resistant in family 6 where as progenies 2 and 8 exhibited maximum disease incidence and intensity. Only two progenies (3 and 5) exhibited disease incidence in family 7 and all others were resistant to the disease. In family 8, progenies 4 and 6 were highly susceptible to anthracnose while progeny 5 was highly resistant and all others were moderately resistant. However, Pearson *et al.* (1984) while studying 23 cultivars found anthracnose incidence rates ranging from 0-

17.2 percent. In the present investigation, disease intensity gradually increased from 45 DAT to 60 DAT. Majority of the progenies in each of the eight families were observed to be resistant to anthracnose disease at 45 DAT. Several progenies were found to be moderately resistant while few were severely affected by the disease. Jeyalakshmi and Seetharaman (1998), Roy *et al.* (1997) and Basak (1997) noticed chilly types which were resistant to anthracnose disease.

Two progenies from each family were screened out which had comparatively higher disease incidence among the eight progenies. On the basis of anthracnose disease incidence and intensity, yield and yield attributes the progenies 4 and 8, 1 and 4, 4 and 7, 4 and 5, 2 and 5, 2 and 8, 3 and 5 and 4 and 6 from families 1, 2,3,4,5,6,7,8 respectively were screened out and the remaining six superior progenies from each family were considered for the field experiment.

5.1.3 **Genetic parameters**

The genetic parameters like genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance provide a clear insight into the extent of variability and on the relative measure of efficiency of selection based on phenotype. Eight characters such as days to first flowering, no. of fruits per plant, and average green fruit weight, length of fruit, girth of fruit, plant height, fruit yield per plant and duration of crop were studied.

5.1.3.1 ***Coefficient of variation***

Being unit free, coefficient of variation is an ideal tool for comparing the characters measured in diverse units. As phenotypic value is an aggregate of genotypic effect and environmental influence, selection solely based on external parameters may be misleading. Thus genotypic coefficient of variation (GCV) is a more precise indicator of genetic variability in a population compared to phenotypic coefficient of variation (PCV).

In the present study there was close association between the estimates of PCV and GCV. High phenotypic and genotypic coefficients of variation were observed for fruit yield per plant, fruit length and number of fruits per plant.

Similar results of high GCV and PCV values were observed for yield per plant by Ahmed *et al.* (1990), Varalakshmi and Haribabu (1991), Nandi (1993), Sharma and Roy (1995), Rani *et al.* (1996), Kataria *et al.* (1997), Choudary and Das (1998), Sreelathakumari and Rajamony (2002). Arya and Saini (1976), Sing and Brar (1979), Nair *et al.* (1984) , Gopalakrishnan *et al.*(1987) and Singh *et al.* (2011) observed high GCV and PCV for number of fruits, weight of fruit, total fruit yield and fruit length. Plant height possessed moderate range of GCV and PCV and similar result was observed by Singh *et al.* (2011).

Contradictory to the present study, extreme low variability was reported by Ghai and Thakur (1987) and Basavaraj (1997) for yield per plant, number of fruits per plant and fruit length in chilli.

The characters such as days to first flowering, girth of fruit and duration of crop showed extreme low variance which is in conformity with the findings of Giritammanavar (1995), Bini (2004), Rao (2005) and Sandeep (2007) and Kumari *et al.*(2010), Arya and Saini (1977) and Devi and Arumugam (1999).

5.1.3.2 ***Heritability and Genetic advance***

The ratio of genetic variance to phenotypic variance is known as heritability. According to Hanson *et al.* (1956) heritability in broad sense is the ratio of genotypic variance to total variance in non segregating population. Selection acts on genetic differences and the benefit from selection for a particular trait depends on its heritability (Allard, 1960). The extent to which a crop is capable of transmitting its potential to the succeeding generation is termed as its breeding value. If a breeder chooses certain genotypes as parents according to their phenotypic performance, the success in manipulating the characteristics of population could be predicted from the degree of correspondence between phenotype and breeding value. Heritability estimates show the degree to which the phenotype reflects respective genotype and thereby the effectiveness with which selection of genotype could be practiced based on their phenotypic performance.

High heritability in broad sense does not necessarily indicate high response to selection as it includes non additive genetic variance too. According to Johanson *et al.* (1955) high heritability coupled with high genetic advance would be more reliable criterion than simple heritability value alone in predicting the real effects of selection. Genetic advance indicates the progress that could be expected as a result of practicing selection on a particular population. High value of genetic advance indicates better and definite progress on the mean value of population in the succeeding generation. Traits showing high magnitude of heritability coupled with genetic advance are controlled by additive gene action and hence amenable to genetic improvement through selection.

Present investigation revealed high heritability for length of fruit, average green fruit weight and fruit yield per plant, the characters number of fruits per plant while number of fruits per plant and plant height exhibited moderate range of heritability. The characters such as fruit yield per plant and length of fruit showed high genetic advance where as plant height, average green fruit weight and number of fruits per plant showed moderate genetic advance. Heritability and Genetic advance were low for days to first flowering, girth of fruit and duration of crop.

These results are in conformity with the reports by Bini (2004), Sandeep (2007), Patel *et al.* (2009), Gupta *et al.* (2009), Kumari *et al.* (2010) , Sood *et al.* (2011), Nandi (1993), Sharma and Roy (1995), Rani *et al.* (1996), Warade *et al.* (1996), Kataria *et al.* (1997) and Sreelathakumary and Rajamony (2002) who found high heritability and genetic advance for fruit yield per plant indicating a preponderance of additive gene action. Rao and Chonkar (1981), Singh *et al.* (1994), Pichaimuthu and Pappaih (1995), Bhatt and Shah (1996), , Devi and Arumugam (1999), Nandadevi and Hosamani (2003) and Jabeen *et al.* (1999) found high heritability for fruit length, fruit yield per plant and average green fruit weight and moderate for number of fruits per plant and plant height.

In the present study, high heritability coupled with high genetic advance was observed for the characters fruit length and fruit yield per plant while it was moderate for average green fruit weight and number of fruits per plant. Similar findings were observed by Bavaji and Murthy (1982),Rani and Singh (1996),Munshi and Behera (2000), Sreelathakumary and Rajamony (2002), Ukkund *et al.* (2007), Meshram (1987), Sahoo *et al.* (1989), Bhagyalakshmi *et al.* (1990) ,Rani *et al.* (1996), Nayeema *et al.* (1998), Das and Chaudhary (1999), Acharyya *et al.* (2002) and Gupta *et al.* (2009) observed high heritability coupled with high genetic advance for fruit length, yield per plant ,number of fruits per plant and moderate for average green fruit weight and plant height

As against the present study Gai and Thakur (1987) found number of fruits and total yield to possess the lowest values of heritability in a population of parents, F_1s, F_2s and back crosses. Pichaimuthu and Pappaih (1995), Ukkund *et al.* (2007)and Meshram (1987) observed high heritability and genetic advance for fruit girth and days to first flowering as against to the present study.

5.1.4 Correlation

Correlation analysis provides reliable estimates on the nature, extent and direction of selection. Estimates of correlation coefficient form a strong foundation for developing selection index. The correlation coefficient analysis measures the mutual relationship between various characters and it determines the component traits on which selection can be relied upon the effect of improvement. The coefficient of correlation can vary from +1 to −1.

In the present study most of the character combinations exhibited a trend where in genotypic correlation coefficients were of the highest magnitude, followed by the corresponding phenotypic correlation coefficients. This corroborates with the finding of Ahmed *et al.*(1997a). Environmental correlation was found to be the lowest.

Genotypic correlation coefficient was maximum for fruit yield per plant and was positively correlated with number of fruits per plant and average green fruit weight. Girth of fruit was negatively correlated and highly significant with number of fruits per plant. Average green fruit weight showed significant positive correlation with days to first flowering. Fruit length possessed positive significant correlation with average green fruit weight. Plant height was significant and negatively correlated with length and girth of fruit. Duration of crop possessed negatively significant correlation with girth of fruit and also it showed positive significant correlation with plant height.

In the case of phenotypic correlation, fruit yield per plant possessed positive significant correlation with number of fruits per plant and average green fruit weight. Length of fruit showed positive significant correlation with average green fruit weight and it was negatively correlated with number of fruits per plant. Plant height possessed negative correlation with length of fruit and was highly significant. Duration of crop was negatively correlated and highly significant with length of fruit and it was significant and positively correlated with girth of fruit.

Fruit yield per plant was positively correlated with all the eight characters in the present investigation. Some of the reports supporting the present findings are : positive association of fruit yield with fruit length, number of fruits per plant, average green fruit weight, girth of fruit, plant height and duration by Gopalakrishnan *et al.* (1985), Aliyu *et* *al.* (2000), Nandadevi and Hosamani (2003), Jose (2001), Pawade *et al.* (1995), Basavaraja (1997), Chang (1977), Depestre *et al.* (1981), Ibrahim *et al.* (2001), Rathod *et al.* (2002), Mubarak *et al.* (2002), Sonia *et al.* (2006, 2007), Smitha and Basavaraja (2006), Mini (2003), Chaudhary *et al.* (1985), Khadi (1983), Ghai and Thakur (1987), Subashri and Natarajan (1999), Munshi *et al.* (2000) ,Sreelathakumary and Rajamony (2002), Jabeen *et al.* (2009), Gupta *et al.* (2009), Chattopadhyay *et al.*, (2011), and Singh and Singh (2011).

Contradictory to the present findings by Chaim and Paran (2000) and Gopalakrishnan *et al.* (1985) reported negative correlation with length of fruit and fruit girth for fruit yield per plant. Arya and Saini (1976) also reported negative correlation with plant height and fruit yield as against to the present study.

Days to first flowering was negatively correlated with fruit length and plant height while the remaining characters showed positive correlation, similar to the findings by Mini (2003). Contradictory to the present study ,Muthuswamy (2004) reported negative association of days to first flowering with many of the characters studied while it showed positive association with fruit length. Number of fruits per plant showed positive association with average green fruit weight, plant height (Basavaraja, 1997, Ibrahim *et al,* 2001) and it showed negative association with length of fruit, girth of fruit and duration. Smitha (2005) reported negative association with length of fruit. Contradictory to the present findings by Jose (2001), Mini, (2003), Yadwad (2005), Pawade *et al.* (1995) and Akhilesh *et al.*, (2001) observed significant positive correlation of number of fruits per plant with duration, fruit girth and fruit length. Average green fruit weight was found to be positively correlated with length of fruit and girth of fruit and was negatively correlated with plant height and duration in the present study, as against the findings of (Mini 2003). Length of fruit was positively correlated with girth of fruit, similar to the findings of Gopalakrishnan *et al.* (1985).

5.2 FIELD EXPERIMENT

A field experiment was conducted in compact family block design to study the performance of progenies within and between families. Six superior progenies selected from the pot culture experiment were used for the field trial on the basis of yield, yield attributes and anthracnose disease resistance. In field evaluation, anthracnose disease incidence was screened under natural condition. The salient results obtained from the field experiment are discussed hereunder.

There was sufficient variation between families and between progenies for all the characters studied. With respect to days to first flowering, the plants in family 1 possessed early flowering nature compared to the other families. Among progenies, progeny 4 possessed early flowering nature in families 2, 4, 5 and 8, progeny 6 in family 1, progeny 3 in families 3 and7 and progeny 1 exhibited early flowering in family 6. In the case of primary branches per plant, mean performance of family 1 was superior to the others and among the progenies, 5 and 6 in family 1, progeny 4 in the case of families 2 and 3, progeny 2 in family 4, progenies 1 and 5 in families 5 and 6 ,progeny 3 in families 7 and 8. Families 8 and 2 showed high mean values in the case of number of fruits per plant and among the progenies 1,2,3,and 4 possessed highest mean values for number of fruits per plant in families 1,2,3,and 4 respectively and progenies 3 and 1 in families 5 and 6 and progeny 6 in families 7 and 8.

Mean performance was high for average green fruit weight in families 5 and 8 while it was high in progenies 1,2 and 3 for families 1,2 and 3 respectively, progeny 4 in families 4,5, and 8, progeny 5 in families 6 and 7. In the case of fruit length families 6, 7 and 8 were superior with respect to the mean performance and progeny 1 in family progeny 6 in families 4, 6 and 8. In families 1 and 2 progenies 5 and 1 in families 1 and 2.

Singh and Singh (1976) found high variability for plant height, days to flowering, days to maturity, number of branches, fruit length, fruit thickness, number of fruits per plant and yield per plant. Arya and Saini (1977), Hiremath and Mathapati (1977), Elangovan *et al.* (1981) , Ramakumar *et al.* (1981) , Nair *et al.* (1984), Ado *et al.* (1987) , Gopalakrishnan *et al.* (1987) ,Adamu and Ado (1988), Acharya *et al.* (1992) , Sahoo *et al.* (1990), Dwivedi and Bhandari (1999) and Das *et al.* (1990) reported high variability for fruit yield per plant, number of seeds per fruit, number of fruits per plant, fruit size per plant, fruit girth, primary branches, average green fruit weight and plant height. Das and Chaudhary (1999) observed high variability for length of fruit.

High range of variation was observed for all the characters by Ukkund *et al.* (2007), Gupta *et al.* (2009), Munshi and Behera (2000), Nandadevi and Hosamani (2003), Acharyya *et al.* (2002) , Rathod *et al.* (2002) and Prabhudeva (2003) especially for the characters, fruit yield per plant, fruit length, fruit girth, number of fruits per plant, fruit weight, plant height, number of primary branches per plant, capsaicin content and oleoresin content same as in the present study. High variability for the characters number of fruits per plant, weight of fruits per plant and fruit yield was reported by Singh and Singh (2011).

Biochemical analysis was conducted for determining the capsaicin and oleoresin content in chilli. It was noticed that capsaicin content was maximum in family 2, followed by families 8 and 1. Among progenies, progeny 1 showed high capsaicin content in families 1, 5, and 6. Progeny 4 had high capsaicin content in family 2, progeny 6 in families 3 and 4, progenies 3 and 2 in families 7 and 8. Percentage of oleoresin was highest in family 3 followed by family 5. In family 1 maximum oleoresin was observed by progeny 4, in family 2 by progeny 2 followed by

1, 2 in families 2 and 6, progeny 4 in families 3 and 5, progeny 5 in families 4 and 7 and progeny 3 in family 8. Girth of fruit was high in families 5 and 3 according to the mean value and progenies such as 3 in the case of families 1 and 7, progeny 6 in families 2 and 3, and progenies 4,2,5 and 1 possessed maximum mean range for the families 4,5,6 and 8 respectively. Fruit yield per plant was maximum in family 8 and progenies 1,2,3 and 4 possessed higher yield in families 1,2,3 and 4 respectively and progeny 4 in family 5, progeny 1 in family 6 and progeny 6 in families 7 and 8 also exhibited high yield. Number of seeds per fruit was high in family 8 and was on par with family 7. Among the progenies 5 and 3, 2 and 3, 3 and 5, 2,3 and 1, progeny 5, progenies 1 and 6 in families 1,2,3,4,5 and 8 respectively and progeny 1 showed high mean value for number of seeds per fruit in families 6 and 7.

Family 3 possessed maximum 100 seed weight among the families and followed by 5, 2 and 1. Progeny 5 showed maximum 100 seed weight in family 1 followed by progenies 4,2 and 6. In family 2, progeny 4 possessed maximum seed weight followed by progenies 2, 1 and 5. In family 3 maximum seed weight was observed in progeny 1 followed by progenies 2, 6, 4 and 3. Progeny 2 showed high mean value for 100 seed weight in family 4 followed by progenies 6, 4, 1 and 5. In family 5, progeny 4 possessed maximum mean value for 100 seed weight followed by progenies 5,2 and 3. Progeny 4 possessed high value in family 7 and was on par with progenies 6, 3 and 1. Maximum 100 seed weight was observed in progeny 6 in the case of family 8, followed by progenies 3, 4 and 5. Plant height was maximum in family 3, followed by progenies 4, 5 and 6. Progeny 4 possessed maximum height in families 1, 5 and 8. Progeny 6 in families 2, 3 and 6. Height of plant was maximum in progenies 2 and 5 in families 4 and 7 respectively. Duration of crop was minimum in family 8 and was significantly superior. Among progenies, progeny 4 possessed short duration nature in families 3, 5, and 7,

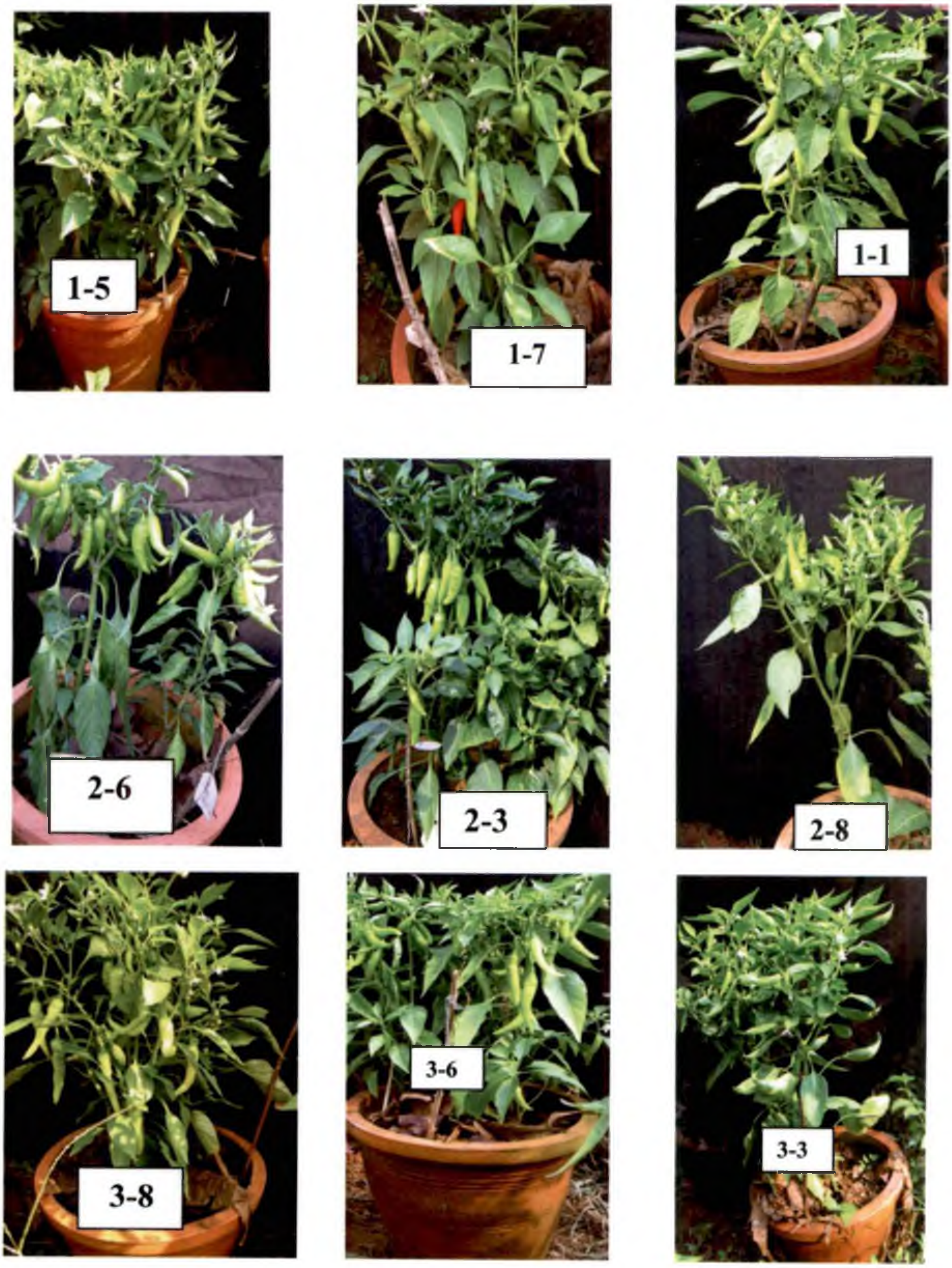

Plate 10. Superior progenies selected from F_4 generation

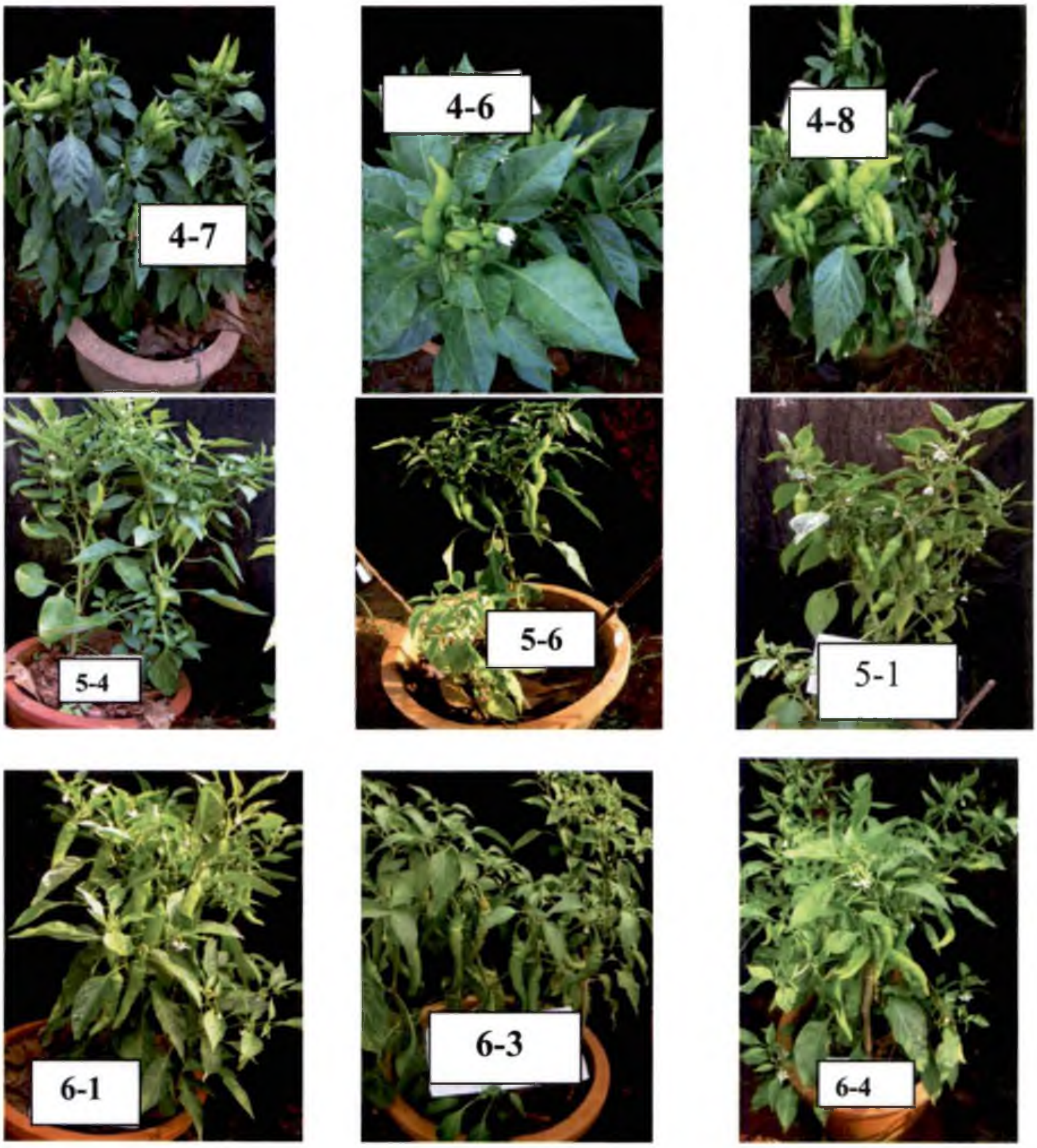

Plate 10 (contd.). Superior progenies selected from F_4 generation

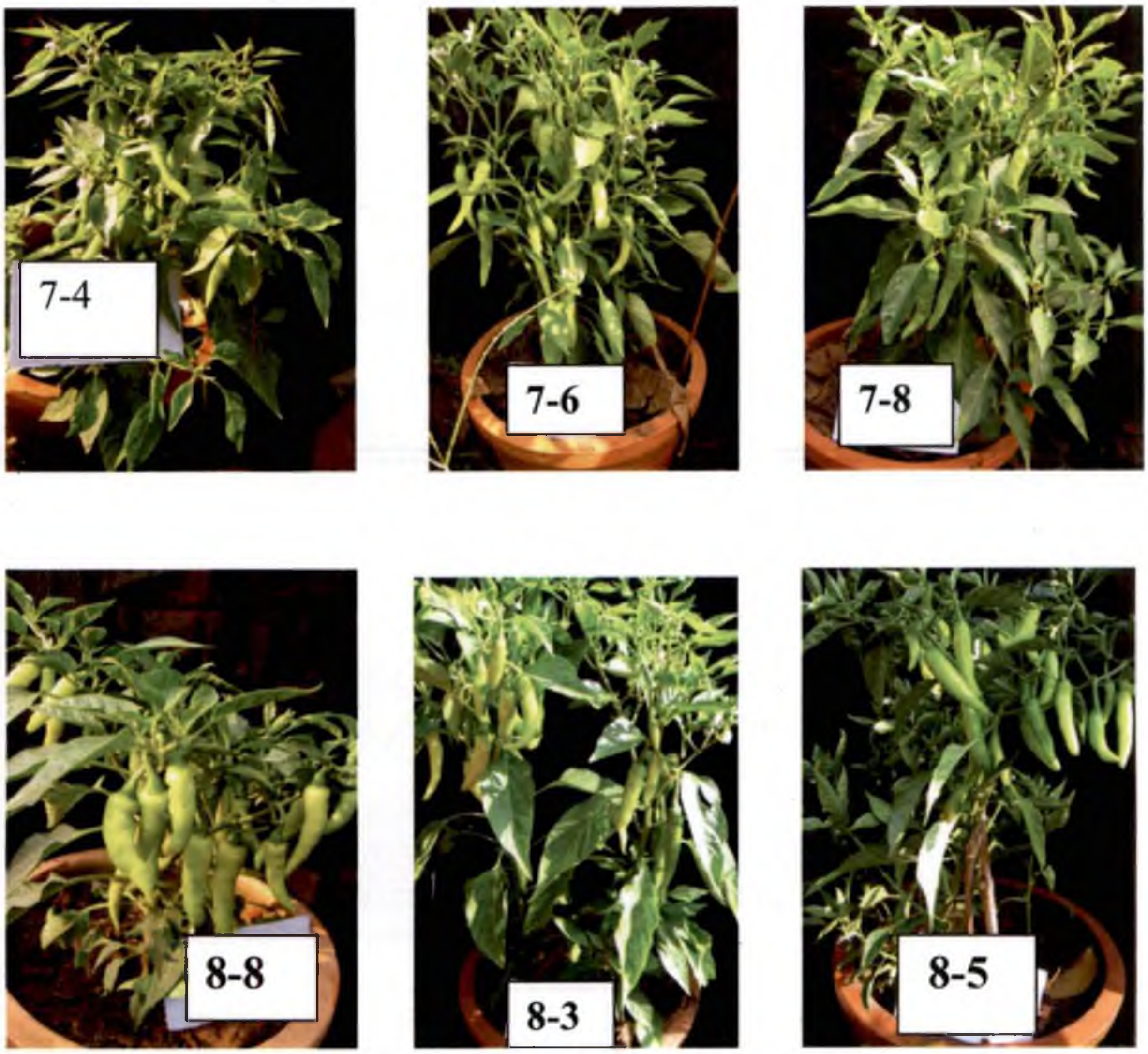

Plate 10 (Contd.). Superior progenies selected from F_4 generation

progeny 4. In family 3 by progeny 6. In families 4 and 6 by progeny 5, in family 7 by progeny 3 and in families 5 and 8 by progeny 1.

Similar studies on capsaicin and oleoresin were conducted by several authors. Indira (1994) classified genotypes with capsaicin in the range 1.0 to 1.5 per cent as highly pungent, 0.25 to 0.75 per cent medium pungent and 0.11 to 0.25 per cent as less pungent and in the present study capsaicin content was ranged from 0.153 to 0.88 was medium pungent. The wide range of variation in capsaicin was reported by several workers, Pradeepkumar (1990), Rani (1996), Mini (1997), Cherian (2000) and Sreelathakumary (2000). In the present study progenies which were found resistant possessed high amount of capsaicin. Azad (1991) also reported that the percentage of capsaicin was maximum in resistant variety while minimum in susceptible variety of chilli. In the present study oleoresin content ranged from 6.76 to 14.87 per cent in this investigation. Some of the earlier workers found wide range variation to the trait, Pradeepkumar (1990), Papalkar *et al.* (1991), Cherian (2000), Sreelathakumary (2000), Manju (2001) and Robi (2003).

The study revealed that (Kidangoor local x Ujwala) x Jwalasakhi (family 8) was the best and was significantly superior followed by (Samkranthi local x Vellayani Athulya) x Kidangoor local (family 5), (Jwalasakhi x Vellayani Athulya) x Kidangoor local (family 3), (Vellayani Athulya x Jwalasakhi) x Samkranthi local (family 6), (Vellayani Athulya x Ujwala) x Jwalamukhi (family 7) and (Jwalamukhi x Ujwala) x Vellayani Athulya (family 2). The progenies that were found to be superior within these families in the F_4 generation (Plate 10) will be selected based on yield and yield attributes as well as anthracnose disease resistance for further evaluation of the recombinants in the F_5 segregating generation.

Summary

6. SUMMARY

Chilli is an important spice cum vegetable crop grown on a commercial scale in India. Though India is the largest producer, consumer and exporter of chillies in the world, productivity of chilli in India has remained low compared to the world average. One of the reasons for low productivity is the damage due to various diseases among which anthracnose or die back and fruit rot is a serious one. Hence it is essential to evolve varieties resistant to anthracnose disease. The present investigation was undertaken in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 2011-2013 to study the genetic evaluation of yield and anthracnose resistant types through evaluation from among the segregating generation of three way cross hybrids in chilli.

The eight three way cross hybrids were considered as families and within each family eight progenies were studied. The eight families are given below

Family 1 - (Jwalamukhi x Kidangoor local) x Jwalasakhi
Family 2 - (Jwalamukhi x Ujwala) x Vellayani Athulya
Family 3 - (Jwalasakhi x Vellayani Athulya) x Kidangoor local
Family 4 - (Jwalamukhi x Ujwala) x Kidangoor local
Family 5 - (Samkranthi local x Vellayani Athulya) x Kidangoor local
Family 6 - (Vellayani Athulya x Jwalasakhi) x Samkranthi local
Family 7 - (Vellayani Athulya x Ujwala) x Jwalamukhi
Family 8 - (Kidangoor local x Ujwala) x Jwalasakhi.

The evaluation of the eight three way cross hybrids was conducted as two experiments, *viz.,* pot culture and field experiment. Evaluation of yield traits, screening for anthracnose resistance, genetic parameters and correlation studies were conducted in pot culture experiment. Screening of anthracnose resistance was carried out through artificial inoculation of

pathogenic spore by application of spore suspension at 35 DAT and 50 DAT (Days After Transplanting) and observations were taken at two crop stages viz., 45 and 60 DAT.

Evaluation for yield traits revealed significant variation among the progenies and families with respect to all characters studied in pot culture and field experiments. In pot culture experiment among eight families and progenies, family 3 took minimum days to first flowering (where progeny 8 was superior), followed by family 1 (progenies 5 and 8). Number of fruits was maximum in family 8 (progeny 8), followed by families 7, 5, 3 and 2 (progenies 8, 4, 8 and 3 respectively). Average green fruit weight was superior in family 5 (progenies 6 and 1), followed by family 7 (progeny 8), long fruits was observed in families 7 (progeny 1), family 6 (progeny 1) and family 8 (progeny 2). Families such as 7, 6, 3 and 2 exhibited high fruit girth where several progenies were superior. Height of plant was maximum in family 5, followed by families 3 and 7. Best yielder among the family was 8 (progenies 8 and 3), followed by families 5, 3 and 7. Crop duration was minimum in family 7 (progeny 1).

Genetic parameters *viz.*, phenotypic and genotypic coefficient of variation, heritability and genetic advance were estimated for eight characters. The maximum values of both phenotypic and genotypic coefficients of variation were observed for fruit yield per plant followed by length of fruit. High heritability was exhibited by length of fruit followed by average green fruit weight and fruit yield per plant. Maximum genetic advance was observed for fruit yield per plant followed by length of fruit. Correlation analysis indicated that most of the character combinations had higher genotypic correlation coefficient than phenotypic correlation coefficient. Fruit yield per plant was significantly and positively correlated with number of fruits per plant and average green fruit weight, and was positively correlated with all the characters.

The artificial screening for anthracnose disease resistant revealed that majority of the progenies had no disease incidence at 45 DAT while at 60 DAT the progenies exhibited low incidence of the disease. Based on the high disease incidence and poor yield performance two progenies from each family were screened out. With regard to incidence and intensity, number of susceptible progenies increased gradually from 45 to 60 DAT and some of the progenies were highly resistant and others were moderately resistant at all the two crop stages. The selected six superior progenies were subjected to the field trail.

In the case of field experiment, early flowering nature was minimum in family 5 (progeny 4), number of primary branches was high in family 1(progenies 5 and 6), number of fruits was maximum in family 8 (progeny 6) followed by family 2 (progeny 2), average green fruit weight was high in families 5 and 8 (progeny 4). Fruit length was in family 6 (progeny 2), followed by families 7,5 and 8 (progenies 5,4 and 3 respectively), family 5 possessed maximum fruit girth followed by families 3 and 8. Yield per plant was highest family 8 (progeny 6) followed by families 5 and 3 (progenies 4 and 3 respectively). Number of seeds per fruit and 100 seed weight was maximum in families 8 and 3 respectively. Height of plant was maximum in family 3 (progeny 6), capsaicin content was high in family 2 followed by family 8 while oleoresin was maximum in family 3. Anthracnose disease was observed under natural incidence and the results revealed that disease incidence was very low compared to the artificial inoculation. It was noticed that the progenies having high capsaicin content was resistant to anthracnose disease. In family 5, majority of the progenies had slight disease incidence and was considered as moderately resistant, family 6 was also considered to be moderately resistant to the disease where as families 7 and 8 were highly resistant, majority of the progenies in the remaining families were free from the disease incidence.

The study revealed that (Kidangoor local x Ujwala) x Jwalasakhi (family 8) was the best and was significantly superior followed by (Samkranthi local x Vellayani Athulya) x Kidangoor local (family 5), (Jwalasakhi x Vellayani Athulya) x Kidangoor local (family 3), (Vellayani Athulya x Jwalasakhi) x Samkranthi local (family 6), (Vellayani Athulya x Ujwala) x Jwalamukhi (family 7) and (Jwalamukhi x Ujwala) x Vellayani Athulya (family 2). The progenies that were found to be superior within these families will be selected based on yield and yield attributes as well as anthracnose disease resistance for further evaluation of the recombinants in the F_5 segregating generation.

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*Originals not seen

GENETIC EVALUATION OF YIELD AND ANTHRACNOSE RESISTANCE IN THE SEGREGATING GENERATION OF THREE WAY CROSS HYBRIDS IN CHILLI (*Capsicum annuum* L.)

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ABSTRACT

Chilli (*Capsicum annuum* L.) is an important spice cum vegetable crop, grown on a commercial scale in India. It is an important constituent of many foods since it adds flavor, colour, vitamin C and pungency, productivity of the crop remains low mostly due to destructive diseases. One of the most dreaded diseases affecting chilli is anthracnose, which is also called dieback and fruit rot.

The best way to tackle this disease is to grow resistant varieties. Hence it is essential to identify the sources of anthracnose resistance and study the inheritance of resistance to develop high yielding anthracnose resistant varieties of chilli. The aim of the project was to identify high yielding anthracnose resistant types through evaluation from among the F_4 segregating generation of three way cross hybrids in chilli. Eight promising three-way cross hybrids with regard to fruit yield and resistance to anthracnose selected from a previous PG project was used as the material for this study.

The eight three way cross hybrids were considered as families and within each family eight progenies were studied. The eight families are given below

Family 1 - (Jwalamukhi x Kidangoor local) x Jwalasakhi
Family 2 - (Jwalamukhi x Ujwala) x Vellayani Athulya
Family 3 - (Jwalasakhi x Vellayani Athulya) x Kidangoor local
Family 4 - (Jwalamukhi x Ujwala) x Kidangoor local
Family 5 - (Samkranthi local x Vellayani Athulya) x Kidangoor local
Family 6 - (Vellayani Athulya x Jwalasakhi) x Samkranthi local
Family 7 - (Vellayani Athulya x Ujwala) x Jwalamukhi
Family 8 - (Kidangoor local x Ujwala) x Jwalasakhi

The investigation was carried out as two separate experiments- Pot culture experiment and Field experiment. Pot culture experiment was laid out in CRD with 8 families and 8 progenies with three replications to score for anthracnose disease by creating disease pressure by artificial inoculation of the plants with the pathogen at 35 DAT and 50 DAT. Six superior progenies from each family with regard to yield and anthracnose resistance were selected for field experiment after eliminating two progenies which exhibited low yield and high anthracnose disease incidence. *Viz.*, progeny 4 and 8, 1 and 4, 4 and 7, 4 and 5, 2 and 5, 2 and 8, 3 and 5, 4 and 6 from families 1, 2, 3,4,5,6,7 and 8 respectively. Family 8 was superior for yield and showed resistance to anthracnose followed by three other families. Progenies which were superior within these families were 8 and 3 in family 8, 6 and 1 in family 5, 8 in family 7 and progeny 3 in family 2.

Genetic parameters such as phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance and correlation of 8 families were studied. Fruit yield per plant showed maximum GCV, PCV and genetic advance while heritability percentage was maximum for fruit length and average green fruit weight. Fruit yield per plant showed positive and significant genotypic and phenotypic correlations with average green fruit weight and length of fruit while it showed negative correlation with duration among the families.

The field experiment was laid out in Compact Family Block Design, with 8 families and 6 progenies in four replications. Scoring for anthracnose disease was done under natural condition in the field. Among the 8 families, family 8 was highly superior for the important traits such as number of fruits per plant, average green fruit weight, fruit length, fruit girth, fruit yield per plant and was resistant to anthracnose disease.

Based on the evaluation of progenies in each family, progeny 1 was significantly superior in family 1, progeny 2 in family 2, progeny 3 in family 3, progeny 4 in family 4, progenies 3 and 4 in family 5, progeny 1 in family 6, progenies 4 and 6 in family 7 and progeny 6 in family 8.

Biochemical analysis on chilli revealed that capsaicin and oleoresin were found to be maximum in the above selected progenies in each family which were superior for yield and anthracnose resistance. Progenies which exhibited high capsaicin content were found to exhibit low disease incidence.

The study revealed that Kidangoor local x Ujwala x Jwalasakhi (family 8) was the best and was significantly superior followed by Samkranthi local x Vellayani Athulya x Kidangoor local (family 5), Jwalasakhi x Vellayani Athulya x Kidangoor local (family 3), Vellayani Athulya x Jwalasakhi x Samkranthi local (family 6), Vellayani Athulya x Ujwala x Jwalamukhi (family 7) and Jwalamukhi x Ujwala x Vellayani Athulya (family 2). The progenies that were found to be superior within these families will be selected based on yield and yield attributes as well as anthracnose disease resistance for further evaluation of the recombinants in the F_5 segregating generation.