COMPATIBILITY AMONG VARIETIES IN *Capsicum annuum L. and Capsicum frutescens L.*

By

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THESIS

Submitted in partial fulfilment of the
requirement for the Degree

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University

Department of Olericulture

COLLEGE OF HORTICULTURE

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1984

DECLARATION

I hereby declare that this thesis entitled "Compatibility among varieties in *Sesamum angustifolium* L. and *Sesamum prostratum* L." is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,

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Krishnakumar 13/4/84

KRISHNAKUMAR, K.

CERTIFICATE

Certified that the thesis entitled "Compatibility among varieties in *Canavalia ensiformis* L. and *Canavalia gladiata* L." is a record of research work done independently by Mrs. Krishnakumary, K. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Dr. K.V. Peter,
Chairman,
Advisory Committe,
Professor and Head,
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Vellanikkara,

-- -- 1984.

CERTIFICATE

We, the undersigned members of the Advisory Committee of Mrs. Krishnakumary, K. a candidate for the degree of Master of Science in Horticulture agree that the thesis entitled "Compatibility among varieties in *Cocos nucifera* L. and *Cocos fructosa* L." may be submitted by Mrs. Krishnakumary, K. in partial fulfilment of the requirement for the degree.

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Introduction

INTRODUCTION

The genus Capsicum to which chilli belongs has two main species of considerable importance, Capsicum annuum L. and Capsicum frutescens L. Capsicum frutescens is a true diploid (2n = 24) (Smith and Heiser, 1951). In Capsicum annuum, majority of varieties are true diploids with 2n = 24. Polyploid forms (2n = 36,48) have also been observed especially in the botanical variety Capsicum annuum var. grossum. Capsicum frutescens is valued for its high pungent principle, capsaicin. This species is also the source of resistance to viral diseases leaf curl and mosaic complex. Attempts made to cross Capsicum frutescens (variety - White Kanthari) with Capsicum annuum (variety - Jwala) resulted in negligible seed set and flower fall (Balasubramanian, 1981). Reports on systematic approach to effect crossing between Capsicum annuum and Capsicum frutescens are rather a few. With the availability of typical Capsicum frutescens lines like White Kanthari, Green Chuna and Ornamental Type and Capsicum annuum lines like Jwala and K_2, the prospect of such experiment was greater. Besides there is need to identify the most appropriate method(s) which would bring out compatibility between incompatible parents, if any.

The present study was formulated with the following objectives:

1. To study the cross compatibility among varieties of *Capsicum annuum* L. and *Capsicum frutescens* L.

2. To test utility and efficiency of different methods to break cross incompatibility, if any, between specific parents.

3. To estimate interspecific F_1 heterosis for earliness, yield and their components.

Review of Literature

REVIEW OF LITERATURE

Nettancourt (1977) defined interspecific incompatibility as any of the post-pollination processes preventing, through an absence of pollen germination or an abnormal behaviour of the pollen tubes, the formation of hybrid zygotes combining the genomes of two different fertile species. This phenomenon prevents gene flow among species. Frankel (1977) recognised different types of interspecific incompatibility.

Gametophytic incompatibility

This is characterised by its pollen reaction being determined by the genotype of the gametophyte.

Sporophytic incompatability

Here the pollen reaction is determined by the genome of the somatic tissue (of the sporophyte) in which the pollen is developed.

Nettancourt (1972) applied many methods successfully to eliminate incompatibility barriers enabling to obtain seeds from incompatible combinations. The methods included bud pollination, delayed pollination, mixed pollination, grafting and pollination, somatic hybridisation, use of growth regulators, irradiated pollen and thermally stimulated pollen.

Anthesis and pollination in chilli

Murthy and Murthy (1962) reported that the extent of natural cross pollination was between 58 and 68% in chilli. Markus (1963) observed that plant and row spacing did not affect degree of cross pollination in unemasculated plants. According to him maximum cross pollination occurred between 7 and 11 A.M. Cochran and Dempsey (1966) noted that the length of receptivity period altered greatly with prevailing temperature during and after anthesis. When the mean temperature was relatively high (> 72°F) there was a progressive decrease in receptivity with each days increase in stigma age from the day of anthesis. Setlach and Novak (1971) stated that suitable time for emasculation was 4 to 6 P.M. and the deciding factor was the temperature at the time of pollination (18 to 24°C). Vijay et al. (1979) observed that anthesis commenced at 7.15 A.M. and continued upto 11.15 A.M. Anthers dehisced after 30 minutes of anthesis. The stigma was receptive for two days after anthesis. The pollen grains were fertile one day prior to anthesis and remained fertile for two days after anthesis.

Crossability studies in chilli

Intergeneric crossability

Chirilei (1968) attempted intergeneric hybridisation

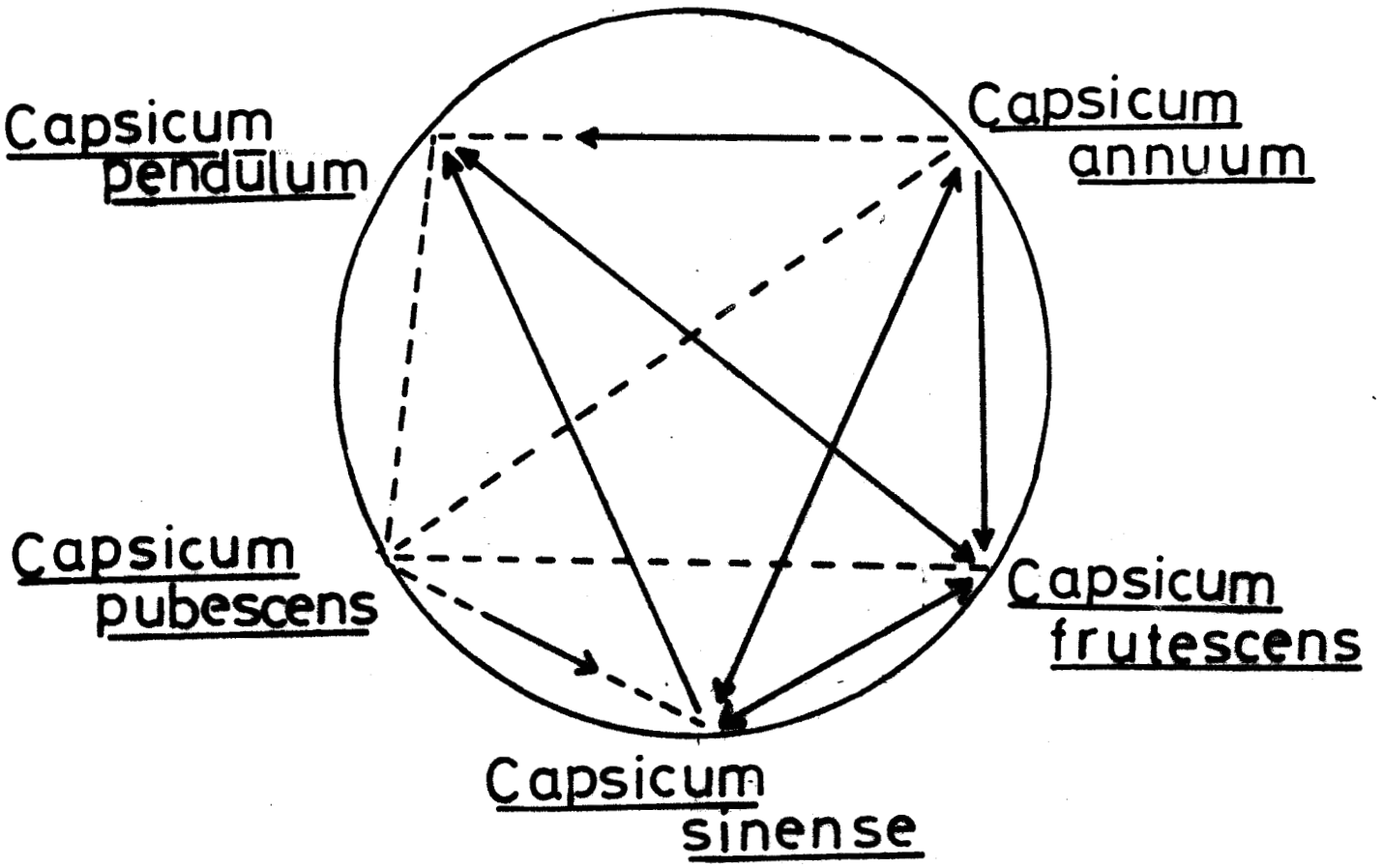
between tomato and chilli. Fruits derived from pollinations of tomato by Capsicum annuum variety 'Green Kalinkov' resembled those of chilli in shape and colour. 89% of plants in the F_1 and 86.3% in F_2 had the long shape and colour of chilli. Of the remaining fruits, 10% in F_1 and 10.7% in F_2 were of pear shape and of chilli colour and 1% in F_1 and three per cent in F_2 resembled the tomato. The hybrids yielded high and had the distinctive tomato flavour. They had 13 to 15 pairs of chromosomes compared to the parental 12.

Omidiji (1979) obtained parthenocarpic fruits when Lycopersicon esculentum was hybridised with Capsicum and Solanum species. The parthenocarpic fruit development was in response to hormones released through the stimulus of pollination and cannot be taken as evidence of close relationship among these genera.

Interspecific crossability

Smith and Heiser (1957) studied the crossing behaviour of five Capsicum species - Capsicum annuum, Capsicum frutescens, Capsicum pendulum, Capsicum pubescens and Capsicum sinense (Fig. 2.1). About two per cent of the seeds were viable when Capsicum frutescens was used as the female. The reciprocal cross had never been successfully made. The F_1 plants ranged from

Figure 2-1. Level of compatibility among five species of Capsicum



------ No viable crosses obtained
--→-- Crosses by embryoculture only
——→ Cross fertile
(Arrow points in direction of female parent)

completely pollen sterile to partially fertile. Back crosses to both parents had been obtained, but both F_2 and back cross plants showed much pollen sterility. Seed viability in the interspecific hybrids are given in Table 2.1.

Hirose et al. (1961) made the following crosses : Capsicum frutescens x Capsicum annuum, Capsicum annuum x Capsicum pendulum, Capsicum pendulum x Capsicum frutescens, Capsicum sinense x Capsicum frutescens and Capsicum sinense x Capsicum pendulum. He found that all crosses except those involving Capsicum annuum were heterotic. Ganesan (1965) reported that no fertile hybrids were obtained from interspecific hybridisation among Capsicum annuum, Capsicum conicum, Capsicum annulatum and Capsicum pubescens. Malhova (1967) reported that incompatibility between Capsicum annuum (4X) and Capsicum pubescens (2X) could be overcome by using the tetraploid as the seed parent. But the hybrid (3X) resulting from the cross was wholly sterile. Kaps (1968) studied the genetic basis of incompatibility and indicated that incompatibility was of a gametophytic type. He also showed that all strains of Capsicum frutescens and Capsicum annuum tested were self compatible. Cochran (1970) observed pollen tube growth through

Table 2.1. Variability in the interspecific hybrids involving five species of *Capsicum*

	Initial cross	Viable F_2 seed	Viable back cross seed
Capsicum annuum x *Capsicum frutescens*	+	+	+
Capsicum annuum x *Capsicum sinense*	++	++	++
Capsicum annuum x *Capsicum pendulum*	E	+	-
Capsicum annuum x *Capsicum pubescens*	-	-	-
Capsicum frutescens x *Capsicum sinense*	+	+	+
Capsicum frutescens x *Capsicum pendulum*	++	+	+
Capsicum frutescens x *Capsicum pubescens*	-	-	-
Capsicum sinense x *Capsicum pendulum*	+	-	-
Capsicum sinense x *Capsicum pubescens*	E	-	-
Capsicum pendulum x *Capsicum pubescens*	-	-	-

E = Seed germinated by embryoculture only
\- = No viable seed
\+ = Few viable seed
++ = Many viable seed

the style of Capsicum frutescens. The style was removed 12, 24, 36, 48 or 60 h after pollination. No fruit set was observed in plants with styles removed upto 24 h, but by the end of 36 h 40% of fruit set was noted and the proportion increased progressively with time. It is evident that by the end of 36 h pollen tube reached the ovary and so fruit set was noted. Keshav Ram and Saini (1971) studied compatibility among three varieties each from Capsicum annuum and Capsicum frutescens and found that they were successfully intercrossed in all directions. The F_1s were fertile and they readily set seed. Kiss and Paal (1976) studied pollen tube growth in vivo in Capsicum annuum. Pollen tubes reached the ovary after 16 h and micropyles of all the ovules after 24 h. In a few combinations, pollen tube formation was very poor, and fruit set was low. Radhakrishnan et al. (1977) developed a technique in which the upper part of the style and stigma were excised and a drop of five per cent sucrose solution applied to the cut surface prior to pollination. This resulted in fruit and seed set in crosses among Capsicum annuum, Capsicum frutescens and Capsicum pendulum. In crosses where Capsicum annuum was female, the

percentage of fruit set was considerably lower than in the reciprocals. Pillai et al. (1977) did not get success with Capsicum annuum as the female parent and seedlings did not survive from Capsicum frutescens x Capsicum pendulum cross. There was no seed set in Capsicum baccatum x Capsicum annuum. No viable seeds were obtained from Capsicum pendulum x Capsicum annuum and Capsicum frutescens x Capsicum annuum crosses. Maximum seed germination (73%) was observed in Capsicum frutescens x Capsicum baccatum and the lowest (9%) in Capsicum microcarpum x Capsicum annuum. Popova et al. (1978) stated that higher temperature and humidity resulted in a more rapid growth of pollen tubes and more seeds/fruit. Mayer et al. (1979) obtained F_1 hybrids by pollinating decapitated styles of Capsicum annuum 'Pendulum long' with pollen of Capsicum frutescens 'Lavengi' after spraying a 5% sucrose solution. Sundaresan and Chandrasekaran (1979) reported one way incompatibility between Capsicum annuum and Capsicum frutescens. The failure of cross pollination when Capsicum annuum was used as the female parent was due to pre-fertilisation barriers. This was revealed by non-germination of pollen in the stigma of Capsicum annuum. When Capsicum frutescens was used as the female parent, fruit set occurred to the extent of 17.1%. But the

development of plumpy seeds was not uniform, indicating thereby different intensities of post-fertilisation barriers. It was found that the cross between White Kanthari (*Capsicum frutescens*) and Pant C-1 (*Capsicum annuum*) resulted in premature flower fall. This tempted Peter and Mc Gollum (1983) to conduct a study to trace out areas of cross incompatibility. They observed perfect pollen stigma compatibility in direct and reciprocal crosses which otherwise failed to set fruit after artificial pollination both under field and green house conditions. Pollen germination and pollen tube growth were observed 3 h after pollination in both direct and reciprocal crosses. Pollen tubes reached the ovule within 24 h of pollination. The failure to set fruit has to be attributed to reasons other than pollen stigma incompatibility and pollen tube growth (Fig.2.1a, b, c, d). Smith (1983) studied crossability of fourteen *Capsicum* species (Table 2.2).

Intervarietal incompatibility

Angeli (1957) recorded that hybrid chillies were suited for early cropping both in glass house and in the field, being earlier, more productive, more

Table 2.2. Crossability among *Capsicum* species

	[illegible]93 (unnamed)	praetermissum	(tovarii)	cardenasii	pubescens	eximium	buforum	schottianum	galapogense	chacoense	1230	baccatum	chinense	frutescens
annuum	–	–		–	–	–	–	–	–	–	?	?	+	+
frutescens	–	?		–	–	–	–	–	–	–	?		+	
chinense	–	–		–	–	–	–	–	–	–		?		
baccatum	–	+	–	–	–	–	–	–	–	–	+			
1230 (unnamed)	–	–		–	–	–	–	–	–	–				
chacoense	–	–		–	–	–	–	–	–					
galapogense	–	–		–	–	–	–	–						
schottianum	–	–		–	–	–	?							
buforum	–	–		–	–	–								
eximium	–	–	–	+	+									
pubescens	–			+										
cardenasii	–	–												
2017 (tovarii)	–	–												
praetermissum	–													

– = No apparent gene flow, sterile F_1 plants sometimes obtained

\+ = Gene flow possible

? = Uncertain, gene transfer may be possible with difficulty

resistant to diseases and better adapted to consumer requirements than the parental varieties. Setlach (1966) reported an average fruit set of 39.7% and 47.47% in two hybrids of Capsicum annuum. Mishra et al. (1976) recorded heterosis in F_1 of Capsicum annuum varieties to an extent of -14.69% for days to flower and +68.33% for fruits/plant. Nwankiti (1981) reported that hybrids between Capsicum annuum varieties OS/UI/80 and Tatasi did not set fruits without artificial pollination. Lack of self fruit setting was attributed to low viable pollen production and also due to the pattern of arrangement of the reproductive organs. Singh (1981) noted an increase of 193 to 284% in fruit yield and 8.84 to 60.31% in fruit length in all hybrids of Capsicum annuum varieties.

Cytological basis of incompatibility

Molhova (1965) recorded a complete or partial sterility in Capsicum caused by disturbed meiosis of pollen mother cells and by structural and functional defects of the embryosac. He could also recognise that the mode of inheritance of hybrids was influenced by the degree of sterility and course of megasporogenesis in the crosses. Shopova (1966) made a cytological

comparison of chromosome structure and behaviour in the genus Capsicum and showed that all three species Capsicum annuum, Capsicum frutescens and Capsicum pubescens differed in chiasma frequency, amount of heterochromatin material and distribution of nucleolar organising chromosomes, although they had a common chromosome number of 2n = 24. Sundaresan and Chandrasekaran (1979) studied the cytomorphology of the interspecific hybrid Capsicum frutescens x Capsicum annuum which pointed to the non-development of genic mechanisms inhibiting pairing of chromosomes in the F_1s. According to them chromosomal sterility was also brought about by multivalent association of chromosomes and the production of gametes with unbalanced chromosomes.

Effect of NAA on fruit set

Jayanandam et al. (1976) reported that NAA (15 ppm) induced more flowering and minimised flower drop. Chandramony and George (1976) found that spraying Planofix (NAA - 20 ppm) at the flower initiation stage increased fruit yield by 132% in the variety 'Kanthari'. Warade and Singh (1977) observed maximum fruit set (70.5%), higher fruit volume (1.8 cm^3) and higher yield/plant (0.74 kg) with foliar treatment of NAA (200 ppm).

Chemical studies in chilli

Pungency in chilli is due to a crystalline volatile alkaloid, first isolated by Thresh in 1876, who assigned the name 'Capsaicin' (Tewari, 1979). Quagliotti and Ottaviano (1967) in an evaluation of 640 plants observed that capsaicin content was the highest in the first fruits to ripen and in plants which were transplanted early. Among twelve varieties studied by Thirumalachar (1967), the capsaicin content of the dried fruits varied from 0.2723 mg to 1.1267 mg/100 mg. Arya and Saini (1977) reported that capsaicin content was negatively correlated with fruit yield and rind thickness and positively correlated with fruit number. The capsaicin content of thirty varieties studied ranged from 0.005 to 0.089%. Tewari (1979) reported that the placental tissue contained most of the alkaloid capsaicin. The capsaicin and oleoresin content of Jwala were recorded as 0.7% and 9% respectively.

Interspecific heterosis in chilli

Pillai et al. (1977) recorded positive heterosis for plant height in the cross Capsicum microcarpum x Capsicum frutescens and negative heterosis in the reciprocal cross. The highest percentage of fruit set

and the maximum fruits/plant were obtained in Capsicum frutescens x Capsicum baccatum. Sundaresan and Chandrasekaran (1979) found that F_1s from the cross Capsicum frutescens x Capsicum annuum were in general more vigorous than the parents. The hybrids were intermediate for many of the characters plant height, spread, flower and fruit characteristics. Hybrids exceeded both the parents in respect of length of petal and size of seed though the quantity of seed set was very much reduced. The F_1S resembled the female parent in pigmentation of plant parts and also the deciduous nature of the fruit. The hybrids resembled the male parent in respect of shape of leaf, flowers/node and protrusion of style. Sundaram et al. (1980) revealed no relationship between genetic and geographical diversity in Capsicum frutescens. Branches/plant and fruits/plant were the primary contributing characters to genetic divergence.

The present study was conducted to reason out cross incompatibility in specific crosses, and to work out methods to overcome the bottleneck.

Materials and Methods

MATERIALS AND METHODS

The present studies were conducted during September-February, 1982-83 and May-September, 1983 at the Instructional Farm of the College of Horticulture, Vellanikkara, Trichur. This research farm is located at an altitude of 22.25 m above mean sea level and at 10°32' N latitude and 76°16' E longitude. The farm experiences a typical warm humid tropical climate. The soil type is well drained sandy loam with pH 5.1.

The experiment consisted mainly of two parts.

A. Cross compatibility between lines of *Capsicum annuum* L. and *Capsicum frutescens* L.

B. Estimation of interspecific F_1 heterosis.

A. Cross compatibility between lines of *Capsicum annuum* L. and *Capsicum frutescens* L.

1. Materials

The materials for the study comprised of two lines of *Capsicum annuum* L. and three lines of *Capsicum frutescens* L. The *Capsicum annuum* lines were Jwala (CA 60) (Fig. 3.1) and K_2 (CA 94) (Fig. 3.2) and *Capsicum frutescens* lines were White Kanthari (CA 89) (Fig. 3.3), Green Chunn (CA 123) (Fig. 3.4) and Ornamental Type (CA 136) (Fig. 3.5). These five lines were chosen from a germplasm collection maintained at the Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara, Trichur.

The origin and morphological descriptions of five parental lines are given in Table 3.1.

2. Methods

The five parental materials were grown in pots for hybridisation. Hybridisation was attempted by taking initially Capsicum annuum lines Jwala and K_2 as female parents and Capsicum frutescens lines White Kanthari, Green Chunn and Ornamental Type as male parents. Reciprocal F_1 hybrids were also synthesised. At the same time selfing of the lines were also done.

Procedure for hybridisation

The time of flower opening and dehiscence of anthers was between 7 to 9.30 A.M. and hence crossing work was done during this time interval. Procedures adopted for selfing and crossing were as follows:

a. Selfing

Well developed flower buds which would open the next day were selected in each line. The flower buds were covered with tissue paper bags during the evening prior to opening and labelled. The bags were allowed to remain for about three days and then removed.

b. Crossing

In the evening of the day prior to crossing, the

well developed flower buds which would open the next day were selected and emasculated with the help of a needle. Then the emasculated flower buds were covered with tissue paper bags and pinned in position. The flower buds from male parent were similarly protected to avoid contamination with foreign pollengrains. Pollination was performed in the very next day of emasculation. Pollinated flowers were again covered and labelled. The bags were removed after about three days.

In addition to hand pollination, effect of mixed pollination on compatibility was also studied. Here, pollen of both parents were mixed and transferred to the stigma of the female parent.

Besides, Planofix (NAA 15 ppm) was sprayed and then crossing done to find out whether NAA spraying would increase the cross efficiency.

After making crosses following observations were made.

i. Percentage of fruit set in F_0 plant and in maternal parent (A).

ii. Seeds/fruit in F_0 fruit and in maternal parent (B)

iii. Percentage of germination in seeds from F_0 fruit and in maternal parent (C)

iv. Percentage of seedlings survival in F_0 plant and in maternal parent (D)

Percentage of seed set efficiency was calculated as :

Percentage of seed set efficiency =

$$\frac{\text{Seeds in crosses} \times 100}{\text{Seeds in selfed maternal parent}}$$

Crossability index was calculated (Rao, 1979) as :

Crossability index = $\frac{\text{Crossing efficiency of the cross} \times 100}{\text{Selfing efficiency of the female parent}}$

$$= \frac{A^{C^*} \times B^{C^*} \times C^{C^*} \times D^{C^*} \times 100}{A^{S^*} \times B^{S^*} \times C^{S^*} \times D^{S^*}}$$

C^* = Crosses

S^* = Selfs

Effect of maternal parent on crossability index and percentage seed set efficiency was tested as:

$$t = \frac{\bar{X}}{\sqrt{\frac{}{n}}}$$

Where $\bar{X}$ = difference in crossability indices without regarding their signs.

C. Chromosome numbers

Chromosome numbers of the five parental lines were also observed. The flower buds of suitable size were fixed in Carnoy's fluid (1 acetic acid: 3 chloroform: 6 alcohol). The best time of fixing flower buds was found to be between 9.30 and 10.30 A.M. The fixed buds were kept in a refrigerator for 12 to 24 h. After that buds were transferred to 70% ethyl alcohol. The anthers were kept in a drop of acetocarmine on the slide and pressed gently to facilitate the separation of

cells. After putting the cover glass, the slide was slightly warmed and pressed between the folds of a blotting paper. Photographs were taken with an oil immersion objective.

B. Estimation of interspecific F_1 heterosis

1. Materials

Materials under this experiment included five parental lines and their ten F_1 hybrids including reciprocals. They were

Sonchus asper ← Jwala and K_2

Sonchus fruticosus ← White Xanthari, Green Chuna and Ornamental type

Out of the twelve cross combinations made, including directs and reciprocals, only ten crosses were found successful. They were Jwala x White Xanthari, Jwala x Green Chuna (Fig. 3.6), Jwala x Ornamental Type (Fig. 3.7), K_2 x White Xanthari (Fig. 3.8), K_2 x Green Chuna (Fig. 3.9), K_2 x Ornamental Type (Fig. 3.10), Green Chuna x Jwala (Fig. 3.11), Green Chuna x K_2 (Fig. 3.12), Ornamental Type x Jwala (Fig. 3.13) and Ornamental Type x K_2 (Fig. 3.14). They were grown during May-September, 1981.

2. Methods

The experimental design used was Randomized block design with three replications. Five plants were

randomly tagged in each block and following observations were recorded from each of them.

Vegetative characters:

Plant height

Primary branches/plant

Earliness:

Days to flower

Days to first harvest (for green fruits)

Days to maturity (for red fruits)

Productive characters:

Fruits/plant

Green fruit yield/plant

Dry fruit yield/plant

Seeds/fruit

Seed yield/plant

3. Chemical studies

The parents and hybrids were analysed for oleoresin content using Soxhelts apparatus and acetone as the solvent.

4. Statistical analysis

a. Estimation of crossability index and percentage of seed set efficiency

Crossability index and percentage of seed set efficiency were analysed in three different methods of pollination - hand pollination, mixed pollination and

pollination after EAA spraying. Critical differences were calculated to test the significance of the differences among the three methods.

b. Estimation of heterosis

The data on earliness, vegetative characters, productive characters and their components were analysed. Heterosis was calculated as percentage increase or decrease of F_1s over better parent (Hayes et al. 1965) and over mid parental values (Briggle, 1963).

$$\text{Heterobeltiosis} = \frac{\bar{F}_1 - \bar{BP} \times 100}{\bar{BP}}$$

$$\text{Relative heterosis} = \frac{\bar{F}_1 - \bar{MP} \times 100}{\bar{MP}}$$

Heterobeltiosis was tested using the standard error.

$$SE = \sqrt{\frac{\sigma^2 F_1}{n_1} + \frac{\sigma^2 BP}{n_2}}$$

Where $\sigma^2 F_1$ = F_1 variance

$\sigma^2 BP$ = Better parental variance

n_1 = Number of F_1 plants

n_2 = Number of better parental plants

The relative heterosis was tested using standard error.

$$SE = \sqrt{\frac{\sigma^2 F_1}{n_1} + \frac{1}{4}\left(\frac{\sigma^2 P_1}{n_2} + \frac{\sigma^2 P_2}{n_3}\right)}$$

Where $\sigma^2 P_1$ = Maternal parental variance

$\sigma^2 P_2$ = Paternal parental variance

n_2 = Number of maternal parents

n_3 = Number of paternal parents

e. Estimation of different genetic parameters like genotypic (gcv) and phenotypic coefficients of variability (pcv) (Burton, 1952), heritability in broad sense (h^2b) (Allard, 1960), expected genetic advance (ga) at 5% intensity of selection (Allard, 1960) and genetic advance (ga) expressed as percentage of mean (Allard, 1960) were made.

$$gcv = \frac{\sigma g \times 100}{AM}$$

Where σg = Genotypic standard deviation

AM = Arithmetic mean

$$pcv = \frac{\sigma p \times 100}{AM}$$

Where σp = Phenotypic standard deviation

$$h^2(b) = \frac{\sigma^2 g}{\sigma^2 p}$$

Where $\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

$ga = i.\ h^2.\ \sigma p$

Where i = 2.06 at 5% intensity of selection

h^2 = Heritability in broad sense

σp = Phenotypic standard deviation

ga expressed as percentage of mean $= \frac{ga}{AM} \times 100$

Where ga = Genetic advance

AM = Arithmetic mean

d. Estimation of genetic distance between the species Capsicum annuum and Capsicum frutescens

The genetic distance was calculated considering plant height, days to flower, green fruit yield/plant and seeds/fruit. The method suggested by Mahalanobis (1928) was used to estimate the total D^2 between the two species with X_1, X_2, X_3 and X_4 as the multiple measurements available on each species and d_1, d_2, d_3 and d_4 as $\bar{x}_1^1 - \bar{x}_1^2$, $\bar{x}_2^1 - \bar{x}_2^2$, $\bar{x}_3^1 - \bar{x}_3^2$ and $\bar{x}_4^1 - \bar{x}_4^2$ respectively, being the difference in the means of above two species. Mahalanobis D^2 - statistics is defined as follows:

$$_4D^2 = b_1d_1 + b_2d_2 + b_3d_3 + b_4d_4$$

Here, the b_i values are to be estimated such that the ratio of variance between the populations to the variance within the populations was maximised. In terms of variances and covariances, the D^2 value was obtained as:

$$_4D^2 = w_{ij}\,(\bar{x}_i^1 - \bar{x}_i^2)(\bar{x}_j^1 - \bar{x}_j^2)$$

Where w_{ij} is the inverse of estimated variance - covariance matrix.

The D^2 value was tested with χ^2 at four degrees of freedom as suggested by Rao (1948) and Singh and Choudhary (1979).

The component character contributing maximum to total genetic distance was identified based on the relative magnitude of the component deviation squares and their relative ranks.

RESULTS

The data collected in the two sets of experiments were analysed and are presented below:

A. Cross compatibility involving lines of *Capsicum annuum* L. and *Capsicum frutescens* L.

Crossability index was calculated in crosses involving two *Capsicum annuum* lines (Jwala and X_2) and three *Capsicum frutescens* lines (White Kanthari, Green Chana and Ornamental Type) after hand pollination (Table 4.1a). It was observed that no barrier existed in the success of crosses except in two combinations where White Kanthari was used as the female parent.

Percentage of fruit set was lower in crosses (minimum value - 18%) than in the selfed maternal parent (minimum value - 80%). Similarly seeds/fruit and percentage of germination were higher in the selfed maternal parent (minimum seeds/fruit - 22) than in the crosses (minimum seeds/fruit - 1). Once the seeds germinated, the percentage of seedlings survival was more or less similar in crosses and in selfed maternal parent. Among crosses, the highest percentage of fruit set was obtained in White Kanthari x X_2 (54.50%) followed by White Kanthari x Jwala (54.30%).

Table 4.1a. Crossability between two lines of Capsicum annuum and three lines of Capsicum frutescens after hand pollination

Genotypes	A^{SX}	B^{SX}	C^{SX}	D^{SX}	A^{CX}	B^{CX}	C^{CX}	D^{SX}	Crossability index (C_1I_1)%
1	80.00	58.00	84.00	90.48	—	—	—	—	—
2	88.80	54.00	80.10	95.00	—	—	—	—	—
3	88.80	31.00	72.01	100.00	—	—	—	—	—
4	85.60	22.00	80.01	100.00	—	—	—	—	—
5	86.40	48.00	34.00	95.24	—	—	—	—	—
1 x 3	—	—	—	—	18.00	40.00	64.00	87.50	11.43
1 x 4	—	—	—	—	19.60	31.00	60.00	86.67	8.96
1 x 5	—	—	—	—	32.20	51.00	68.00	94.12	20.00
2 x 3	—	—	—	—	20.00	36.00	60.00	91.30	12.15
2 x 4	—	—	—	—	20.00	30.00	60.00	73.30	7.96
2 x 5	—	—	—	—	28.80	49.00	72.00	100.00	30.64
3 x 1	—	—	—	—	54.30	1.00	—	—	0.00
3 x 2	—	—	—	—	54.80	1.00	—	—	0.00
4 x 1	—	—	—	—	23.70	21.00	52.00	92.31	15.86
4 x 2	—	—	—	—	20.50	22.00	48.00	83.33	11.97
5 x 1	—	—	—	—	31.03	51.00	72.00	100.00	34.34
5 x 2	—	—	—	—	32.20	50.00	68.00	94.12	31.06

1. Jwala
2. K$_2$
3. White Kanthari
4. Green Chunn
5. Ornamental Type

A - Percentage of fruit set
B - Seeds/fruit
C - Percentage of germination
D - Percentage of seedlings survival

The lowest percentage of fruit set was observed in the cross Jwala x White Kanthari (18%). Jwala x Ornamental Type and Ornamental Type x Jwala had the highest seeds/fruit (51) while the crosses White Kanthari x Jwala and White Kanthari x K_2 had the lowest seeds/fruit (1). The only one seed obtained in crosses involving White Kanthari as the female parent did not germinate. Maximum percentage of germination was observed in crosses K_2 x Ornamental Type and Ornamental Type x Jwala (72%). Crossability indices calculated based on mixed pollination and pollination after NAA (15 ppm) spraying were presented in Table 4.1b and 4.1c. Higher values for crossability index was observed in mixed pollination, maximum in the cross Jwala x Ornamental Type (84.12%).

Percentage of seed set efficiency of the crosses under three methods at F_0 level were given in Table 4.2a, 4.2b and 4.2c. Under hand pollination method, a maximum value of 93.75% was observed in the cross Ornamental Type x Jwala followed by K_2 x Ornamental Type (90.74%). A minimum value of 3.23% was observed in crosses White Kanthari x Jwala and White Kanthari x K_2.

Relative efficiency of the three methods (hand pollination, mixed pollination and pollination after NAA (15 ppm) spraying on cross compatibility was

Table 4.1b. Crossability between two lines of *Capsicum annuum* and three lines of *Capsicum frutescens* after mixed pollination.

Genotypes	A^{SX}	B^{SX}	C^{SX}	D^{SX}	A^{CX}	B^{CX}	C^{CX}	D^{CX}	Crossability index (C.I)%
1	80.00	58.00	86.30	92.30					
2	82.30	50.00	81.10	96.20					
3	88.60	35.00	75.00	98.30					
4	84.40	24.40	85.10	92.50					
5	89.20	47.00	85.30	96.30					
1 x 3					76.00	43.00	73.00	91.00	58.76
1 x 4					80.00	36.00	70.00	88.00	53.49
1 x 5					81.60	53.00	70.00	91.00	86.12
2 x 3					75.00	43.00	72.00	87.00	61.16
2 x 4					76.20	35.00	76.00	85.00	52.16
2 x 5					77.70	50.00	78.00	90.00	82.57
3 x 1					80.00	33.00	78.00	91.00	75.92
3 x 2					81.90	32.00	69.00	86.00	70.21
4 x 1					77.70	23.00	75.00	85.00	71.45
4 x 2					76.20	21.00	71.00	88.00	62.70
5 x 1					82.30	46.00	80.00	92.00	80.57
5 x 2					78.90	44.00	79.00	93.00	73.75

Table 4.1c. Crossability between two lines of *Cucumis sativus* and three lines of *Cucumis trabeccanus* under pollination after NAA (15 ppm) spraying

Genotypes	A^{SX}	B^{SX}	C^{SX}	D^{SX}	A^{CX}	B^{CX}	C^{CX}	D^{CX}	Crossability index (C.I.)%
1	81.00	51.00	83.00	88.00					
2	83.10	53.00	78.50	92.30					
3	86.30	38.00	72.30	100.00					
4	82.50	18.00	79.30	92.00					
5	87.30	46.00	82.40	96.80					
1 x 3					23.30	38.00	68.00	83.80	18.44
1 x 4					20.00	33.00	62.80	82.60	11.03
1 x 5					31.40	48.00	66.00	95.00	30.91
2 x 3					21.70	38.00	59.00	91.30	15.69
2 x 4					19.60	31.00	63.00	75.20	9.02
2 x 5					25.00	46.00	74.00	96.30	25.68
3 x 1					54.20	2.00	—	—	0.00
3 x 2					54.30	1.00	—	—	0.00
4 x 1					24.10	18.00	56.00	91.30	20.25
4 x 2					20.00	17.00	51.00	82.42	13.05
5 x 1					32.10	44.00	70.00	93.34	29.67
5 x 2					32.30	45.00	66.00	91.32	28.68

Table 4.2a. Percentage seed set efficiency of the crosses at F_0 level after hand pollination

Genotypes	Seeds in selfed maternal parent	Seeds in crosses	Seed set efficiency (%)
1	58	—	—
2	54	—	—
3	31	—	—
4	22	—	—
5	48	—	—
1 x 3	—	40	68.97
1 x 4	—	31	52.45
1 x 5	—	51	87.93
2 x 3	—	36	66.67
2 x 4	—	30	55.56
2 x 5	—	49	90.76
3 x 1	—	1	3.23
3 x 2	—	1	3.23
4 x 1	—	18	81.82
4 x 2	—	19	86.36
5 x 1	—	45	93.75
5 x 2	—	43	89.58

Table 4.2b. Percentage seed set efficiency of the crosses at F_0 level after mixed pollination

Genotypes	Seeds in selfed maternal parent	Seeds in crosses	Seed set efficiency (%)
1	58	—	—
2	50	—	—
3	35	—	—
4	24	—	—
5	47	—	—
1 x 3	—	43	74.14
1 x 4	—	36	62.07
1 x 5	—	53	91.38
2 x 3	—	43	86.66
2 x 4	—	25	69.72
2 x 5	—	50	99.60
3 x 1	—	33	94.02
3 x 2	—	32	91.17
4 x 1	—	23	95.80
4 x 2	—	21	87.50
5 x 1	—	46	97.46
5 x 2	—	44	93.22

Table 4.12e. Percentage seed set efficiency of the crosses at F_0 level under pollination after NAA (15 ppm) spraying

Genotypes	Seeds in selfed maternal parent	Seeds in crosses	Seed set efficiency (%)
1	51	—	—
2	53	—	—
3	30	—	—
4	18	—	—
5	46	—	—
1 x 3	—	26	74.36
1 x 4	—	33	64.28
1 x 5	—	48	92.93
2 x 3	—	39	73.58
2 x 4	—	31	58.49
2 x 5	—	46	86.79
3 x 1	—	2	6.67
3 x 2	—	1	3.33
4 x 1	—	18	100.00
4 x 2	—	17	94.44
5 x 1	—	44	95.65
5 x 2	—	45	97.83

studied by calculating the crossability index and percentage seed set efficiency (Table 4.3). The crosses White Kanthari x Jwala and White Kanthari x K_2 failed after two methods - hand pollination and pollination after NAA spraying. In mixed pollination, these crosses were successful with crossability indices 75.92% and 70.21% respectively. The highest value for crossability index was found in crosses involving Ornamental Type as one of the parents. Crossability index was high in mixed pollination method compared to other methods; a maximum of 84.12% in the cross Jwala x Ornamental Type and a minimum value of 52.16% in the cross K_2 x Green Chuna. Under hand pollination, crossability index was maximum in the cross Ornamental Type x Jwala (34.34%) followed by Ornamental Type x K_2 (31%). The lowest value (0) was in crosses White Kanthari x Jwala and White Kanthari x K_2. Pollination after NAA spraying resulted in a crossability index of 30.91% in the cross Jwala x Ornamental Type, followed by Ornamental Type x Jwala (28.67%). Crossability index was zero in crosses White Kanthari x Jwala and White Kanthari x K_2. This revealed that NAA spraying had no effect in increasing the crossability index. Effect of maternal parent on crossability index was studied and it was found that there was maternal effect on overall basi

Percentage seed set efficiency was estimated separately for the three methods of crossing (Table 4.3). Percentage of seed set efficiency was the highest in mixed pollination method in the cross K_2 x Ornamental Type (99.6%). With hand pollination, value for percentage of seed set was 93.75% in Ornamental Type x Jwala, White Kanthari x Jwala and White Kanthari x K_2 had a value of 3.23% each. In the third method, pollination after NAA spraying, percentage of seed set was the highest in the cross Green Chuna x Jwala (100%) and the lowest in White Kanthari x K_2 (3.33%). The maternal effect for the character percentage of seed set efficiency was found to be significant.

Significant differences among the three methods were noted in respect of crossability index (Table 4.4). It was found that mixed pollination was significantly superior to other methods. Hand pollination and pollination after NAA spraying were equally effective to bring out high crossability index. No significant differences were found among methods to determine percentage of seed set efficiency.

Gametic chromosome numbers of the five parental lines were found to be n = 12 (Fig. 4.1a, 4.1b, 4.1c, 4.1d and 4.1e). Twelve distinct bivalents were observed.

Table 4.3. Relative efficiency of hand pollination, mixed pollination and pollination after NAA (15 ppm) spraying to bring out cross compatibility

Crosses	Crossability index (%)			Seed set efficiency (%)		
	Hand pollination	Mixed pollination	Pollination after NAA spraying	Hand pollination	Mixed pollination	Pollination after NAA spraying
1 x 3	11.43	58.74	16.44	68.97	74.14	74.38
1 x 4	8.96	53.49	11.03	53.45	62.07	64.38
1 x 5	29.80	84.12	30.91	87.93	91.38	93.03
2 x 3	12.15	61.16	15.60	66.67	68.66	73.08
2 x 4	7.96	52.16	9.82	55.56	60.72	58.60
2 x 5	30.64	82.57	25.68	90.74	90.68	86.79
3 x 1	0.00	78.92	0.00	3.23	94.82	6.67
3 x 2	0.00	70.21	0.00	3.23	91.17	3.33
4 x 1	25.86	71.45	28.25	81.82	95.80	100.00
4 x 2	11.97	62.70	13.65	86.36	87.50	94.44
5 x 1	34.34	80.57	29.67	93.75	97.46	95.65
5 x 2	31.06	73.75	28.08	89.58	93.22	97.83

Table 4.4. General analysis of variance

Sources of variation	df	Mean squares	
		Crossability index	Percentage of seed set efficiency
Total	35	751.45	974.21
Methods	2	11021.80**	1519.82
Error	33	129.00	933.82

** P = 0.01 NS

CD (0.05) = 9.09

8. Interspecific F_1 heterosis

The five parental lines and the ten F_1 hybrids could be successfully raised to maturity. The mean performances of the genotypes were given in Table 4.5.

The fifteen chilli genotypes were significantly different for plant height, days to flower, days to first harvest, days to maturity, fruits/plant, green fruit yield/plant, seeds/fruit and seed yield/plant (Table 4.6). The five parental lines showed significant differences for plant height, primary branches/plant, days to first harvest, days to maturity, fruits/plant, green fruit yield/plant, dry fruit yield/plant, seeds/fruit and seed yield/plant. They were not different for days to flower. The F_1 hybrids showed significant differences for plant height, days to first harvest, days to maturity, fruits/plant, green fruit yield/plant, seeds/fruit and seed yield/plant. Variances due to parents vs F_1 hybrids were significant for plant height, days to flower, days to first harvest, days to maturity, fruits/plant, green fruit yield/plant, seeds/fruit and seed yield/plant.

Heterosis was expressed as percentage increase or decrease of F_1s over better and mid parental values and significance was tested (Table 4.7).

Table 4.5. Mean performance of five chilli lines and ten F_1 hybrids

Genotypes	Characters									
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
Capsicum annuum										
1	28.17	2.23	86.67	122.67	143.33	11.43	22.67	4.43	55.33	11.77
2	32.80	2.17	86.00	121.00	141.67	12.70	26.50	5.13	60.00	10.97
Capsicum frutescens										
3	47.97	2.27	88.30	126.67	148.33	19.43	28.33	7.23	33.33	11.80
4	50.27	2.10	89.00	124.67	145.33	21.83	25.20	4.77	38.00	8.70
5	41.77	1.80	87.30	127.33	148.00	15.63	22.37	6.23	48.33	22.60
F_1 hybrids										
1 x 3	38.27	2.13	77.67	124.00	136.00	12.10	28.60	4.97	53.67	18.53
1 x 4	39.57	2.07	78.67	121.67	127.33	14.70	27.77	4.27	58.00	11.67
1 x 5	38.43	2.30	88.33	126.33	132.67	24.23	40.60	9.73	62.67	18.33
2 x 3	41.43	2.23	78.00	120.00	130.33	16.83	30.57	6.67	54.33	11.67
2 x 4	41.87	2.30	76.30	120.67	129.00	17.43	32.27	6.77	59.00	10.87
2 x 5	41.73	2.30	75.67	120.00	128.33	23.67	48.17	9.50	56.67	16.77
4 x 1	38.53	2.13	77.67	121.33	122.00	26.82	32.45	6.70	18.00	11.93
4 x 2	39.93	2.23	75.00	112.00	133.00	28.20	36.37	6.80	18.33	10.90
5 x 1	46.87	2.20	76.30	110.00	120.00	25.03	40.47	9.67	54.67	17.27
5 x 2	47.40	2.07	79.30	115.33	135.33	26.80	52.63	10.47	47.00	17.33
S. error	1.96	0.18	1.36	0.97	1.52	1.48	3.72	0.64	1.46	0.44
CD (P = 0.05)	5.69	3.04	3.94	2.80	4.41	6.04	7.68	5.89	4.22	1.27

x_1 - Plant height (cm)
x_2 - Primary branches/plant
x_3 - Days to flower
x_4 - Days to first harvest
x_5 - Days to maturity
x_6 - Fruits/plant
x_7 - Green fruit yield/plant (g)
x_8 - Dry fruit yield/plant (g)
x_9 - Seeds/fruit
x_{10} - Seed yield/plant (g)

Plant height

Four F_1 hybrids Green Chuna x Jwala (50.53 cm), Green Chuna x K_2 (50.93 cm), Ornamental Type x Jwala (46.87 cm) and Ornamental Type x K_2 (47.40 cm) were taller than taller parents and their mean differences were significant. All the hybrids exhibited heterosis over mid parental values. Relative heterosis was significant in five hybrids. The hybrid Green Chuna x K_2 was the tallest (50.93 cm) and the mean difference was significant at 1% level.

Days to flower

All hybrids flowered earlier than the early parent and the earliness was significant. Heterosis varied from -7.31% to -12.79% over better parental values. The hybrid Green Chuna x K_2 was the earliest (75 days) and had a heterotic value of -12.79% which was significant at 1% level. All the ten F_1 hybrids flowered earlier than the mid parent and the values of relative heterosis were significantly different.

Days to first harvest

This character exhibited significant heterobeltiosis in all hybrids except Ornamental Type x K_2. Compared to the mid parent, all hybrids were earlier for days to first harvest. The hybrid K_2 x Ornamental Type took only 109 days to first harvest. The hybrid Ornamental Type x K_2 was the latest (115 days).

Days to maturity

All hybrids except Ornamental Type x K_2 matured earlier than the early parents. Significant relative heterosis was observed in all hybrids except Ornamental Type x K_2. The hybrid Jwala x Green Chuna took 127 days to mature. The hybrid Ornamental Type x K_2 took the maximum of 135 days.

Fruits/plant

Six hybrids Jwala x Ornamental Type, K_2 x Ornamental Type, Green Chuna x Jwala, Green Chuna x K_2, Ornamental Type x Jwala and Ornamental Type x K_2 expressed significant heterosis over better parents. The hybrid Ornamental type x K_2 gave an increased yield (27 fruits/plant) showing heterosis to an extent of 71.47% over better parent. Four hybrids yielded lower than the parents and the yield differences were significant. Relative heterosis was significant in eight out of ten hybrids. The hybrid Jwala x White Kanthari was the poorest (13 fruits/plant) manifesting a negative heterotic value of -15.18%.

Green fruit yield/plant

Heterobeltiosis was negative in two hybrids, Jwala x White Kanthari (-35.80%) and K_2 x White Kanthari (-22.88%). All the eight hybrids showed significant positive heterosis. Maximum yield (52.63 g) was produced

by Ornamental Type x K_2. Relative heterosis was negative in two hybrids Jwala x White Kanthari and K_2 x White Kanthari. The lowest yield of 24.60 g was in Jwala x White Kanthari.

Seeds/fruit

The hybrid Jwala x Ornamental Type exhibited heterobeltiosis to an extent of 13.27%. This was significant at 1% level. Significant relative heterosis was observed in seven hybrids. The hybrid Green Chuna x K_2 had 18 seeds/fruit which is 53% lesser than the mid parents.

Seed yield/plant

Two hybrids Jwala x White Kanthari and Green Chuna x Jwala showed significant heterobeltiosis. Significant relative heterosis was observed in all hybrids except Ornamental Type x Jwala (17.37 g) and K_2 x Ornamental Type (16.77 g) where the heterosis was non-significant.

Genetic parameters like range, genotypic and phenotypic coefficients of variation, heritability in broad sense, genetic advance and genetic advance expressed as percentage of mean were estimated for different characters (Table 4.8). Plant height ranged from 24 cm in Jwala to 62.5 cm in Green Chuna x K_2.

Table 4.8. Range, mean, genotypic coefficient of variation (gcv), phenotypic coefficient of variation (pcv), heritability in broad sense (h^2b), genetic advance (ga) and genetic advance expressed as percentage of mean in a population of Capsicum annuum and Capsicum frutescens lines and their F_1 hybrids

Characters	Range	Mean	Genotypic coefficient of variation (gcv)	Phenotypic coefficient of variation (pcv)	Heritability (h^2b)	Genetic advance (ga)	ga, expressed as percentage of mean
Plant height	24.06 - 62.50	43.34	19.29	20.81	0.86	16.03	36.82
Primary branches/plant	1.60 - 2.90	2.17	4.61	9.22	0.25	0.10	4.75
Days to flower	72.00 - 91.00	80.68	6.21	6.87	0.82	9.36	11.60
Days to first harvest	100.00 -129.00	115.98	5.64	5.82	0.94	13.07	11.27
Days to maturity	122.00 -151.00	135.91	5.31	5.65	0.88	13.92	10.24
Fruits/plant	10.60 - 36.30	19.79	27.74	38.62	0.82	10.24	51.74
Green fruit yield/plant	19.20 - 65.00	35.08	27.42	38.36	0.81	17.89	51.00
Dry fruit yield/plant	3.10 - 13.10	7.03	26.32	30.73	0.73	3.25	46.23
Seeds/fruit	16.00 - 67.00	46.49	34.76	35.19	0.98	33.03	71.05
Seed yield/plant	8.30 - 23.90	11.62	27.83	28.34	0.96	7.63	56.02

Fruits/plant showed a variation of 11 in Jwala and 36 in Ornamental Type x K_2. Seeds/fruit were 16 in Green Chuna while it was 67 in Jwala x Ornamental Type. Considerable variability was observed for seeds/fruit (gcv = 34.76). The scope for selection as measured through higher values of genetic advance as percentage of mean was observed for seeds/fruit (71.05). High heritability associated with high variability was noted for seeds/fruit (h^2b = 0.98, gcv = 34.76), seed yield/plant (h^2b = 0.96, gcv = 27.83) and fruits/plant (h^2b = 0.82, gcv = 27.74).

The expression of heterosis for many of the characters were considered as a function of genetic distance existing between the two species. Pooled variance co-variance matrix is given in Appendix I. The coefficients of 'x' in the uncorrelated linear function of 'y' is given in Table 4.9. These coefficients were used to transform the correlated variables into uncorrelated linear function of 'y'. The D^2 values were estimated (Table 4.10). It was found that the cross Jwala x Green Chuna was the farthest (D^2 = 18.69) and K_2 x Ornamental Type the nearest (D^2 = 1.49). The character plant height contributed maximum towards genetic distance (80%) (Table 4.11). It was followed by seeds/fruit (20%). Days to flower and green fruit yield/plant did not contribute to divergence.

The parents and hybrids were analysed for oleoresin content (Table 4.12). Among parents, maximum

Table 4.9. Coefficient of x in a linear function of y used to transform correlated variables into uncorrelated variables

y	$\frac{-1x_3}{15.70}$
y	$\frac{(0.0013x_2) + (-1x_3)}{11.29}$
y	$\frac{(0.0002x_1) + (-0.0027x_2) + (-1x_3)}{21.37}$
y	$\frac{(1.3157x_1) + (-0.0479x_2) + (-0.0012x_3) + (-1x_4)}{21.58}$

Table 4.10. Genetic distance (D^2) between two varieties of Capsicum annuum and three varieties of Capsicum frutescens

Parents	White Kanthari	Green Chunn	Ornamental Type
Jwala	6.70	10.69*	2.19
X_2	5.53	9.54*	1.69

$\chi^2(4df) = 9.49$
*P = 0.05

Table 4.11. Contribution of each character to divergence

Character	Percentage contribution towards total D^2
X_1	80
X_2	0
X_3	0
X_4	20

X_1 - Plant height (cm) X_3 - Green fruit yield/plant (g)
X_2 - Days to flower X_4 - Fruits/bunch

oleoresin content was in Jwala (16.83%) and minimum in White Kantheri (10.1%). The F_1 hybrids with higher oleoresin content were Jwala x Ornamental Type (16.6%) followed by Ornamental Type x Jwala (15.37%).

Discussion

DISCUSSION

Inspite of the constancy in chromosome number, attempts at interspecific hybridization in the genus Capsicum have succeeded only in a few cases. Investigations on the nature of barriers to successful realisation of hybrids have been very limited. The present study was aimed to find out crossability and related aspects involving two cultivated varieties of Capsicum annuum L. and three useful lines of Capsicum frutescens L. Attempts were also made to reason out cross incompatibility, if any, and work out method(s) to overcome the barrier.

A. Cross compatibility between lines of Capsicum annuum L. and Capsicum frutescens L.

Hand emasculation and pollination were done and crossability index calculated as suggested by Rao (1979). Crossability index being a function of percentage of fruit set, viable seeds/fruit, percentage of germination and percentage of seedlings survival both in crosses and selfed maternal parent reflected a measure of crossability. There was no barrier which prevented the successful crossing of lines of Capsicum annuum and Capsicum frutescens except in two combinations where White Kanthari was used as the female parent.

Obviously this revealed cross compatibility between Capsicum annuum and Capsicum frutescens except in the two specific cases, White Kanthari x Jwala and White Kanthari x K_2.

Pillai et al. (1977) and Sundaresan and Chandrasekaran (1979) reported one way incompatibility between Capsicum annuum and Capsicum frutescens, where the cross failed when Capsicum annuum was used as the female parent. According to Smith and Heiser (1957), about 2% of viable seeds were obtained when Capsicum frutescens was used as the female parent. The reciprocal cross had never been successfully made. In this study when Capsicum annuum lines were used as the female parent, crossability index values ranged from 7.96% in K_2 x Green Chuma to 30.64% in K_2 x Ornamental Type after hand pollination. This indicated that they were comparatively crossable. Crosses White Kanthari x Jwala and White Kanthari x K_2 had a crossability index of zero indicating complete cross incompatibility. Crossability index is a multiplicative function of components like percentage of fruit set, viable seeds/fruit, percentage germination and percentage of seedlings survival. Higher crossability index in a few crosses might be due to higher values of any of these components. The maximum crossability index (34.34%) was found in Ornamental Type x Jwala after hand pollination which was due to 100% survival of the seedlings.

The cross K_2 x Green Chuna had a lower crossability index value (7.99%) which resulted from lower percentage of fruit set (20). The crosses White Kanthari x Jwala and White Kanthari x K_2 with crossability indices of zero each, had the maximum percentage of fruit set (54.50%), but the number of viable seeds was the lowest (1).

In order to find out the reasons for incompatibility between White Kanthari (Capsicum frutescens) and Pant C-1 (Capsicum annuum), Peter and Mc Collum (1983) conducted a detailed study. They observed perfect pollen stigma compatibility in direct and reciprocal crosses involving White Kanthari and Pant C-1 which otherwise failed to set fruit after artificial pollination under field conditions. Cochran (1970) and Peter and Mc Collum (1983) observed pollen tube growth which finally reached the ovule. The failure to set fruits might be due to reasons other than pollen stigma incompatibility and pollen tube growth. This could be attributed to the incompatibility between ovule and generative nuclei and cytoplasmic incompatibility in the above specific cases. However, Keshav Ram and Saini (1971) found that Capsicum annuum and Capsicum frutescens varieties were successfully intercrossed in all directions.

Crosses involving Ornamental Type as one of the parents were found to be highly crossable (crossability index 29.80% to 36.34%) (Table 5.1a). The crosses Jwala x Green Chuna and K_2 x Green Chuna were classified as often compatible and their crossability index values were 8.96% and 7.96% respectively. In mixed pollination, all crosses were found to be compatible with crossability indices ranging between 52.16% and 84.12% (Table 5.1b). In the case of pollination after NAA spraying, the two crosses involving White Kanthari as the female parent (White Kanthari x Jwala and White Kanthari x K_2) were found to be incompatible (Table 5.1c) as in hand pollination method. The cross K_2 x Green Chuna was classified as often compatible since the crossability index was 9.92%. The different methods of pollination were tried to find out their relative efficiency to increase the compatibility. Mixed pollination was found to be superior among the three methods and all crosses were successful with higher crossability index values ranging from 52.16% to 84.12%. It was evident that pollination after NAA spraying had no effect to increase compatibility. Studies on effect of maternal parent on crossability index and percentage of seed set efficiency revealed that there was maternal effect on overall basis. The direct and reciprocal crosses differed significantly for crossability index and percentage seed set efficiency.

Table 5.1a. Compatibility between two varieties of *Capsicum annuum* and three varieties of *Capsicum frutescens* based on hand pollination

	Jwala	K_2	White Kanthari	Green Chuma	Ornamental Type
Jwala	+++	++	← +	-	← ++
K_2	++	+++	← +	-	← ++
White Kanthari	—	—	+++	++	++
Green Chuma	← +	← +	++	+++	++
Ornamental Type	← ++	← ++	++	++	+++

+++ .. Self compatible ($C.I._{.} > 35$)

++ .. Highly cross compatible ($C.I._{.} > 20 < 35$)

+ .. Moderately cross compatible ($C.I._{.} > 10 < 20$)

- .. Often compatible ($C.I._{.} > 0 < 10$)

— .. Incompatible ($C.I._{.} = 0$)

← .. Indicates direction of female parent, when more compatible

Table 3.1b. Compatibility between two varieties of *Capsicum annuum* and three varieties of *Capsicum frutescens* based on mixed pollination

	Jwala	K_2	White Kanthari	Green Chuna	Ornamental Type
Jwala	+++	++	← ++	← ++	← ++
K_2	++	+++	← ++	← ++	← ++
White Kanthari	← ++	← ++	+++	++	++
Green Chuna	← ++	← ++	++	+++	++
Ornamental Type	← ++	← ++	++	++	+++

Table 5.1c. Compatibility between two varieties of *Capsicum annuum* and three varieties of *Capsicum frutescens* based on pollination after NAA (15 ppm) spraying

	Jwala	K_2	White Kanthari	Green Chunna	Ornamental Type
Jwala	+++	++	← +	← +	← ++
K_2	++	+++	← +	-	← ++
White Kanthari	—	—	+++	++	++
Green Chunna	← ++	← +	++	+++	++
Ornamental Type	← ++	← ++	++	++	+++

Formation of fruits in interspecific F_0 cross, presence of viable seeds in F_0 fruit and development of normal F_1 plants indicated compatibility between the two species except in specific combinations. Crossability was found to be specific and genotype dependent.

B. Interspecific F_1 heterosis

The compatibility of interspecific F_1 hybrids was further proved through the manifestation of heterosis for a number of quantitative characters. Heterosis was significant for plant height, days to flower, days to first harvest, days to maturity, fruits/plant, green fruit yield/plant, seeds/fruit and seed yield/plant. No heterosis was observed for primary branches and dry fruit yield/plant. Heterobeltiosis, being a function of overdominant gene action would lead to generation of considerable variability resulting in transgressive segregants for economic characters. Pillai *et al.* (1977) and Sundaresan and Chandrasekaran (1979) reported heterosis for plant height. The present study revealed heterobeltiosis ranging from -21.29% to 19.22% and relative heterosis ranging from 0.53% to 49.34%. Earliness to bloom is an important economic attribute. All hybrids flowered earlier and the heterotic decrease ranged from -7.31% to -12.79% over early parent. The hybrid Green Chuma x K_2 was the earliest, flowering on 75th day of sowing. Mishra *et al.* (1976) also reported heterosis for this character. All hybrids exhibited heterosis for days to

first harvest and days to maturity. Mishra et al. (1976) and Sundaresan and Chandrasekaran (1979) also obtained heterosis for earliness. Heterobeltiosis for yield varied from -35.80% to 62.59% and relative heterosis from -19.36% to 78.77%. The hybrid Ornamental Type x K_2 produced a maximum yield of 52.63 g/ plant. Heterosis for yield was also reported by Mishra et al. (1976), Singh and Singh (1976), Singh and Singh (1978) and Singh (1981).

Information on variability and its components are vital to any plant improvement programme. Genetic advance expected in succeeding generations depended considerably on variability of the base population and heritability of the character under selection (Allard, 1960). In the present study appropriately such informations were collected. Considerable scope existed for selection for higher seeds/fruit. High heritability associated with high variability was noted for seeds/fruit, seed yield/plant and fruits/plant. Singh and Singh (1977) also estimated high heritability for fruits/plant.

F_1 heterosis for many of the quantitative characters were considered as a function of genetic distance existing between the two species in the present study. The relation between genetic distance (D^2) and heterobeltiosis in the F_1 hybrids were given in Table 5.2. Maximum D^2 value of 10.69 was found between Jwala and Green Chana which indicated that the two parents are genetically

Table 5.2. Relation between genetic distance and heterobeltiosis in the interspecific hybrids involving *Capsicum annuum* L. and *Capsicum frutescens* L.

Crosses	Genetic distance D^2	Heterobeltiosis (%)			
		Plant height	Days to flower	Fruit yield/ plant	Seed yield/ plant
1 x 3	6.70	-20.22**	-10.38**	-35.80**	6.19**
1 x 4	10.69*	-21.29**	-9.23*	10.20*	-5.96**
1 x 5	2.19	-12.31**	-7.31*	50.76**	-18.17**
2 x 3	5.53	-13.65*	-11.63**	-22.85**	-1.29
2 x 4	9.54*	-16.71**	-11.38*	21.77**	-8.91*
2 x 5	1.69	-8.10	-12.91**	48.81**	-25.13**
4 x 1	10.69*	16.43**	-10.38*	28.77**	1.36
4 x 2	9.54*	19.22**	-12.79**	37.25**	-8.64
5 x 1	2.19	12.21*	-11.96**	69.74**	-22.90**
5 x 2	1.49	13.48*	-7.79**	62.59**	-22.63**

distant. The direct and reciprocal hybrids differed in heterotic values for plant height (-21.29% and 16.43% respectively), fruit yield/plant (10.20% and 28.77% respectively) and seed yield/plant (-5.94% and 1.36% respectively). These differences were attributed to the effect of maternal parent in the hybrid. K_2 and Ornamental Type had the lowest D^2 (1.49) indicating their closeness.

Cross compatibility between Capsicum annuum and Capsicum frutescens was further confirmed. Cross incompatibility if observed in interspecific crosses could be attributed to specific parental combinations resulting from intercytoplasmic, ovular-generative nucleus interaction and many factors of zygote abortion. Mixed pollination was observed effective to bring out cross compatibility and could be used if appropriate markers could be tagged to the male/female parents. The cross compatibility was again confirmed through manifestation of heterosis for earliness, fruit yield and their components. The closeness/distance between breeding lines was worked out to explain magnitude of heterosis. A perfect relation between genetic distance and heterosis could not be visualised in the present study. Selection of characters of divergence was mainly arbitrary and a detailed study involving independant

quantitative characters could explain such a well established relation. Maternal effect was significant for crossability index and percentage seed set efficiency. This indicates the need for proper selection of maternal parents in such interspecific hybridization programmes.

Summary

SUMMARY

1. The present investigation on Compatibility among varieties of Capsicum annuum L. and Capsicum frutescens L. was conducted during September-February, 1982-83 and May-September, 1983 at the Instructional Farm, College of Horticulture, Vellanikkara, Trichur. The experimental materials consisted of two lines of Capsicum annuum (Jwala and K_2) and three lines of Capsicum frutescens (White Kanthari, Green Chunn and Ornamental Type).

2. The compatibility between Capsicum annuum and Capsicum frutescens was studied by calculating the crossability index and percentage seed set efficiency at F_0 level. All crosses including directs and reciprocals were found to be compatible except in two combinations where White Kanthari was used as the female parent.

3. Relative efficiency of the three methods (hand pollination, mixed pollination and pollination after NAA 15 ppm spraying) on cross compatibility was studied by calculating the crossability index and percentage seed set efficiency. The results indicated that the crosses White Kanthari x Jwala and White Kanthari x K_2 failed after hand pollination and pollination after NAA spraying, whereas these crosses were successful after mixed pollination. Study of the effect of maternal

parent on crossability index and percentage seed set efficiency revealed that there was maternal effect on overall basis. The chromosome numbers of the five parental materials were found to be 2n = 24.

4. Significant heterosis was observed for plant height, days to flower, days to first harvest, days to maturity, fruits/plant, green fruit yield/plant, seeds/fruit and seed yield/plant.

5. Different genetic parameters were studied to find out the scope for selection. Values of heritability and genetic advance were higher for seeds/fruit indicating that there is scope for selection.

6. Genetic distance between Capsicum annuum and Capsicum frutescens was estimated. It was found that the parents Jwala and Green Chunn were the fartheat whereas K_2 and Ornamental Type were the nearest. The character plant height contributed maximum towards genetic distance followed by seeds/fruit. Days to flower and green fruit yield/plant did not contribute to divergence.

7. Among parents maximum oleoresin content was in Jwala (16.83%) and minimum in White Kanthari (10.1%). In hybrids, Jwala x Ornamental Type had the highest (16.6%) followed by Ornamental Type x Jwala (15.37%).

References

REFERENCES

*Allard, R.W. 1960. Principles of Plant Breeding. pp. 93 John Wiley and Sons, Inc. London.

Angeli, L. 1957. Production trials with hybrid pepper. Kert. Kut. Int. Bil. 3: 131-140.

*Arya, P.S. and Saini, S.S. 1977. Capsaicin content of chilli varieties. Indian Agronomy Science Congress Jour. 1(1): 7-10.

Balasubramanian, P. 1981. Personal communication.

Betlach, J. 1966. Some results of hybridisation in sweet peppers (Capsicum annuum L.). Bull. Vynk. Vstav. Zelen. 10: 13-21.

Betlach, J. and Novak, F. 1971. Studies on artificial hybridisation in green pepper (Capsicum annuum L.). Zahradnictvi. (2/3): 97-106.

*Briggle, L.W. 1963. Heterosis in wheat - A Review. Crop Sci. 3: 407-412.

Burton, G.W. 1952. Quantitative inheritance in grasses. Proc. 6th Int. Grassld. Cong. 1: 277-281.

*Chandramony, D. and George, M.K. 1976. Effect of planofix foliar spraying on some varieties of Capsicum. Agri. Res. Jour. Kerala. 14(2): 196-197.

Chirilei, H. 1968. Results of intergeneric hybridisation of tomato and pepper. Bull. Inst. Biol. Sir. Bot. 13(1-2): 19-26.

Cochran, H.L. 1970. Pollen tube growth through the style of Pimiento pepper (Capsicum frutescens L.). Hort Science 5 (1): 30-31.

*Cochran, H.L. and Dempsey, A.H. 1966. Stigma structure and period of receptivity in Pimientos (Capsicum frutescens L.). Proc. Amer. Soc. Hort. Sci. 89: 454-457.

*Frankel, R. 1977. Pollination mechanisms, Reproduction and Plant Breeding. pp. 172. Springer-Verlag, New York.

Ganesamba, V.L. 1965. Brief results of the work with Capsicum peppers at Majlap station of the Institute of Plant Industry. Sci. Rep. Malkam. Hum. Sta. All. Un. Inst. Pl. Industr. 1: 49-55.

Hayes, H.K., Immer, F.R. and Smith, D.C. 1955. Methods of Plant Breeding. pp. 329-332. Mc Graw Hill Book Company, Inc. New York.

Hirose, T., Nishi, S. and Takashima, S. 1961. Studies on interspecific hybridization between cultivated species of Capsicum. II. Some characteristics of F, interspecific hybrids. Kyoto Daigaku Gakujutsu Hokoku. 13: 23-28.

*Jayanandam, U.D.S., Savaji, J.N. and Murthy, N.S. 1976. A note on beneficial effects of NAA (Planofix) on chilli. Andhra Agr. Jour. 23 (1&2): 80-82.

Keshava Ram, N. and Saini, S.S. 1971. Compatibility studies in some Capsicum species. Himachal Jour. Agr. Res. 1(1): 34-39.

Kiss, A. and Paal, H. 1976. Studies on in vivo pollen tube growth in red pepper. (Capsicum annuum L.). Acta Bot. 16: 89-95.

Mahalanobis, P.C. 1928. A statistical study at Chinese head measurement. Jour. Asiatic Soc. Bengal. 25: 301-377.

Markus, F. 1963. Investigations on cross pollination in red pepper for spice. Doma - Tiana Kozl Mezogazd. Kiseki. Int. Evk. 119-121.

*Mishra, S.P., Singh, H.N. and Singh, A. 1976. Note on heterosis in chilli (Capsicum annuum L.). Prog. Hort. 8 (3): 61-62.

Molhova, E. 1965. A study of the female gametophytes in relation to nature of sterility in the interspecific hybrids of Capsicum pendulatum x Capsicum annuum. Rasten. Nauk. 2(5): 31-46.

Molhova, E. 1967. A cytoembryological study of the sesquidiploid hybrid Capsicum annuum x Capsicum pubescens. Genetical Research. A collection of papers. Bulgar. Akad. Nai. 91-98.

*Murthy, N.S.R. and Murthy, B.S. 1962. Natural Cross pollination in chilli. Andhra Agr. Jour. 9 (3): 161-165.

*Nayar, K.M.D., Rao, M.G. and Reddy, B.G.S. 1979. New interspecific chilli strains for Karnataka. Curr. Res. 8(9): 158-160.

Nettancourt, D. de. 1972. Self-incompatibility in basic and applied researches with higher plants. Genet. Agr. 26: 163-226.

*Nettancourt, D. de. 1977. Incompatibility in Angiosperms. pp. 141. Springer - Verlag, New York.

*Nwankiti, O.C. 1981. Sterility in intraspecific hybrids of Capsicum. Indian Jour. Genet. 41: 200-204.

*Omidiji, M.O. 1979. Crossability relationships between some spices of Solanum, Lycopersicon and Capsicum cultivated in Nigeria (In) Hawker, J.W., Lester, R.N. and Skelding, A.D. (ed.). The Biology and Taxonomy of the Solanaceae. pp. 599-604. Linnean Society of London, London.

*Peter, K.V. and Mc Callum, G.D. 1983. Pollen-stigma compatibility in direct and reciprocal crosses of Capsicum species. Jour. Hered. 74 (in press).

*Pillai, S.E.R., George, M.K. and Mercy, S.T. 1977. Studies on interspecific hybrids of five species of Capsicum - with special reference to its qualitative and quantitative characters. Agr. Res. Jour. Kerala. 15 (1): 1-8.

Popova, D., Mikhailov, L. and Petrova, N. 1978. Effect of temperature and humidity on pollen germination and formation of pollen tubes in Capsicum annuum. Biologik Ximiarya (1): 81-82.

Quagliotti, L. and Ottaviano, E. 1967. Study of the variability in the capsaicin content of the berries of different cultivated populations of pepper (Capsicum annuum L.). Genet. Agr. Pavia. 21: 249-264.

*Radhakrishnan, K.P., Mercy, S.T. and George, M.K. 1977. Crossability studies and analysis of incompatibility in 3 species of Capsicum. Agr. Res. Jour. Kerala. 15(2): 124-127.

Rao, C.R. 1948. The utilisation of multiple measurement in problems of biological classification. Jour. Roy. Stat. Soc. 10 B: 159-203.

*Rao, N.N. 1979. Barriers to hybridisation between Solanum melongena and some other species of Solanum. (In) Hawker, J.W., Lester, R.N. and Skelding, A.D. (ed.). The Biology and Taxonomy of the Solanaceae. pp. 605-615. Linnean Society of London, London.

Shopova, M. 1966. Studies in the genus Capsicum L. species differentiation. Chromosoma 18: 338-348.

*Singh, J. 1981. A note on hybrid vigour studies in chilli (Capsicum annuum). Punjab Vav. annuum. 16: 31-33.

*Singh, K.K. and Chaudhary, B.D. 1979. Biometrical methods in quantitative genetic analysis. pp. 215-231. Kalyani Publications, Ludhiana.

*Singh, A. and Singh, H.N. 1976. Heterosis and inbreeding depression in three traits in chilli (Capsicum annuum). Indian Jour. Agr. Res. 10(2): 105-110.

*Singh, A. and Singh, H.N. 1977. Note on heritability genetic advance and minimum number of genes in chilli. Indian Jour. Agr. Sci. 47 (5): 260-262.

*Singh, A. and Singh, H.N. 1978. Heterosis and its components for yield in chilli. Indian Jour. Agr. Sci. 48(7): 387-389.

*Smith, P.G. 1983. Crossability of Capsicum species. Personal Communication.

Smith, P.G. and Heiser, C.B. 1951. Taxonomic and genetic studies on the cultivated peppers, Capsicum annuum L. and Capsicum frutescens L. Amer. Jour. Bot. 38(5): 362-368.

*Smith, P.G. and Heiser, C.B. 1957. Breeding behaviour of cultivated peppers. Proc. Amer. Soc. Hort. Sci. 70: 286-290.

*Sundaram, A., Ramakrishnan, A., Ranganathan, C.R. and Ramalingam, S. 1980. Genetic divergence in chilli. Indian Jour. Agr. Sci. 50 (5): 391-393.

*Sundaresan, N. and Chandrasekaran, P. 1979. The cytomorphology of an interspecific hybrid in Capsicum. Madras Agr. Jour. 66 (8): 493-502.

*Tewari, V.P. 1979. Increasing capsaicin content in chillies. Indian Arecanut, Spices Cocoa Jour. 11 (3): 90-91.

*Thirumalachar, M.K. 1967. Variability for capsaicin content in chilli. Cur. Sci. 36: 269-270.

*Vijay, O.P., Singh, D.P. and Yadav, I.S. 1979. Studies on flower development, fruit maturity and floral biology in sweet pepper (Capsicum annuum L.). Veg. Sci. 6(1): 5-10.

Warde, S.D. and Singh, K. 1977. Effect of Planofix on control of flower drop and fruit set in chillies (Capsicum annuum L.). Pesticides. 11 (3): 24-26.

Yaqub, C.M. 1968. The genetic basis of self-incompatibility in Capsicum pubescens R. and P. and Capsicum sarmentosii H. and B. Diss. Abst. 28: 891-894.

*Originals seen

Appendices

Appendix I. Pooled variance-covariance matrix

x_1	x_2	x_3	x_4
246.43	0.32	0.85	3242.21
	127.55	-0.38	-5.69
		488.17	-0.48
			936.47

x_1 = Plant height

x_2 = Days to flower

x_3 = Green fruit yield/plant

x_4 = Seeds/fruit

Fig. 2.2. Pollen tube growth in gynoecia following interspecific pollinations in *Canna* 'Pant C-1' (PC) and *Canna* 'White Kanthari' (WK)

a. PC x WK, 6 hours, no pressure applied to gynoecium

b. WK x PC, 6 hours, moderate pressure applied to gynoecium

Fig. 2.2. Pollen tube growth in gynoecia following interspecific pollinations in *Saccharum officinarum* 'Pant C-1' (PC) and *Saccharum fuscum* 'White Kanthari' (WK)

c. PC x WK, 24 hours, pollen tubes have reached vicinity of ovules

d. WK x PC, 24 hours, pollen tubes in contact with ovules

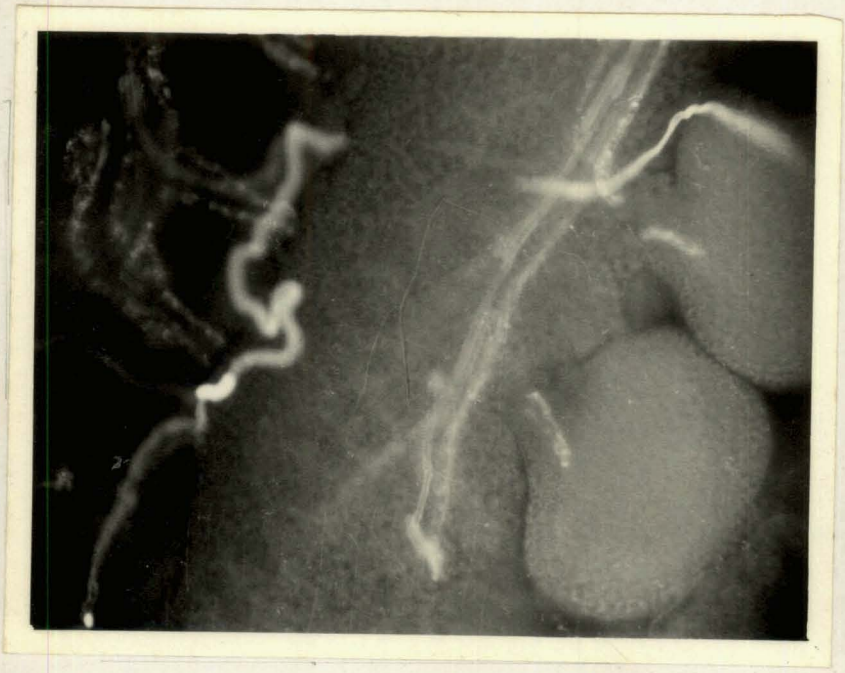


Fig. 3.1. [redacted] line - Scale

Fig. 3.2. [redacted] line - Σ_g


JWALA


K2

Fig. 3.3. [redacted] line - White Kasthuri

Fig. 3.4. [redacted] line - Green Chuna


WHITE KANTHARI


CHUNA

Fig. 3.5. [redacted] Linn -
[redacted]


ORNAMENTAL TYPE

Fig. 3.6. [redacted] line - Jwala

x

[redacted] line - Green Chana

Fig. 3.7. [redacted] line - Chola

x

[redacted] line - Ornamental Type


JWALA
F1
CHUNA


JWALA
F1
ORNAMENTAL TYPE

Fig. 3.8. [redacted]

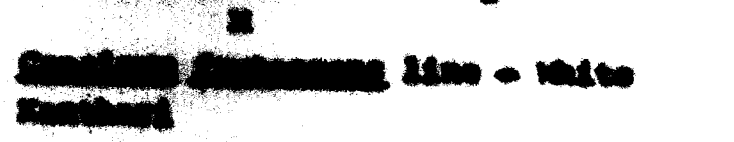


Fig. 3.9. [redacted]

K2 F1 CHUNA

Fig. 2.10a [illegible]

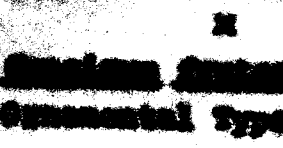
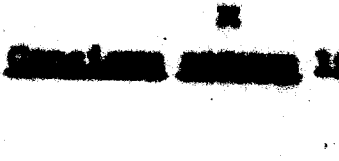


Fig. 2.11a [illegible]



K_2 F_1 ORNAMENTAL TYPE

Fig. 3.11. [redacted] line -
Cruza Chica
x
[redacted] line - x_2

Fig. 3.13. [redacted] line -
Ornamental type
x
[redacted] line - Jwala


CHUNA
F1
K2


ORNAMENTAL TYPE
F1
JWALA

Fig. 1.14. [illegible] [illegible] Line - Ornamental Type

x

[illegible] [illegible] Line - F_2


ORNAMENTAL TYPE
F1
K2

Fig. 4.1. [redacted] number of the five parental lines to be found at n = 12

a) [redacted] line - Svala

b. [redacted] line - F_2

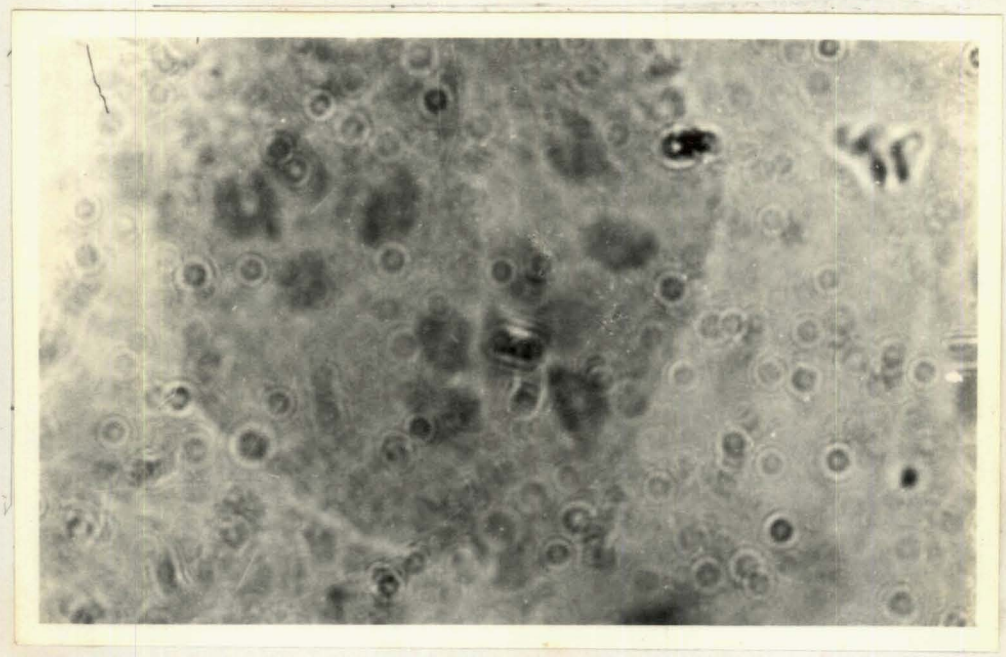
Fig. 4.14 Chromosome numbers of the five parental lines to be found as n = 12

a. Sorghum bicolour line - White Kaoliang

b. Sorghum bicolour line - Green Cluma

Fig. 4.1a [illegible] of the five parental lines to be found as n = 12

(a) [illegible] line - [illegible]



COMPATIBILITY AMONG VARIETIES IN

Capsicum annuum L. and Capsicum frutescens L.

By

KRISHNAKUMARI, K.

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the

requirement for the Degree

Master of Science in Horticulture

Faculty of Agriculture

Kerala Agricultural University

Department of Olericulture

COLLEGE OF HORTICULTURE

Vellanikkara—Trichur.

1984

ABSTRACT

Attempts at interspecific hybridisation in the genus Capsicum have succeeded only in a few cases. Most of the crosses resulted in negligible seed set and flower fall. Capsicum frutescens is valued for its high pungency and also for the source of resistance to leaf curl and mosaic complex. An experiment was planned and carried out during 1982-83 at the Instructional Farm of the College of Horticulture, Vellanikkara, Trichur to find out crossability and related aspects involving two cultivated varieties of Capsicum annuum (Jwala and K_2) and three useful lines of Capsicum frutescens (White Kanthari, Green Chuma and Ornamental Type).

All crosses including directs and reciprocals were found to be compatible except in two combinations where White Kanthari was used as the female parent. Relative efficiency of hand pollination, mixed pollination and pollination after NAA (15 ppm) spraying on compatibility indicated that the crosses White Kanthari x Jwala and White Kanthari x K_2 failed with hand pollination and pollination after NAA spraying whereas these crosses were successful with mixed pollination. Effect of maternal parent on crossability index and percentage seed set efficiency was found to be significant. The chromosome numbers of the five

parental lines were found to be 2n = 24.

Significant heterosis was observed for many of the characters. Genetic distance reveals that parents Jwala and Green Chana were the farthest whereas K_2 and Ornamental Type were the closest. Maximum oleoresin content was in Jwala (16.83%) and in hybrids Jwala x Ornamental Type had the highest (16.6 %).