GENETIC CATALOGUING OF HOT CHILLI (*Capsicum chinense* Jacq.)

BY

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THESIS
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Dedicated

to

Amma and Achan

DECLARATION

I hereby declare that this thesis entitled **Genetic cataloguing of hot chilli** (*Capsicum chinense* **Jacq**) s a bonafide record of research work done by me dur ng the course of research and that the thesis has not prev ously formed the bas s for the award of any degree d ploma assoc atesh p fellowsh p or other s m lar t tle of any other un vers ty or soc ety

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CERTIFICATE

Cert f ed that th s thes s ent tled **Genetic cataloguing of hot chilli (*Capsicum chinense* Jacq)** s a record of research work done ndependently by Ms Manju P R (99 12 09) under my guidance and s perv s on and l at t has not previously formed the bas s for the award of any degree fellowship or associateship to her

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Introduction

1 INTRODUCTION

Chilli or red pepper is an important vegetable cum spice crop grown throughout India for domestic as well as export markets They are consumed in green red as well as in sun dried conditions It is unique among spice crops being a natural source of capsaicin the pungent principle in chilli and colour

Capsaicin is an effective counter irritant and hence chilli extracts are used in pharmaceutical and cosmetic preparations Since many countries including India are applying more and more restriction on the use of artificial colours chilli colour may have a good demand as a substitute in food industry Also oleoresin obtained by solvent extraction find application in food pharmaceutical and cosmetic industries The green chilli fruits are valuable on account of their richness in ascorbic acid

Chilli belongs to the family Solanaceae and comes under the genus *Capsicum* Recognizing the extent of variability modern taxonomists have consolidated the cultivated *Capsicum* into the following five species *Capsicum annuum* *C frutescens* *C chinense* *C baccatum* and *C pubescens*

Most of the chillies available in the market belong to *C annuum* which is the most widely cultivated species The present breeding works in chilli is mainly concentrated on the utilization of a relatively narrow gene base within the various cultivar groups eventhough a wide genetic diversity exists both intraspecifically and interspecifically To evolve varieties suited for specific purpose widening of genetic base is inevitable

C chinense one of the species grown in the homesteads of Kerala can be utilized for the improvement of the present day cultivars of *C annuum* Characterized by its typical flavour and aroma the species is noted for its high oleoresin content and pungency The plant is perennial in habit and bears two to five flowers per node as against solitary bearing in *C annuum* cult vars Moreover the species is reported to be resistant to several pathogens including *Ralstonia solanacearum* and tomato spotted wilt virus which attack *C annuum* in the humid tropics

Recently this crop is being exported to Maldives from Thiruvananthapuram airport where it has got much demand because of its flavour It is known that this hot chilli is being largely used for the preparation of tuna fish which is one of the most favourite dishes of the people of Maldives

Kerala is blessed with diverse climatic and soil conditions which have helped n the development of different landraces of *C chinense* having a wide range of variability But so far there is no commercial variety available in this spec es in India A critical estimate of genet c variability in the available germplasm is a pre requisite in a breeding programme for effective selection of superior genotypes and no systematic effort has been taken in this species so far

Taking into consideration of all these aspects the present study was undertaken w tl the following objectives

1 To genetically catalogue the available landraces in *C chinense*

2 To ıdent fy super or genotypes based on yıeld qualıty and pest and d sease res stance

3 To est mate the extent of ava lable var abıl ty for mportant cl aracters n *C chıncn e*

4 To study the extent of genetıc dıvergence among the landraces and to group them ınto clusters based on genetıc dıstance

5 To est mate the role of genetıc contrıbutıon ın the expressıon of each character and

6 To measure the degree and pattern of assocıat on between the characters

Review of Literature

2 REVIEW OF LITERATURE

Capsicum chinense an economically important species of vegetable chilli originated in the New World (Smith and Heiser 1957) The species which is noted for its biennial or perennial habit and for the highly pungent deep red coloured fruits are grown in the western hemisphere tropical South America Carribbean and South Central America (Loewenfeld and Back 1985) Scotch Bonnet and Habanero peppers the highly pungent cultivar classes of this crop are extremely popular in the United States (Fery and Thies 1997)

Eventhough considerable efforts have been made for the improvement of *C annuum* the rich diversity in *C chinense* has not received much attention

The available literature on the variability in *Capsicum* spp are reviewed under the following subheads

2 1 Genetic cataloguing

2 2 Variability

2 3 Heritability and genetic advance

2 4 Correlation studies

2 5 Path coefficient analysis

2 6 Selection index

2 7 Genetic divergence

2 8 Chemical constituents

2 9 Reaction towards mosaic disease

2 1 Genetic cataloguing

The genus *Cap cum* possess a wide var ation n several morphological characters (Murthy and Bavajee 1982)

Ort z and de la Flor (1990) evaluated f ve cultivated spec es of *Cap cu n* and dentified the principal characters d fferent at ng them Si n larly Pradeepk nar (1990) grou ped the accessions under *C ch nense* nto three morpholog cally d st nct groups based on corolla colour and calyx annular constrict on

Ind ra (1994) subjected e ghty two ch lli genotypes to modern taxonom c treatments as suggested by IBPGR and ass gned them nto four *Caps cum* spec es namely *C annuum C fri te ccn C ch ncn c* and *C baccati n*

In *C frutescens* h gh var ability for morpholog cal characters was observed by Sheela (1998)

Based on plant growth hab t flower and fruit characters Si n l and Ahmad (1998) class f ed 160 accessions of chill (*Caps cum* spp) nto four cultivated spec es

A w de range of var at on has been reported for var ous qual tat ve and quant tat ve characters n ch ll (Verma *et al* 1998 and Fat ma 1999) Twenty e ght access ons of *C ch nense* were catalogued for morpholog cal characters using the IBPGR descr ptor l st for *Capsicum* (Cher an 2000)

2 2 Variability

Genetic var ab l ty n the base population s a pre requ s te for effect ve crop mprovement Cons derable var at on for several characters n chilli was reported by Hiremath and Mathapati (1977) Gopalakrishnan *et al* (1987) Kumar *et al* (1993) and Cherian (2000)

2 2 1 Morphological characters

High values for phenotypic and genotypic variances were observed for plant height by Arya and Saini (1977) Ramalingam and Murugarajendran (1977) and Gopalakrishnan *et al* (1987) Ahmed *et al* (1990) and Sahoo *et al* (1990) revealed a low range of variation in plant height In *C chinense* Cherian (2000) obtained a phenotypic and genotypic coefficients of variation of 14 68 and 13 10 per cent respectively

In *C annuum* Ramalingam and Murugarajendran (1977) noticed high values of phenotypic and genotypic variances for branches per plant whereas Bai *et al* (1987) observed low values Low phenotypic and genotypic variances for primary branches per plant was reported by Sahoo *et al* (1990) Similarly Varalakshmi and Haribabu (1991) obtained low phenotypic and genotypic coefficients of variation for the character

In the case of plant spread high phenotypic and genotypic coefficients of variation was observed by Vijayalakshmi *et al* (1989) whereas Ahmed *et al* (1990) obtained low values Wide range of variation for plant spread was noticed by Sahoo *et al* (1990)

Low phenotypic and genotypic coefficients of variation was reported for days to first flowering (Arya and Saini 1977 Varalakshmi and Haribabu 1991 Cherian 2000)

Pollen fertility was observed to have a range of 95 6 96 0 per cent in sweet pepper (*C annuum* L) on the day of anthesis (Vijay *et al* 1979)

Pradeepkumar (1990) obtained a range of 37 24 per cent in *C chacoense* to 94 11 per cent in *C annuum*

Arya and Saini (1976) reported a moderate genotypic coefficient of variation for days to maturity in *C annuum* A high genetic variation for the character was observed by Kumar *et al* (1993) and low variation by Cherian (2000)

2 2 2 Economic characters

2 2 2 1 Fruit and fruit yield

A wide range of variation in fruit and fruit yield per plant was reported by Arya and Saini (1977) Hiremath and Mathapati (1977) Ramalingam and Murugarajendran (1977) Gopalakrishnan *et al* (1985) Ahmed *et al* (1990) Sahoo *et al* (1990) and Kataria (1997)

High phenotypic and genotypic coefficients of variation was observed by Singh and Brar (1979) Rajput *et al* (1981) Nair *et al* (1984) Jabeen *et al* (1999) and Cherian (2000)

In *C frutescens* Sheela (1998) obtained high genotypic coefficient of variation for fruit yield

2 2 2 2 Fruit characters

Low phenotypic and genotypic coefficients of variation was observed for fruit length fruit girth and fruit weight by Vijayalakshmi *et al* (1989) whereas Sheela (1998) Das and Choudhary (1999b) Fatima (1999) and Sreelathakumary (2000) reported high values

Rajput *et al* (1981) and Nair *et al* (1984) observed high genotypic coefficients of variation in fruit weight In the case of fruit girth a narrow genetic variability was reported by Gopalakrishnan *et al* (1987) and Munsh and Behera (2000)

Pedicel length exhibited a low range of variability in *C* [illegible] (Choudhary *et al* 1985) On the other hand Rani (1996a) observed considerable variation for the character In *C chinense* a pedicel length range of 1 35 to 4 25 cm with 25 93 and 25 39 per cent of phenotypic and genotypic coefficients of variation respectively was reported by Cherian (2000)

2 2 2 3 Seed characters

Wide variability in seeds per fruit was observed by Arya and Saini (1976) Vijayalakshmi *et al* (1989) Varalakshmi and Haribabu (1991) and Rani (1996b)

Sahoo *et al* (1990) reported a low range of variation in 100 seed weight whereas Rani (1996b) noticed a four fold variability in fruit seed weight Rani *et al* (1996) revealed high genotypic coefficient of variation in 100 seed weight

2 3 Heritability and genetic advance

Effectiveness of selection depends upon the heritability and genetic advance of the character studied

Singh and Singh (1970) reported low values of heritability and genetic advance for most of the traits studied while Jabeen *et al* (1998) obtained high values for several characters

High heritability has been reported for plant height in *C. annuum* (Singh and Brar 1979; Ghai and Thakur 1987). On the other hand, low heritability was observed by Vijayalakshmi *et al.* (1989).

In *C. annuum*, branches per plant exhibited high heritability and genetic advance (Ramalingam and Murugarajendran 1977; Nair *et al.* 1984). Low heritability and genetic advance for primary branches per plant was reported by Rani *et al.* (1996).

Plant spread was reported to have low heritability and genetic advance by Ramakumar *et al.* (1981), while Vijayalakshmi *et al.* (1989) and Sahoo *et al.* (1990) observed high values.

Nair *et al.* (1984) and Vijayalakshmi *et al.* (1989) reported high heritability and low genetic advance for days to first flowering, while moderate heritability along with low genetic advance for the character was observed by Rani *et al.* (1996). Singh and Singh (1998) reported low heritability for days to first flowering.

High heritability was observed for days to maturity in *C. annuum* (Ghai and Thakur 1987). Vallejo and Costa (1987) obtained a narrow sense heritability of 47 per cent for the character in *C. chinense*.

Fruit and fruit yield per plant was reported to have high heritability and genetic advance (Arya and Saini 1977; Rajput *et al.* 1981; Ramakumar *et al.* 1981; Sahoo *et al.* 1990 and Kumar *et al.* 1993). Rani *et al.* (1996) obtained heritability estimates of 99.3 per cent for fruits and 99.5 per cent for fruit yield. Similar results were also reported by Das and Choudhary (1996b) and Jabeen *et al.* (1999) in *C. annuum* and Cherian (2000) in *C. chinense*.

Sıngh and Brar (1979) and Gopalakrıshnan *et al* (1985) notıced moderate her tab l ty for fruıt y eld

Hıgh her tabılıty and genet c advance for several fruıt characters was reported by S ngh *et al* (1994) Pıtchaımuthu and Papp ah (1995) Bhatt and Shah (1996) Ghıld yal *et al* (1996) and Cherıan (2000)

Choudhary *et al* (1985) revealed low herıtabıl ty and genet c advance for fruıt gırth whereas Ranı *et al* (1996) observed the same for fru t length Munshı and Behera (2000) reported moderate herıtab lıty and hıgh genetıc advance for fru t g rth and fru t we ght

In the case of seeds per fruıt low herıtabıl ty coupled wıth low genet c advance was reported by Ramakumar *et al* (1981)

Sıngh and Sıngh (1970) observed low herıtabıl ty coupled w th low genet c advance for 1000 seed weıght whereas Mehra (1978) notıced h gh her tabıl ty for seed we ght of 25 pods

2 4 Correlatıon studıes

A thorough knowledge of the relat onshıp between y eld and ts component characters make crop ımprovement more effect ve

Pawade *et al* (1995) reported a strong pos tıve correlatıon of fruıts per plant wıth yıeld Sundaram and Irulappan (1998) concluded that fru ts per plant s the prımary y eld component H gh posıtıve assocıatıon between yıeld and fru ts per plant was also observed by Das and Choudhary (1999a) Al yu *et al* (2000) and Cher an (2000)

Flowers produced was found to have a hıgh posıtıve correlatıon wıth yıeld (Suthanthırapand an and Sıvasubramanıan 1978) A h gh negat ve correlation was observed between yield and days to first flower ng (Warade *et al* 1996 Sreelathakumary 2000)

Arya and Sain (1976) found a negat ve association between yield and plant he ght whereas a pos t ve correlat on was observed by Dev and Arumugam (1999) and Al yu *et al* (2000)

Ramakumar *et al* (1981) reported a strong correlat on between plant height and plant spread In *C annuum* branches and plant spread were positively correlated w th yield (Ghai and Thakur 1987 Rani 1995 Subashr and Natarajan 1999)

Fru t y eld was observed to have a posit ve correlat on w th fr t we ght fruit length and fru t g rth (Warade *et al* 1996) A strong assoc at o of y eld w th fru t we ght and fru t c rcumference was also reported by M shra *et al* (1998) Munshi *et al* (2000) noticed a non s gnificant positive correlation of fru t length and fru t breadth with fruit and fruit yield

Rani (1996d) observed high positive correlation of fruit weight with fruit diameter and seeds per fruit Seeds per fruit was reported to have high correlation with y eld (Chouvey *et al* 1986 Das *et al* 1989 Rani 1996b)

A positive correlat on was observed between yield and seed weight of 25 pods by Mehra (1978) whereas Rani (1997) reported that yield has no correlation w th 1000 seed weight

In *C frutescens* Sheela (1998) obta ned a high positive correlat on between harvests and fru t y eld

2 5 Path coefficient analysis

Rao *et al* (1974) concluded that in ch lli the principal traits influencing green pod yield d rectly or indirectly were days to first flowering days to pod maturity and pods per plant

Seed weight of 25 pods was observed to be the major contr butor to yield followed by days to first fruit set locules per fru t and primary branches per plant (Mehra 1978)

Sundaram and Ranganathan (1978) reported that fruits per plant exerted the maximum positive direct effect on yield The indirect effects of other characters through fru ts per plant were consistently h gh

Fru ts secondary branches fru t we ght fru t c rcumference and duration exh bited pos t ve d rect effects on yield (Na r *et al* 1984)

Fruits per plant and fruit weight were reported to be the primary y eld determinants n chill (Rao and Chhonkar 1981 Depestre *et al* 1989 Pawade *et al* 1995 Das and Choudhary 1999a Cherian 2000 Munshi *et al* 2000)

Chouvey *et al* (1986) obtained direct positive effects of seeds per fruit fruit c rcumference and peduncle length on fru t y eld

In sweet pepper (*C annuum* L) fruits per plant and fru t size exhibited posit ve ndirect effects *a* branches per plant (Deka and Shadeque 1997)

Deshmukh *et al* (1997) reported that weight of 50 red ripe fruits exerted the highest d rect pos tive effect on y eld followed by plant diameter and weight of 50 dr ed fru ts

Plant spread and fru ts per plant recorded the hıghest posıtıve d rect effects on yıeld (M shra *et al* 1998)

Dev and Arumugam (1999) not ced a negat ve d rect effect of plant heıght on yıeld but nfluenced ınd rectly through fruıts per plant fru t shape ındex secondary branches capsa cm content and seeds per fruıt

Fatıma (1999) found that fruıt weıght exhıb ted the hıghest posıt ve dırect effect on yıeld whereas Legesse *et al* (1999) observed that canopy wıdth leaf area fru ts per plant and perıcarp thıckness had posıt ve dırect effects on fruıt yıeld

In pepper (*C annuum* L) total dry weıght exerted the maxımum d rect effect on yıeld followed by leaf area ndex fruıts and seeds per fruıt (Al yu *et al* 2000)

2 6 Selectıon ındex

Sıngh and Sıngh (1977) suggested that selectıon based on plant heıght branches days to first flowerıng days to maturıty fruıt length fruıt sıze and fruıts per plant may be done to evolve hıgh yıeldıng lınes ın chıllı On the other hand Mehra (1978) found that genetıc advance through straıght select on for yıeld per plant *per se* was hıgher than that calculated by dıscrımınant functıon cons derıng all comb natıons of component characters

Fru ts per plant and branches are the mportant characters that shoı ld be taken for selectıon n ımprovement programmes n chıllı (Sı ndaram *et al* 1979)

Ramakumar *et al* (1981) opıned that dıscrımınant functıon based on fruıt g rth fruıts per plant and plant spread may be more eff c ent than straıght select on

Selection index involving yield per plant, fruit weight and fruits per plant was suitable to identify superior genotypes in *C. chinense* (Cherian, 2000).

2.7 Genetic divergence

Singh and Singh (1976) grouped forty five strains of chilli into ten clusters based on their divergence pattern. The clustering pattern revealed that strains belonging to a particular geographical location generally tended to be in the same cluster.

Mehra (1978) studied genetic divergence in chilli using Mahalanobis D^2 statistic and grouped 27 chilli varieties into nine gene constellations. Yield per plant was observed in contributing maximum towards divergence.

Sundaram *et al.* (1980) could not observe any relation between genetic and genotypic diversity when they subjected 35 Indian and 15 exotic lines of *C. frutescens* to D^2 analysis. Branches per plant and fruits per plant were the important characters contributing to genetic divergence.

In sweet pepper, six parents and their fifteen F hybrids formed seven clusters irrespective of the number of genotypes in each cluster (Gill *et al.*, 1982).

Varalakshmi and Haribabu (1991) grouped 32 genotypes of *C. annuum* based on ten characters into eleven gene constellations.

Indira (1994) assessed genetic diversity among chilli genotypes including *C. chinense* considering eight quantitative characters. Based on genetic distances, 71 genotypes were grouped into nine clusters during the first season and 72 genotypes into six clusters during the second season.

Roy and Sharma (1996) grouped 20 genotypes of chilli into seven clusters and observed that yield per plant primary branches per plant fruit girth and plant height were the highest contributors to total divergence

2 8 Chemical constituents of chilli

The important chemical constituents of chilli fruits include capsaicin oleoresin and ascorbic acid contents But systematic studies on the physico chemical qualities of *C chinense* is very little

2 8 1 Capsaicin

The pungent principle in chilli capsaicin ($C_{18}H_{27}O_3N$) is a substituted benzylamine derivative (Narayanan *et al* 1999)

About 90 per cent of capsaicin are concentrated in the placenta which has a capsaicin content of about 7 per cent (Sumathykutty and Mathew 1984) Teotia and Raina (1987) determined capsaicin by thin layer chromatography method and observed a range of 98 7 to 199 9 mg percentage Tewari (1990) reported that capsaicin content can be improved by delaying the harvest to withering stage

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 as medium pungent and 0 11 to 0 25 per cent as less pungent

Mini (1997) evaluated different *Capsicum* species and reported that *C chinense* accessions CA 640 and CA 645 were having the highest pungency

Mathur *et al* (2000) conducted a survey to find out chilli with high capsaicin and dihydro capsaicin The Tezpur cultivar of *C frutescens* (Nagahari) was found to contain the highest amounts of capsaicin and dihydrocapsa c n (4 28 and 1 42 per cent respect vely) which s the hottest chilli known to date

S ngh *et al* (2001) reported capsaicin contents of 2 15 per cent and 2 06 per cent with acetone and ethyl alcohol as solvents respectively

Nair *et al* (1984) observed high heritability and genetic advance for capsaicin A negative correlation of capsaicin with fruit weight was reported by Jiang *et al* (1987) and Rani (1995)

The w de range of variation in capsaicin reported by several workers are summarized below

Reported by	Range of capsaic n (%)	Species
Pradeepkumar (1990)	0 42 2 54	*Capsicum* spp
Rani (1994)	0 056 1 81	*C annuum* L
Ran (1996c)	0 11 1 81	*C anni i m* L
Mini (1997)	1 10 2 20	*Capsicum* spp
Sheela (1998)	0 43 1 70	*C frutescens*
Cherian (2000)	0 82 1 85	*C chinen e*
Sreelathakumary (2000)	0 65 1 06	*Capsici m* spp

2 8 2 Oleoresin

Oleoresin consists of fixed oil capsaicin pigments sugars and resin (Bajaj *et al* 1980) Pradeepkumar (1990) reported an oleoresin range from

18.70 per cent in *C. annuum* to 31.70 per cent in *C. chinense*. In *C. annuum* Papalkar *et al.* (1991) observed a range of 6.27 to 8.67 per cent.

Mini (1997) reported a positive correlation of oleoresin with fruits per plant and negative correlation with earliness. Days to first flowering had the maximum direct effect on oleoresin yield. Oleoresin recovery was maximum at full ripe stage which was on par with turning stage.

Mandal *et al.* (1998) observed a higher oleoresin yield from the pulp of the fruit than the whole fruit. Mini *et al.* (1999) evaluated nine chilli genotypes under three different seasons and identified variety Arka Lohit as the highest oleoresin yielder (30.4 per cent). Genotypes were higher in oleoresin content during winter. Cherian (2000) observed a range of 9.0 to 25.75 per cent in *C. chinense*. Sreelathakumary (2000) obtained an oleoresin range of 12.40 per cent in *C. annuum* to 23.35 per cent in *C. chinense*. Singh *et al.* (2001) reported acetone as the best solvent for oleoresin extraction.

2.8.3 Ascorbic acid

The fruits of most *Capsicum* species contain high amounts of vitamin C upto 340 mg per 100 g when in fresh state (Anu and Peter, 2000).

Ascorbic acid content were reported to have high heritability and genetic advance by Bhagyalakshmi *et al.* (1990), Kumar *et al.* (1993) and Rani *et al.* (1996).

Bajaj *et al.* (1980) observed an ascorbic acid range of 53.77 to 221.86 mg per 100 g and reported that the varietal variation also depended upon the maturity of the fruits. Maurya *et al.* (1984) reported a range of 158 to 171 mg per 100 g fresh fruit weight for ascorbic acid in *C. annuum* L. A wide variation in ascorbic acid (58.73 to 193.1 mg per 100 g) was reported by

Ranı (1994) Todorova *et al* (1997) observed a range of 147 1 to 343 8 mg per 100 g fresh fruıt we ght for ascorbıc acıd and reported a posıtıve correlatıon w th dry matter content and th ckness of perıcarp Sreelathakumary (2000) reported a range of 92 74 to 97 01 mg per 100 g n *C ch nen e*

2 9 Reactıon towards mosaıc dısease of chıllı

Mosaıc s a serıous v rus d sease found ın ch llı all over the country It causes stuntıng of the chıllı plant and reductıon of leaves and fruıts (Tewarı 1983) Bıdarı and Reddy (1991) reported that mosa c ncıdence of *Caps cı m* was w despread ın commerc ally cult vated fields ın Karnataka w th dısease ınc dence from 11 8 to 94 8 per cent

2 9 1 Causal organısm

A number of v ruses have been assocıated wıth mosaıc dısease of ch llı ın Indıa Chıef among them are cucumber mosaıc vırus (CMV) potato vırus X (PVX) potato vırus Y (PVY) ch ll mosaıc vırus tobacco mosaıc v rus (TMV) and tobacco leaf curl vırus (TLCV)

The v rus s transm tted by aph d vectors namely *Aph go ƴp A evonymı* and *Myzus pers cae* and ıs not seed transm tted (Chattopadhyay and Satyabratamaıt 1990)

2 9 2 Physıologıcal effects

Vıruses cause a lot of abnormalıtıes and physıolog cal ımbalances lead ng to a drastıc reductıon n the yıeld (Jayarajan and Ramakr shnan 1961) Abnormal sheddıng of flower buds faılure of anthers to mature wh ch s partıally filled wıth non funct onal pollen are reported by Jayarajan and Ramakr shnan (1961) a d

Awasthi and S ngh (1974) Chauhan (1980) observed 80 to 90 per cent ster l ty in virus infected chill plants In egg plant Gupta *et al* (1988) observed 55 68 to 87 45 per cent pollen ster lity due to egg plant mild mosa c virus

2 9 3 Source of resistance

A good number of sources of res stance to different v ruses have been located by var ous sc entists

Singh (1973) evaluated 105 varieties of ch lli involv ng five spec es and reported that the var eties Pur Red Puri Orange G2 Kond verum and Suryamukhi were res stant to mosaic Konai and Nariani (1980) reported that varieties Pant C1 and Pant C2 were tolerant to CMV TMV PVX and TLCV

A local perenn al chilli (IC 31339) has been reported to be mmune against both CMV and PVX and tolerant to TMV and TLCV It is also resistant to ch ll mosa c virus (Tewar 1983)

Thakur *et al* (1985) screened 51 varieties of pepper against PVY and found two resistant ones Four var eties were moderately resistant and the rest were either susceptible or highly susceptible

Sixty one genotypes of chill were screened for res stance to PVY and identified one culture (Acc No 426) as moderately resistant (Anandam 1992)

Kalloo (1994) reported a *C chinense* accession PI 159236 resistant to TMV Singh and S ngh (1998) and Acharyya (1999) reported that variety Punjab Lal is resistant to CMV

In a screening tr al nvolv ng 53 access ons of ch ll (*C annu* L) Fat ma (1999) observed that n ne accessions were found to be resistant twelve were moderately res stant and the rema n ng were suscept ble

Materials and Methods

3 MATERIALS AND METHODS

The present nvestigation was carr ed out n the Department of Olericulture College of Agr culture Vellayani dur ng September 2000 May 2001 The area is s tuated at 8 5^0 N lat tude 76 9^0 E long tude at an alt tude of 29 0 m above mean sea level Experimental site has a later t c red loa n soil with a pH of 5 2 The area enjoys a warm humid tropical climate

The study consisted of the following experiments

3 1 Genetic cataloguing of *Capsicum chinense*

3 2 Variability n *C chinense*

3 1 Genetic cataloguing of *C chinense*

The basic mater al for the study consisted of 32 diverse accessions of *C chinense* collected through survey and correspondence The details of the accessions and the r sources are presented in Table 1 The descr ptor developed by IBPGR (1995) for *Capsicum* was used for catalogu ng (Table 2)

3 2 Variability in *C chinense*

3 2 1 Experimental materials and methods

Thirty two accessions of *C chinense* were grown during September 2000 to May 2001 to ident fy superior genotypes with y eld quality and reaction towards the incidence of pests and diseases

Table 1 Particulars of accessions of *C chinense* used in the study and their sources

Sl No	Accession number	Source
1	CC 1	Vellayani Thiruvananthapuram
2	CC 2	Anchal Kollam
3	CC 3	Neyyattinkara Thiruvananthapuram
4	CC 4	Veliyam Kollam
5	CC 5	Venganoor Thiruvananthapuram
6	CC 6	Nemom Th ruvananthapuram
7	CC 7	Vithura Th ruvananthapuram
8	CC 8	Vithura Th ruvananthapuram
9	CC 9	Indian Cardamom Research Institute Saklespur Karnataka
10	CC 10	Paudikkonam Th ruvananthapuram
11	CC 11	V thura Thiruvananthapuram
12	CC 12	Kumarapuram Thiruvananthapuram
13	CC 13	Vithura Thiruvananthapuram
14	CC 14	Neyyattinkara Thiruvananthapuram
15	CC 15	V lavoorkal Thiruvananthapuram
16	CC 16	Venganoor Th ruvananthapuram
17	CC 17	Paudikkonam Th ruvananthapuram
18	CC 18	Neyyatt nkara Thiruvananthapuram
19	CC 19	Venganoor Th ruvananthapuram
20	CC 20	Sreekaryam Th ruvananthapuram
21	CC 21	Sreekaryam Thiruvananthapuram
22	CC 22	Vithura Thiruvananthapuram
23	CC 23	Nemom Thiruvananthapuram
24	CC 24	V thura Th ruvananthapuram
25	CC 25	Vithura Thiruvananthapuram
26	CC 26	V thura Thiruvananthapι ram
27	CC 27	V thura Thiruvananthapuram
28	CC 28	Pothankode Thiruvananthapuram
29	CC 29	Pothankode Th ruvananthapuram
30	CC 30	Nemom Th ruvananthapuram
31	CC 31	Nemom Th ruvananthapuram
32	CC 32	Neyyatt nkara Th rι vananthapι ram

Table 2 Genetic cataloguing of *C chinense*

1	**Vegetative characters**		
1 1	Hypocotyl colour		White / green / purple
2	Stem pubescence		Sparse / intermediate / dense
3	Leaf colour		Light green / green / dark green / light purple / purple
4	Leaf shape		Deltoid / ovate / lanceolate / elong deltoid
5	Stem colour		Green / green with purple stripes / purple
6	Nodal anthocyanin		Green / light purple / purple / dark purple
7	Plant growth habit		Prostrate / intermediate / erect
8	Stem length (cm)		Height to first bifurcation
2	**Inflorescence characters**		
2 1	Number of flowers per axil	–	One / two / three or more
2	Flower position	–	Pendant / intermediate / erect
3	Corolla colour	–	White / light yellow / yellow green / purple
4	Corolla spot		Absent / present
5	Corolla shape		Rotate / campanulate
6	Anther colour		White / yellow / pale blue / blue / purple
7	Filament colour		White / yellow / green / blue / light purple / purple
8	Stigma exsertion		Inserted / same level / exserted
9	Calyx pigmentation	–	Absent / present
10	Calyx margin		Entire / intermediate / dentate
11	Calyx annular constriction		Absent / present

Table 2 Contd

3	**Fruit and seed characters**		
3 1	Anthocyanin spots or stripes		Absent / present
2	Fruit colour at immature stage		White / yellow / green / orange / purple / deep purple
3	Fruit colour at mature stage		White / lemon yellow / orange yellow orange / light red / red / dark red / purple
4	Fruit shape	–	Elongate / almost round / triangular / campanulate / blocky
5	Fruit shape at peduncle attachment	–	Acute / obtuse / truncate / cordate / lobate
6	Neck at base of fruit		Absent / present
7	Fruit shape at blossom end	–	Pointed / blunt / sunken / sunken and pointed
8	Fruit cross sectional corrugation		Slightly corrugated / intermediate / corrugated
9	Number of locules		Two / three (as percentage of each category)
10	Seed colour	–	Straw / brown / black

Statistical details were as furnished below

Design	RBD
Replications	3
Treatments	32 accessions
Plot size	6 75 m^2
Spacing	75 x 60 cm
Number of plants per plot	15

The crops were raised as per package of practices recommendations of Kerala Agricultural University (KAU 1996) No insecticide or fungicide was applied on the plants during the course of experimentation to observe the reaction of the accessions towards pests and diseases

3 2 2 Observations

Five plants were randomly selected per accession per replication for taking observations and the mean worked out For recording observations on fruit characters five fruits at fully mature green stage were selected at random from each accession in each replication Observations on the following characters were recorded

3 2 2 1 Plant characters

(a) Plant height (cm)

Measured from the ground level to the t p of the plant at the time of final harvest

(b) Primary branches per plant

Branches arising from the main stem were counted

(c) Plant spread / Plant circumference (cm)

Expressed as π d where d is the average of North South and East West spread of the plant taken across the bush in North South and East West direction respectively

3 2 2 2 Flowering characters

(a) Days to first flowering

Number of days from transplanting until 50 per cent of plants in each accession have at least one open flower

(b) Pollen viability

Pollen viability was determined by the acetocarmine staining technique Anthers about to dehisce were collected separately from each accession and the pollen grains were mounted n a drop of acetocarm ne glycerine mixture (1 1) The slides were kept for about 30 minutes to allow pollen grains to take stain properly before examining under a microscope Pollen viability was studied by counting the well filled and stained pollen grains An average of 100 pollen were counted in different microscop c fields in each accession Unfilled and unstained pollen grains were considered as ster le Pollen viability was calculated as follows

$$\% \text{ of pollen viability} - \frac{\text{Number of well filled and sta ned pollen grains}}{\text{Total number of pollen grains counted}} \times 100$$

(c) Days to maturity

Number of days from fru t set unt l the fru t show s gns of r pen n was observed

3 2 2 3 Fruit and yield characters

(a) Fruits per plant

Total number of fruits per plant was observed

(b) Fruit length (cm)

Distance between pedicel attachment and fruit apex

(c) Pedicel length (cm)

D stance between the po nt of attachment of pedicel with the stem and the fru t

(d) Fruit girth (cm)

Measured us ng twine and scale at the maximum w dth of the fru t

(e) Fruit weight (g)

Average of five fruits weight

(f) Seeds per fruit

Seeds per fruit were counted n f ve fru ts and average was taken

(g) 1000 seed weight

The dry weight of randomly selected 1000 seeds were taken

(h) Yield per plant (g)

We ght of fru ts harvested from each plant was recorded

(i) Yield per harvest (g)

Weight of fru ts harvested from each plant was recorded for each harvest and the average taken

(j) Number of harvests

Total number of harvests from each plant was recorded

3 2 2 4 Quality characters

(a) Capsaicin (%)

Capsa c n content of d fferent accessions were determ ned by Fol n Denn s method The pungent pr nc ple reacts with Fol n Denn s reagent to give a blue coloured complex which s estimated colorimetrically (Mathew *et al* 1971)

Reagents

(i) Folin Dennis reagent

Refluxed 750 ml distilled water 100 g sodium tungstate 20 g phosphomolybd c ac d and 50 ml phosphoric acid for two hours Cooled and d luted to 1000 ml with dist lled water

(ii) 25 % aqueous sod um carbonate solution

(ii) Acetone

Procedure

The fru ts harvested at red ripe stage were dried n a hot air oven at 50^0C and powdered finely in a m xer grinder Five hundred mg each of the sample was weighed nto test tubes Added 10 ml acetone to t and kept overnight. Aliquots of 1 ml were pipetted into 100 ml conical flasks, added 25 ml of Folin Dennis reagent and allowed to stand for 30 minutes. Added 25 ml of freshly prepared sodium carbonate solution and shook vigorously. The volume was made up to 100 ml with distilled water and the optical density was determined after 30 minutes at 725 nm against reagent blank (1 ml acetone + 25 ml Folin Dennis reagent + 25 ml aqueous sodium carbonate solution) using a UV spectrophotometer.

To determine the EI per cent value for pure capsaicin, a stock solution of standard capsaicin (200 µg ml) was prepared by dissolving 20 mg in 100 ml acetone. From this a series of solutions of different concentrations were prepared and their optical density measured at 725 nm. Standard graph was prepared and calculated the content of capsaicin in the samples.

(b) Oleoresin (%)

Oleoresin in chilli was extracted in a Soxhlet's apparatus using solvent acetone (Sadasivam and Manikam, 1992).

Procedure

Chilli fruits harvested at red ripe stage were dried in a hot air oven at 50^{0}C, powdered finely in a mixer grinder. Two g of chilli powder was weighed and packed in filter paper and placed in Soxhlet's apparatus. Two hundred ml of acetone was taken in the round bottom flask of the apparatus and heated in a water bath. The temperature was maintained at the boiling point of solvent. After complete extraction (7 to 8 h), the solvent was evaporated to dryness under vacuum.

Yield of oleoresin on dry weight basis was calculated using the formula

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

(c) Ascorbic acid (mg per 100 g fresh fruit weight)

Ascorbic acid content of fruits at red ripe stage was estimated by 2 6 dichlorophenol indophenol dye method (Sadasivam and Manickam 1992)

Reagents

(i) Oxalic acid (4 %)

(ii) Ascorbic acid standard

Prepared a stock solution by dissolving 100 mg of ascorbic acid in 100 ml of four per cent oxalic acid Diluted 10 ml of the stock solution to 100 ml with four per cent oxalic acid to get working standard solution

(iii) 2 6 dichlorophenol indophenol dye

Weighed 42 mg sodium bicarbonate into a small volume of distilled water Dissolved 52 mg 2 6 dichlorophenol indophenol in it and made up to 200 ml with distilled water

Procedure

Pipetted out 5 ml of the working standard solution into a 100 ml conical flask and added 10 ml of four per cent oxalic acid Titrated it against the dye (V ml) Endpoint is the appearance of pink colour which persisted for at least five seconds

Five g of fresh fruit was extracted in an acid medium (4 % oxal c ac d) and titrated as above aga nst the dye solut on to a p nk colour (V_2 ml) Ascorbic ac d content of the sample was calculated us ng the formula

$$\text{Amount of ascorbic acid /100 g sample} = \frac{0.5 \times V_2 \times 100}{V \times 5 \times \text{weight of sample}} \times 100$$

3 2 2 5 Reaction towards major pests and diseases

No scor ng was done for pests since there was no major pest nc de ce in the crop Mosaic was the only disease observed and hence scor ng based on visual observations was done for mosaic incidence

Scoring for chilli mosaic incidence

The rat ng scale g ven by Rajamony *et al* (1990) n melon was used for scoring with minor modif cations Th s was done according to the character stic symptom of each observat onal plant (Table 3 and Plates 1 to 4)

Table 3 Scoring for chilli mosaic disease

Rating scale	Symptom	Category
0	No symptom	H ghly res stant
1	Very l ght mottl ng of green colour	Resistant
2	Prom nent mottl ng of leaves	Moderately res stant
3	Mottl ng covers the entire leaf lamina	Susceptible
4	Stunt ng of the plant Reduction in leaf size with characterist c rat tailing and fork ng at the apex	Highly suscept ble

The individual plant score was util zed to work out the Severity Index or Vulnerab l ty Index (V I) so as to measure the res stance

Plate 1

Plate 3

Plate 2

Plate 4

The ındex was calculated usıng an equatıon adopted by Sılbernagel and Jafrı (1974) for measurıng resıstance ın snap bean (*Phaseolus vulgarıs*) to beet curly top vırus and mod f'ed later by Bos (1982)

$$\text{Vulnerab l ty Index (V I)} \quad \frac{(0n_0 + 1n \;\; + 2n_2 + 3n_3 + 4n_4)}{n \;(n_c \quad 1)} \times 100$$

where

n_0 n n_4 number of plants ın category 0 1   4 respect vely

n – total number of plants

n_c = total number of categorıes 5

The vulnerab l ty ndex was ι sed to class fy the ge otypes nıo dıfferent categorıes

Sl No	Vulnerabılıty Index	Category
1	0 20	Hıghly resıstant
2	21 40	Resıstant
3	41 60	Moderately resıstant
4	61 80	Susceptıble
5	81 100	H ghly susceptıble

3 2 3 Statıstıcal analysıs

3 2 3 1 Analysıs of var ance (ANOVA) and covar ance (ANCOVA) for Random zed Block Desıgn (RBD) n respect of the var οι s characters was done (Panse and Sukhatme 1967)

3 2 3 2 Mean The mean of the character X $(\overline{X})$ was worked out

3 2 3 3 Var abil ty components (phenotyp c and genotyp c) for d fferent characters was estimated as suggested by Kempthorne (1977)

(a) The variance and covariance components were calculated as per the following formulae

For the character X

Env ronmental var ance σ_e MSE

Genotypic variance $\sigma_g{}^2$ $\frac{\text{MST} \quad \text{MSE}}{r}$

Phenotyp c var ance $\sigma_p{}^2$ $\sigma_g{}^2 + \sigma_e{}^2$

where MST and MSE are respectively the mean sum of squares for treatment and error from ANOVA and r the number of replications

For two characters X and X

Env ronmental covariance σ_e MSPE

Genotypic covariance σ_g $\frac{\text{MSPT} \quad \text{MSPE}}{r}$

Phenotypic variance σ_p $\sigma_g + \sigma$

where MSPT and MSPE are respectively the mean sum of products between the ^{h} and j^h characters for genotype and environment respectively from Analysis of Covar ance (ANCOVA)

The genotypes were classif ed into poor med um and better categor es with respect to each character as follows

Definition	Category
Less than mean SE$_m$	Poor
Between mean ± SE$_m$	Medium
More than mean + SE$_m$	Better

where SE$_m$ is the standard error of the mean for each character

$$SE_m \quad \sqrt{\frac{MSE}{r}}$$

For the character days to first flowering the reverse order is being followed for categorization

(b) Coefficient of variation

Variab l ty that ex sted n the populat on for var ous characters were apportioned us ng the est mates of coeff cient of variat on (S ngh and Chaudhary 1985)

For the character X

$$\text{Phenotypic coefficient of variation PCV} - \frac{\sigma_p}{\overline{X}} \times 100$$

$$\text{Genotyp c coefficient of variation GCV} - \frac{\sigma_g}{\overline{X}} \times 100$$

$$\text{Environmental coefficient of variation ECV} - \frac{\sigma_e}{\overline{X}} \times 100$$

where σ_p σ_g and σ_e are respectively the phenotyp c genotyp c and environmental standard dev ations with respect to each character

3 2 3 4 Herıtabılıty

Hanson *et al* (1956) proposed the mathemat cal elat onsh p of va est mates on computat on of her tabıl ty wh ch s us ally expressed as percentage

$$\text{Herıtabılıty (broad sense) } H^2 \quad \frac{\sigma_g^{\ 2}}{\sigma_p^{\ 2}} \times 100$$

The range of herıtab l ty was categor zed as suggested by Robınson *et al* (1949) as follows

Defınıtıon	**Category**
0 30 per cent	Low
31 60 per cent	Med um
61 per cent and above	H gh

3 2 3 5 Genetıc advance

Genet c advance as percentage over mean was calculated as per the formula g ven by Lush (1949) and Johnson *et al* (1955)

$$\text{Genetıc advance GA} \quad \frac{kH^2 \sigma_p}{\overline{X}} \times 100$$

where H^2 her tab l ty n broad sense

σ_p phenotyp c standard dev atıon

k select on dıfferent al wh ch ıs 2 06 n case of 5 % selectıon ın large samples (Mıller *et al* 1958 and Allard 1960)

Genet c advance was categorized according to Robinson *et al* (1949) as follows

Definition	Category
Less than 20 per cent	Low
Greater than 20 per cent	High

3 2 3 6 Correlation analysis

Phenotypic genotypic and environmental correlation coefficients were worked out according to the procedure suggested by Singh and Choudhary (1985)

3 2 3 7 Path analysis

The direct and nd rect effects of y eld contr but ng factors were estimated through path analysis technique (Wright 1954)

3 2 3 8 Mahalanobi s D^2 analysis

Genet c divergence was studied based on ten characters taken together using Mahalanob s D^2 stat st c as descr bed by Rao (1952) The genotypes were clustered by Tochers method

3 2 3 9 Selection index

The various genotypes were discr m nated based on ten characters using the selection index developed by Smith (1936) using the discr minant function of F sher (1936) The selection index is described by the funct on

$$I - b\ X + b_2 X_2 + \quad b_k X_k$$

The function H a G + a_2G_2 + a_k G_k describes the merit of a plant where X X_2 X_k are the phenotypic values and G G_2 G_k are the genotypic values of the plant w th respect to the characters X_1 X_2 X_k H denotes the genetic worth of the plant The economic worth assigned to each character is assumed to be equal to unity i e a a a_k 1 The regression coefficients b b_2 b_k are est mated n such a way that the correlation between H and I s max mum

i e b − P Ga where P and G are the phenotypic and genotypic variance covariance matrices respectively Based on the b estimates and the mean values for the ten characters w th respect to each access o i sco es were calculated and the access ons were ranked

Results

4 RESULTS

Experimental data recorded during the course of investigation were subjected to statist cal analysis and are presented under the following heads

4 1 Genet c catalogu ng in *Caps cum chinense*

4 2 Variability n *C chinense*

4 1 Genetic cataloguing in *C chinense*

Thirty two accessions of *C chinense* were genet cally catalogued based on the descriptor (IBPGR 1995) Morpholog cal characters l ke vegetat ve (Table 4) nflorescence (Table 5) and fru t and seed characters (Table 6) were recorded and access ons were catalogued

All the access ons had green to purple hypocotyl and stem colour The leaf colour var ed between l ght green to l ght purple with deltoid leaf shape Most of the accessions had sparse stem pubescence with green to dark purple nodal anthocyanin Plant growth habit were either erect or compact with a stem length of 21 00 to 55 75 cm

Flowers per axil were e ther two or three with erect to pendant pos tion Corolla colour ranged from l ght yellow to purple with pale blue to purple anther and white to light purple filament All the accessions had rotate corolla w thout corolla spot All the access ons were ident cal with a prom nent annular constr ct on at calyx Calyx pigmentation was absent n all the

Table 4 Vegetative characters in *C. chinense* accessions

Accession number	Hypocotyl colour	Stem pubescence	Leaf colour	Stem colour	Nodal anthocyanin	Plant growth habit	Stem length (cm)
CC 1	Green	Sparse	Light green	Green	Green	Erect	46.00
CC 2	Green	Sparse	Light green	Green with purple stripes	Light purple	Compact	26.60
CC 3	Green	Sparse	Light green	Green with purple stripes	Green	Erect	55.75
CC 4	Green	Sparse	Light green	Green	Green	Erect	44.00
CC 5	Purple	Sparse	Light purple	Purple	Dark purple	Erect	40.50
CC 6	Green	Sparse	Light green	Green	Light purple	Erect	23.33
CC 7	Green	Sparse	Light green	Green with purple stripes	Light purple	Compact	30.50
CC 8	Green	Sparse	Green	Green	Light purple	Erect	25.17
CC 9	Green	Sparse	Light green	Green	Light purple	Erect	28.00
CC 10	Green	Intermediate	Light green	Green	Light purple	Erect	24.67
CC 11	Green	Sparse	Light green	Green with purple stripes	Light purple	Compact	30.00
CC 12	Green	Sparse	Light green	Green with purple stripes	Purple	Erect	32.25
CC 1	Green	Sparse	Light green	Green	Green	Erect	35.00
CC 14	Green	Sparse	Light green	Green with purple stripes	Light purple	Erect	34.00
CC 15	Green	Intermediate	Light green	Green with purple stripes	Green	Erect	27.00
CC 16	Green	Sparse	Light green	Green	Light purple	Compact	34.67
CC 17	Green	Sparse	Light green	Green with purple stripes	Green	Erect	24.00
CC 18	Green	Sparse	Light green	Green with purple stripes	Light purple	Erect	28.00
CC 19	Green	Sparse	Light green	Green with purple stripes	Green	Compact	33.33
CC 20	Green	Sparse	Light green	Green with purple stripes	Light purple	Erect	28.50
CC 21	Green	Sparse	Light green	Green with purple stripes	Purple	Erect	26.50
CC 22	Green	Sparse	Light green	Green	Green	Compact	27.00
CC 2	Green	Sparse	Light green	Green	Green	Compact	35.50
CC 24	Green	Sparse	Light green	Green with purple stripes	Light purple	Erect	23.25
CC 25	Purple	Sparse	Light purple	Purple	Dark purple	Erect	26.00
CC 26	Green	Intermediate	Light green	Green with purple stripes	Green	Erect	33.25
CC 27	Green	Sparse	Light green	Green	Light purple	Erect	31.00
CC 28	Green	Sparse	Light green	Green with purple stripes	Green	Compact	25.67
CC 29	Green	Intermediate	Light green	Green	Green	Compact	21.00
CC 30	Green	Sparse	Light green	Green	Green	Compact	35.00
CC 3	Green	Sparse	Light green	Green with purple stripes	Green	Compact	33.75
CC 32	Green	Sparse	Light green	Green	Green	Erect	28.00

Table 5 Inflorescence characters in *C. chinense* accessions

Accession Number	Number of flowers per axil	Flower position	Corolla colour	Anther colour	Filament colour	Stigma exsertion (out of 10)			Calyx pigmentation	Calyx margin
						Exserted	Same level	Inserted		
CC 1	Two	Erect	Light yellow	Pale blue	White	6	4		Absent	Intermediate
CC 2	Two	Erect	Light yellow	Light purple	White	8	2		Absent	Intermediate
CC 3	Three	Erect	Light yellow	Pale blue	White	6		1	Absent	Entire
CC 4	Three	Erect	Light yellow	Light purple	White	10			Absent	Intermediate
CC 5	Three	Intermediate	Purple	Purple	Light purple	5	5		Present	Intermediate
CC 6	Two	Pendant	Light yellow	Pale blue	White	4	6		Absent	Intermediate
CC 7	Three	Intermediate	Light yellow	Light purple	White	7	3		Absent	Intermediate
CC 8	Two	Intermediate	Light yellow	Light purple	White	6			Absent	Intermediate
CC 9	Three	Intermediate	Light yellow	Light purple	White	4	5	1	Absent	Intermediate
CC 10	Two	Erect	Light yellow	Light purple	White	9		1	Absent	Intermediate
CC 11	Three	Erect	Light yellow	Light purple	White	10			Absent	Intermediate
CC 12	Two	Pendant	Light yellow	Pale blue	White	9	1		Absent	Intermediate
CC 13	Two	Erect	Light yellow	Pale blue	White	10			Absent	Intermediate
CC 14	Two	Intermediate	Light yellow	Light purple	White	8	2		Absent	Intermediate
CC 15	Two	Pendant	Light yellow	Pale blue	White	9	1		Absent	Intermediate
CC 16	Two	Erect	Light yellow	Light purple	White	3	4	3	Absent	Intermediate
CC 17	Two	Intermediate	Light yellow	Light purple	White	7	2	1	Absent	Intermediate
CC 18	Three	Erect	Light yellow	Light purple	White	6	4		Absent	Intermediate
CC 19	Three	Intermediate	Light yellow	Pale blue	White	5	4	1	Absent	Intermediate
CC 20	Three	Intermediate	Light yellow	Light purple	White	6	3	1	Absent	Intermediate
CC 21	Three	Erect	Light yellow	Light purple	White	7			Absent	Intermediate
CC 22	Three	Intermediate	Light yellow	Light purple	White	10			Absent	Intermediate
CC 23	Three	Intermediate	Light yellow	Light purple	White	7	2	1	Absent	Intermediate
CC 24	Two	Pendant	Light yellow	Light purple	White	8	1	1	Absent	Intermediate
CC 25	Three	Intermediate	Purple	Purple	Light purple	2	5	3	Present	Intermediate
CC 26	Two	Intermediate	Light yellow	Pale blue	White	8		1	Absent	Intermediate
CC 27	Three	Pendant	Light yellow	Light purple	White	3	6	1	Absent	Intermediate
CC 28	Two	Erect	Light yellow	Light purple	White	9	1		Absent	Intermediate
CC 29	Three	Intermediate	Light yellow	Light purple	White	8	2		Absent	Intermediate
CC 30	Two	Erect	Light yellow	Pale blue	White	9	1		Absent	Intermediate
CC 31	Three	Erect	Light yellow	Light purple	White	10			Absent	Entire
CC 32	Three	Intermediate	Light yellow	Light purple	White	6		1	Absent	Intermediate

Table 6 Fruit and seed characters in *C. chinense* accessions

Accession Number	Anthocyanin spots or stripes on fruit	Fruit colour at immature stage	Fruit colour at mature stage	Fruit shape	Fruit shape at pedicel attachment	Neck at base of fruit	Fruit shape at blossom end	Fruit cross sectional corrugation	Seed colour
CC 1	Absent	Green	Red	Elongate	Acute	Absent	Pointed	Corrugated	Straw
CC 2	Absent	Green	Red	Campanulate	Truncate	Absent	Pointed	Intermediate	Straw
CC 3	Absent	Green	Red	Elongate	Acute	Present	Pointed	Corrugated	Straw
CC 4	Absent	Green	Dark red	Elongate	Acute	Present	Pointed	Intermediate	Straw
CC 5	Present	Green	Dark red	Campanulate	Acute	Absent	Pointed	Intermediate	Straw
CC 6	Absent	Green	Dark red	Triangular	Truncate	Absent	Pointed	Corrugated	Straw
CC 7	Absent	Green	Dark red	Campanulate	Truncate	Present	Pointed	Corrugated	Straw
CC 8	Absent	Green	Red	Campanulate	Truncate	Absent	Blunt	Corrugated	Straw
CC 9	Absent	Green	Lemon yellow	Campanulate	Cordate	Absent	Blunt	Corrugated	Straw
CC 10	Absent	Green	Red	Triangular	Cordate	Absent	Blunt	Corrugated	Straw
CC [illegible]	Absent	Green	Dark red	Elongate	Acute	Present	Pointed	Corrugated	Straw
CC 12	Absent	Green	Red	Triangular	Truncate	Absent	Pointed	Corrugated	Straw
CC 13	Absent	Green	Dark red	Elongate	Acute	Absent	Pointed	Corrugated	Straw
CC 14	Absent	Green	Red	Campanulate	Truncate	Absent	Blunt	Corrugated	Straw
CC 15	Absent	Green	Red	Blocky	Truncate	Present	Blunt	Corrugated	Straw
CC 16	Absent	Green	Red	Triangular	Truncate	Absent	Pointed	Corrugated	Straw
CC 17	Absent	Green	Red	Triangular	Truncate	Absent	Pointed	Corrugated	Straw
CC 18	Absent	Green	Red	Campanulate	Truncate	Absent	Blunt	Corrugated	Straw
CC 19	Absent	Green	Red	Elongate	Acute	Absent	Blunt	Intermediate	Straw
CC 20	Absent	Green	Red	Campanulate	Truncate	Absent	Pointed	Corrugated	Straw
CC 21	Absent	Green	Red	Campanulate	Truncate	Absent	Pointed	Corrugated	Straw
CC 22	Absent	Green	Red	Blocky	Truncate	Absent	Blunt	Corrugated	Straw
CC 23	Absent	Green	Red	Almost round	Truncate	Absent	Blunt	Slightly corrugated	Straw
CC 24	Absent	Green	Red	Blocky	Truncate	Absent	Pointed	Corrugated	Straw
CC 25	Absent	Deep purple	Red	Campanulate	Acute	Absent	Pointed	Corrugated	Straw
CC 26	Absent	Green	Red	Campanulate	Truncate	Absent	Pointed	Corrugated	Straw
CC 27	Absent	Green	Lemon yellow	Blocky	Cordate	Absent	Pointed	Corrugated	Straw
CC 28	Absent	Green	Red	Triangular	Truncate	Absent	Blunt	Corrugated	Straw
CC 29	Absent	Green	Red	Blocky	Truncate	Absent	Blunt	Corrugated	Straw
CC 30	Absent	Green	Dark red	Triangular	Truncate	Absent	Blunt	Corrugated	Straw
CC 31	Absent	Green	Red	Triangular	Truncate	Absent	Blunt	Corrugated	Straw
CC [illegible]	Absent	Green	Dark Red	Campanulate	Cordate	Absent	Pointed	Corrugated	Straw

accessions except CC 5 and CC 25 while calyx marg n was intermediate n most of the accessions

Fruit colour at mmature stage rema ned green except in CC 25 which had deep purple colour Except for CC 5 all the access ons had no anthocyan n spots or str pes on frt t At mature stage CC 9 a d CC 27 recorded lemon yellow colour while the rest of the access ons had red to dark red colour

Fruit shape varied from elongate to blocky with acute truncate or cordate shape at ped cel attachment Neck at base of fruit was absent n most of the accessions with e ther pointed or blunt blossom end Slightly corrugated to corrugated fruit cross section was noticed with two to three locules per fruit Seed colour was found to be straw n all the access ons

4 2 Variability in *C chinense*

4 2 1 Mean performance

Analys s of variance showed s gn ficant d fferences among the access ons for all the characters stud ed (Table 7) The mean val es of 3? access ons for d fferent characters are presented n Table 8

Plant height

There was significant difference among the accessions for plant height It ranged from 61 33 to 133 33 cm w th an overall mean of 98 69 cm CC 27 was the tallest with a he ght of 133 33 cm which was on par w th CC 7

Table 7 Analysis of variance for 20 characters in 32 accessions of *C chinense* (Mean squares)

Source	df	Plant height	Primary branches per plant	Plant spread	Days to first flowering	Pollen viability	Days to maturity	Fruits per plant
Replication	2	61 19	0 01	1005 50	22 20	5 41	13 20**	687 38
Genotype	31	1083 10**	4 95**	5945 94**	101 42**	839 88**	42 17**	68853 04**
Error	62	48 07	1 68	686 32	7 09	2 63	1 29	272 96

Source	df	Fruit length	Pedicel length	Fruit girth	Fruit weight	Seeds per fruit	1000 seed weight	Yield per plant
Replication	2	0 002	0 03	0 01	0 02	7 95	0 01	3149 00*
Genotype	31	3 11**	1 52**	6 71**	8 31**	438 77**	1 06**	474820 90**
Error	62	0 07	0 02	0 03	0 06	4 41	0 03	987 52

Source	df	Yield per harvest	Number of harvests	Capsaicin	Oleoresin	Ascorbic acid	Mosaic incidence
Replication	2	140 34	0 03	0 02**	0 24	14 84**	5 00
Genotype	31	12885 22**	5 49**	1 41**	59 04**	838 77**	97 21**
Error	62	67 89	0 02	0 002	0 67	0 81	15 83

*Significant at 5 per cent level
** Significant at 1 per cent level

Table 8 Mean value of biometric characters

Accession No	Plant height (cm)	Primary branches per plant	Plant spread (cm)	Days to first flowering	Pollen viability (%)	Days to maturity	Fruits per plant	Fruit length (cm)	Pedicel length (cm)	Fruit girth (cm)	Fruit weight (g)
CC 1	115 00	4 67	271 22	68 00	65 37	36 33	196 45	6 53	4 00	5 77	4 93
CC 2	100 00	3 67	270 44	65 33	75 70	31 00	216 33	5 60	3 80	10 23	8 63
CC 3	118 33	8 67	324 63	69 00	65 47	28 33	274 00	5 57	3 07	6 90	4 08
CC 4	125 67	6 67	304 47	64 00	72 90	37 33	233 33	5 97	3 53	5 27	1 22
CC 5	116 00	6 33	354 58	77 00	4[illegible] 80	29 67	201 00	5 93	5 20	7 93	6 50
CC 6	94 67	4 33	315 21	72 33	40 10	29 00	37 67	6 17	2 95	9 47	5 82
CC 7	128 00	6 33	454 48	65 33	85 10	31 00	508 89	6 75	3 95	9 93	6 38
CC 8	103 67	4 90	286 [illegible]3	68 33	33 [illegible]7	36 67	87 60	5 67	3 2	10 37	6 55
CC 9	77 00	4 33	269 9[illegible]	70 00	4[illegible] 30	31 00	2[illegible] 50	5 53	4 40	10 10	6 55
CC 10	93 00	5 67	294 76	70 00	44 47	29 33	49 00	5 93	2 97	7 23	2 07
CC 11	107 67	5 33	355 69	71 33	80 40	31 33	171 00	8 33	4 10	7 67	5 36
CC 12	122 67	3 33	[illegible]79 87	65 33	47 [illegible]3	35 67	188 50	5 60	3 8	10 10	6 72
CC 13	105 00	3 67	268 61	54 67	79 93	37 33	620 00	6 63	2 87	7 07	5 18
CC 14	102 00	4 67	292 17	66 33	38 23	29 33	56 67	4 57	2 60	10 07	5 97
CC 15	106 67	4 00	350 39	67 67	80 80	29 33	326 67	5 90	3 07	10 00	6 87
CC 16	106	8 33	308 66	69 67	69 93	31 67	201 87	6 63	3 10	8 17	3 32
CC 17	66 00	4 33	329 08	71 67	70 73	27 67	79 28	6 00	3 20	9 77	4 73
CC 18	72 67	6 00	265 73	73 33	70 83	35 67	20 37	4 83	2 50	9 73	4 51
CC 19	86 00	7 00	248 71	67 00	47 70	34 67	111 36	4 57	4 43	6 87	4 15
CC 20	114 67	6 00	382 75	79 33	61 57	31 00	66 00	3 80	2 87	7 77	4 05
CC 21	80 67	5 67	370 70	76 67	45 43	32 67	48 33	6 47	3 17	7 73	3 39
CC 22	81 33	4 33	320 44	71 67	72 50	32 67	136 50	5 57	3 97	9 70	4 00
CC 23	102 00	6 00	299 50	60 67	79 [illegible]0	30 33	637 44	4 10	[illegible]70	8 97	5 88
CC 24	86 00	4 67	324 89	66 67	60 00	28 00	18 99	6 00	3 23	7 50	5 28
CC 25	83 00	5 00	517 56	76 00	46 60	23 00	86 64	3 60	5 50	6 43	3 17
CC 26	99 67	7 00	316 25	76 33	40 27	30 00	35 33	5 87	3 67	6 80	4 27
CC 27	153 [illegible]	5 00	581 97	76 00	81 [illegible]1	31 33	198 43	7 53	4 07	9 70	7 44
CC 28	97 67	5 33	[illegible]75	74 67	86 40	34 67	213 90	6 47	[illegible]60	9 20	7 05
CC 29	61	6 33	249 23	83 00	56 9	26 00	99 89	4 63	2 77	9 77	5 13
CC 30	118 00	4 33	568 61	63 00	77 60	22 00	212 33	6 93	3 90	9 10	3 64
CC 31	86 00	6 33	281 96	70 67	86 93	50 67	205 00	5 60	2 90	8 53	5 33
CC 32	68 00	6 00	[illegible]92 95	74 67	62 43	28 67	19 00	4 93	2 87	6 43	2 42
CD (5%)	11 3[illegible]19	2 1160	4[illegible] 7808	4 3482	2 6488	1 8580	26 9797	0 4[illegible]75	0 202	0 2815	0 4104

Table 8 Contd

Access on No	Seeds pe fru t	1000 seed we ght (g)	Y eld per plant (g)	Y eld per harvest (g)	Number of harvests	Capsa c n (%)	Oleores n (%)	Ascorb c acid (mg/100g)	Mosa c nc dence (V I)
CC 1	13 33	3 79	319 49	106 50	3 00	1 20	13 09	119 60	55 42
CC 2	49 00	5 02	919 90	171 66	5 40	2 41	17 86	94 20	51 19
CC 3	25 00	3 73	408 03	108 55	3 77	3 59	10 91	120 37	51 39
CC 4	5 67	4 11	255 71	79 64	3 22	2 85	16 38	106 20	61 61
CC 5	28 33	3 72	479 80	74 43	6 45	2 36	22 18	94 53	51 67
CC 6	45 67	4 15	130 18	38 50	3 35	1 72	9 17	91 07	54 79
CC 7	42 67	3 46	1059 37	263 17	4 03	2 73	16 25	136 33	52 58
CC 8	30 00	3 15	15 05	83 69	3 75	1 4	9 53	104 10	56 55
CC 9	2 67	3 42	12 20	3 42	3 69	1 75	7 26	85 93	52 08
CC 10	45 00	3 04	102 80	2 90	3 2	2 69	10 79	85 60	61 29
CC 11	40 33	3 30	590 54	74 91	5 22	3 03	13 05	105 53	51 19
CC 12	40 33	4 36	807 62	157 87	5 12	2 23	12 64	61 83	54 86
CC 13	41 67	4 10	1455 60	206 97	6 94	3 03	13 94	102 70	40 6
CC 14	2 00	4 60	140 4	65 03	2 16	1 43	8 66	109 60	56 11
CC 15	44 67	4 21	743 45	1 7 38	6 34	1 98	10 38	102 70	51 39
CC 16	25 33	3 95	414 40	40 43	2 96	3 74	24 25	68 50	67 90
CC 17	41 00	4 63	197 38	45 98	4 29	2 48	11 07	102 70	56 35
CC 18	25 33	4 26	85 67	24 54	3 49	2 48	11 66	89 00	51 67
CC 19	27 33	2 83	248 31	59 81	4 15	2 83	7 16	82 20	58 77
CC 20	29 00	4 92	250 81	71 44	3 51	3 15	8 19	75 30	52 43
CC 21	20 00	5 21	154 53	66 59	2 33	2 17	4 92	89 00	53 62
CC 22	33 67	4 11	331 62	83 19	3 99	3 10	16 24	99 30	46 88
CC 23	47 67	4 29	1649 72	278 31	5 93	1 59	9 25	102 70	50 15
CC 24	18 67	4 58	55 00	2 82	2 42	2 97	13 35	98 60	64 58
CC 25	26 67	4 35	143 07	28 49	5 02	1 25	8 33	82 20	48 61
CC 26	21 00	3 74	73 57	6 40	2 03	2 97	13 96	102 70	64 40
CC 7	49 67	4 42	764 36	39 15	5 49	2 57	10 68	130 10	57 92
CC 28	14 67	4 55	667 71	25 93	5 1	2 53	20 30	123 30	54 25
CC 29	26 3	5 11	275 91	7 43	3 76	3 41	11 66	71 90	63 06
CC 0	26	4 09	696 23	16 06	6 00	2 2	7 89	102 70	60 02
CC 1	57 67	4 57	581 87	116 37	5 00	2 53	12 24	109 60	59 08
CC 2	32 67	4 15	51	19 78	2 (0	3 43	15 01	106 20	5 27
CD (o)	3 4 94	0 2593	51 3 64	1 4553	0 234	0 0693	1 3412	1 4729	6 4976

(128 00 cm) CC 4 (125 67 cm) and CC 12 (122 67 cm) The accession CC 29 was the shortest (61 33 cm)

Primary branches per plant

Primary branches per plant was found to vary from 3 33 to 8 67 The accessions on an average had 5 44 primary branches per plant Max mum primary branches was observed in CC 3 (8 67) and minimum n CC 12 (3 33)

Plant spread

Mean plant spread varied form 248 71 to 454 48 cm with a general mean of 315 39 cm Plant spread was max mum n CC 7 (454 48 cm) and minimum in CC 19 (248 71 cm)

Days to first flowering

Days to first flower ng exhibited a range of 54 67 to 83 00 CC 13 was the earliest to flower (54 67) and was significantly different from all other accessions CC 29 (83 00) was the latest which was on par with CC 20 (79 33)

Pollen viability

Wide var ation among the accessions was observed for pollen viability (Plates 5 and 6) It ranged from 33 27 per cent in CC 8 to 86 93 per cent in CC 31 The access ons CC 28 (86 40 per cent) and CC 7 (85 10 per cent) vere on par w th CC 31

Plate 5

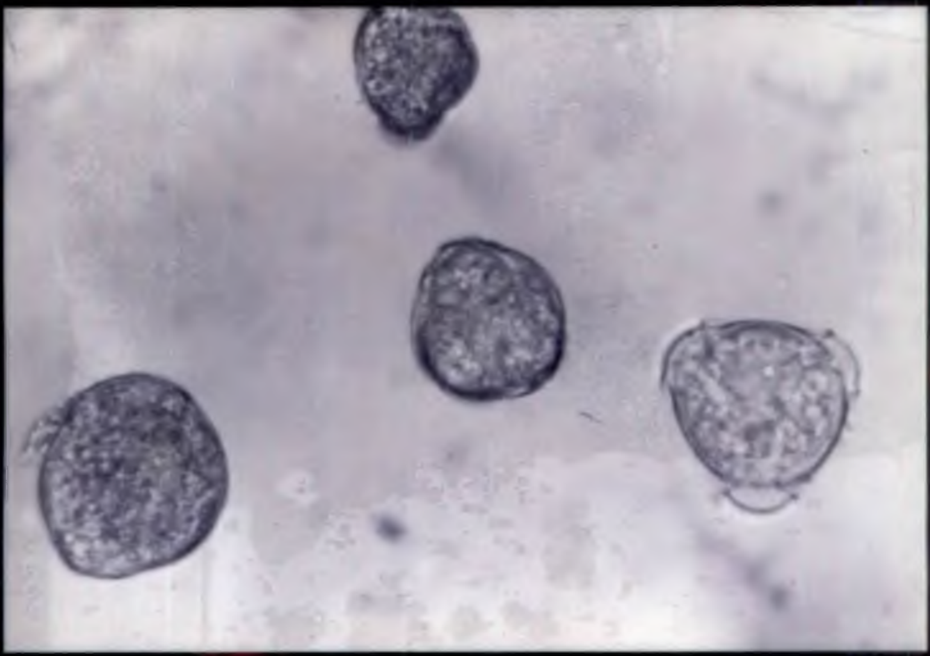
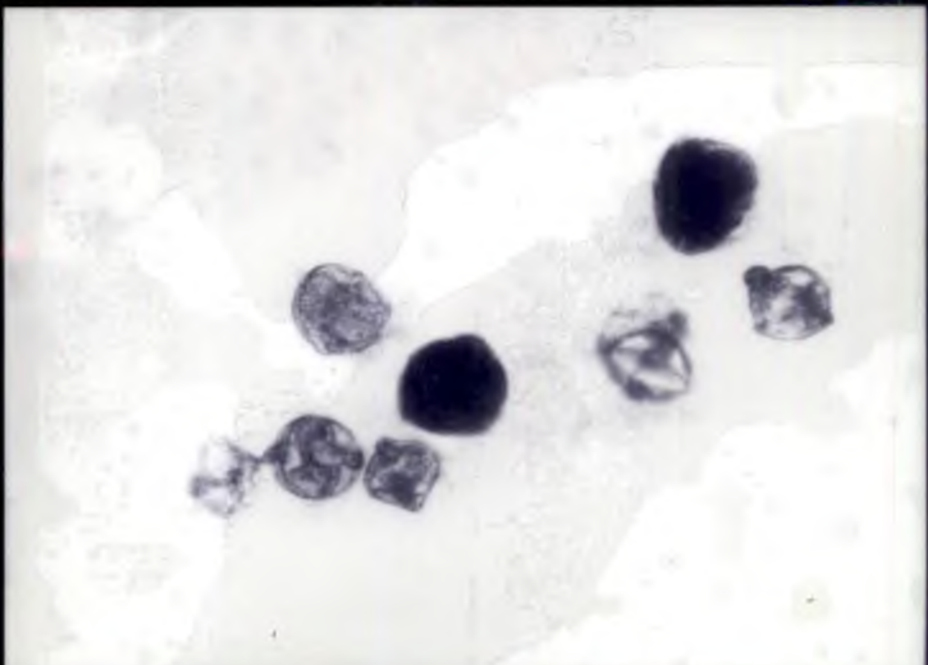


Plate 6



Days to maturity

The accessions varied significantly for days taken from fruit set to harvest. CC 30 was the earliest to mature, which took 22 days, while CC 4 was the latest (37.33).

Fruits per plant

A wide range of variation was noticed for fruits per plant. Maximum fruits were obtained from CC 23 (637.44) which was on par with CC 13 (620.00). CC 24 had the minimum fruits (18.99) which was on par with CC 32 (19.00), CC 18 (20.37), CC 9 (22.50), CC 26 (35.33), CC 14 (36.67) and CC 6 (37.67).

Fruit length

Fruit length varied considerably from 3.60 cm in CC 25 to 8.33 cm in CC 11 with an overall mean of 5.75 cm (Plate 7).

Pedicel length

Pedicel length among the accessions was found to range from 2.50 (CC 18) to 5.50 cm (CC 25).

Fruit girth

Girth of the fruits varied significantly among the accessions from 5.27 to 10.37 cm. Maximum fruit girth was recorded in CC 8 (10.37 cm) which was on par with CC 2 (10.23 cm) and CC 9 (10.10 cm). Accession CC 4 (5.27 cm) had the minimum fruit girth.

Plate 7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Fruit weight

Range in fru t weight among the accessions was from 1 22 to 8 63 g highest in CC 2 (8 63 g) and lowest in CC 4 (1 22 g)

Seeds per fruit

Seeds per fru t observed a range from 5 67 in CC 4 to 57 67 n CC 31 w th an overall mean of 32 14

1000 seed weight

A narrow range of var ation was observed for 1000 seed we ght from 2 83 to 5 21 g CC 21 had the highest 1000 seed weight of 5 21 g and the lowest n CC 19 (2 83 g)

Yield per plant

A wide range of variat on was noticed for y eld per plant CC 23 had the h ghest y eld (1649 72 g) which was significantly different from all other accessions The lowest y eld was obta ned from CC 32 (51 31 g) wh ch was on par w th CC 24 (55 00 g) CC 26 (73 57 g) and CC 18 (85 67 g)

Yield per harvest

Yield per harvest had a range from 19 78 g in CC 32 to 278 31 g in CC 23 with an overall mean of 95 78 g

Number of harvests

Among the access ons the number of harvests was found to vary from 2 03 in CC 26 to 6 94 n CC 13

Capsaicin

Capsaic n content observed a range of 1 20 to 3 74 per cent Among the 32 accessions CC 16 conta ned the maximum capsa cin (3 74 per cent) whereas CC 1 had the m n mum (1 20 per cent)

Oleoresin

Among the access ons oleores n content ranged from 4 92 per cent n CC 21 to 24 25 per cent in CC 16 w th an overall mean of 12 44 per cent

Ascorbic acid

Wide var ation n ascorb c ac d was observed among the access ons with CC 7 containing the max mum of 136 33 mg per 100 g and CC 12 w th the minimum (61 83 mg per 100 g)

Mosaic incidence

The vulnerabil ty index for mosaic incidence ranged from 40 63 to 67 90 Maximum mosa c nc dence was observed in CC 16 (67 90) whereas CC 13 (40 63) was the least affected CC 13 was on par w th CC 22 (46 88) The react on of access ons towards mosaic nc dence (Table 9) ndicated that 26 accessions were moderately res stant and the remaining s x (CC 4 CC 10 CC 16 CC 24 CC 26 and CC 29) were susceptible to the d sease

The accessions were class fied into three based on normal distr but on property and presented n Table 10 CC 2 CC 7 CC 12 CC 13 and CC 23 were found to be performing better for most of the characters whereas CC 18 CC 24 CC 26 and CC 32 were poor n most of the characters

4 2 2 Genetic parameters

The population mean range phenotypic genotypic and environmental variances phenotypic and genotypic coefficients of variat on are g ven n Table 11

H gh phenotyp c and genotypic var ances were observed for several characters includ ng y eld per plant fruits per plant and plant spread Wide variation was observed n phenotypic and genotyp c var ances among the characters A close associat on between phenotypic and genotyp c variances was noticed for y eld per plant fru ts per plant fruit g rth and fru t we ght For most of the characters genotyp c variance makes up the major port on of phenotypic variance w th very l ttle effect of environment

Phenotypic and genotypic coefficients of var at on (PCV and GCV respectively) observed were high for most of the characters (F g 1) Fru ts per plant had the highest PCV (90 08) and GCV (89 54) followed by yield per plant (89 39 and 89 12 respectively) and the lowest PCV and GCV were exhibited by days to f rst flowering (8 85 and 7 99 respectively)

Table 10 Classification of accessions

S No	Character	Poor	Medium	Best
1	Plant height	CC 6 CC 9 CC 10 CC 17 CC 18 CC 9 CC 21 CC 22 CC 24 CC 25 CC 29 CC 31 CC 32	CC 2 CC 14 CC 23 CC 26 CC 28	CC 1 CC 3 CC 4 CC 5 CC 7 CC 8 CC 1 CC 2 CC 3 CC 15 CC 6 CC 2 CC 27 CC 30
2	Primary branches per plant	CC 1 CC 2 CC 6 CC 9 CC 12 CC 13 CC 14 CC 15 CC 17 CC 22 CC 24 CC 30	CC 8 CC 10 CC 11 CC 18 CC 20 CC 21 CC ?3 CC 25 CC 27 CC 28 CC 32	CC 3 CC 4 CC 5 CC 7 CC 6 CC 19 CC 26 CC ?? CC 31
3	Plant spread	CC 1 CC 2 CC 8 CC 9 CC 10 CC 13 CC 14 CC 18 CC 19 CC 23 CC 29 CC 31 CC 32	CC 3 CC 4 CC 6 CC 5 CC 16 CC 17 CC 21 CC 22 CC 24 CC 25 CC 26	CC 5 CC 7 CC 11 CC 12 CC 20 CC 27 CC 28 CC 30
4	Days to first flowering	CC 5 CC 6 CC 18 CC 20 CC 21 CC 25 CC 26 CC 27 CC 28 CC 29 CC 32	CC 3 CC 9 CC 10 CC 11 CC 16 CC 17 CC 22 CC 31	CC 1 CC 2 CC 4 CC 7 CC 8 CC 1? CC 13 CC 14 CC 15 CC 19 CC 23 CC ?4 CC 30
5	Pollen viability	CC 5 CC 6 CC 8 CC 9 CC 10 CC 2 CC 14 CC 9 CC 20 CC 21 CC 24 CC 25 CC 26 CC 29	CC 32	CC 1 CC 2 CC 3 CC 4 CC 7 CC 11 CC 13 CC 5 CC 16 CC 7 CC 18 CC ?2 CC 23 CC ?7 CC 28 CC 30 CC 31
6	Days to maturity	CC 3 CC 5 CC 6 CC 0 CC 4 CC 15 CC 17 CC 23 CC 24 CC 25 CC 26 CC 29 CC 30 CC 32	CC 2 CC 7 CC 9 CC 1 CC 16 CC 20 CC 27 CC 3	CC CC 4 CC 8 CC 12 CC 13 CC 18 CC 19 CC ?1 CC 22 CC 28
7	Fruits per plant	CC 6 CC 8 CC 9 CC 10 CC 14 CC 17 CC 18 CC 19 CC 20 CC 21 CC 22 CC 24 CC 25 CC 26 CC 29 CC 32	CC 11	CC 1 CC 2 CC 3 CC 4 CC 5 CC 7 CC 2 CC 13 CC 5 CC 16 CC 23 CC 27 CC ?8 CC 30 CC

Table 10 Contd

Sl No	Charac e	Poo	Med um	Bette
8	Fru t length	CC 2 CC 3 CC 9 CC 12 CC 4 CC 18 CC 19 CC 20 CC 22 CC 23 CC 25 CC 29 CC 31 CC 32	CC 8 CC 26	CC 1 CC 4 CC 5 CC 6 CC 7 CC 10 CC 11 CC 13 CC 15 CC 16 CC 17 CC 21 CC 24 CC 27 CC 28 CC 30
9	Ped ce length	CC 3 CC 6 CC 8 CC 10 CC 13 CC 14 CC 5 CC 16 CC 17 CC 18 CC 20 CC 21 CC 24 CC 29 CC 31 CC 32	CC 4 CC 28	CC 1 CC 2 CC 5 CC 7 CC 9 CC 11 CC 2 CC 19 CC 22 CC 23 CC 25 CC 26 CC 27 CC 30
10	Fru t g h	CC 1 CC 3 CC 4 CC 5 CC 10 CC 1 CC 13 CC 16 CC 19 CC 20 CC 2 CC 24 CC 25 CC 26 CC 32	CC 31	CC 2 CC 6 CC 7 CC 8 CC 9 CC 12 CC 14 CC 15 CC 17 CC 18 CC 2? CC 2 CC 27 CC 28 CC 29 CC 30
11	F u we gh	CC 3 CC 4 CC 0 CC 6 CC 17 CC 18 CC 9 CC 20 CC 2 CC 22 CC 25 CC 26 CC 30 CC 32	CC 1 CC 29	CC 2 CC 5 CC 6 CC 7 CC 8 CC 9 CC 1 CC 1 CC 3 CC 4 CC 15 CC 23 CC 24 CC 27 CC 28 CC 31
12	Seeds per fru t	CC 1 CC 3 CC 4 CC 5 CC 8 CC 9 CC 16 CC 8 CC 19 CC 20 CC 21 CC 24 CC 25 CC 26 CC 28 CC 29 CC 30	CC 14 CC 32	CC 2 CC 6 CC 7 CC 10 CC 1 CC 12 CC 13 CC 15 CC 7 CC 22 CC 23 CC 7 CC 3
13	1000 seed ve gh	CC 1 CC 3 CC 5 CC 7 CC 8 CC 9 CC 10 CC 1 CC 16 CC 19 CC 26	CC 4 CC 6 CC 13 CC 5 CC 22 CC 30 CC 32	CC 2 CC 12 CC 14 CC 17 CC 8 CC 20 CC 21 CC 23 CC 24 CC 25 CC 27 CC 28 CC 29 CC 31

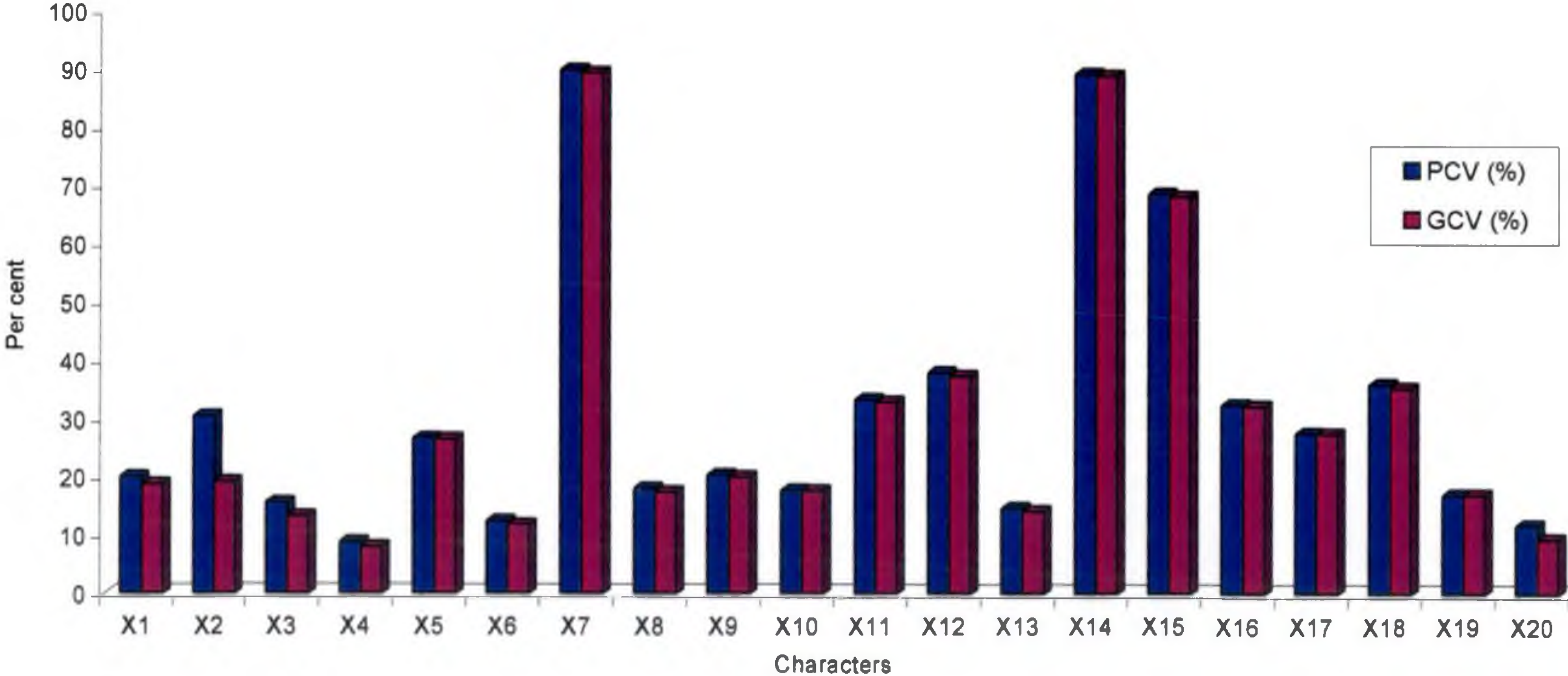
Table 10 Contd

S No	Character	Poor	Med um	Bette
14	Y eld per p an	CC 1 CC 3 CC 4 CC 6 CC 8 CC 9 CC 10 CC 11 CC 14 CC 16 CC 17 CC 18 CC 19 CC 20 CC 21 CC 22 CC 24 CC 25 CC 26 CC 29 CC 32		CC 2 CC 5 CC 7 CC ? CC 13 CC 5 CC 23 CC 27 CC 28 CC 30 CC 31
15	Y eld per harvest	CC 4 CC 5 CC 6 CC 8 CC 9 CC 10 CC 11 CC 14 CC 17 CC 18 CC 19 CC 20 CC 21 CC 22 CC 24 CC 25 CC 26 CC 29 CC 32		CC 1 CC 2 CC 3 CC 7 CC 2 CC CC 1ɔ CC 16 CC 23 CC 27 CC 28 CC 30 CC 31
16	Number of harves s	CC 1 CC 3 CC 4 CC 6 CC 7 CC 8 CC 9 CC 10 CC 14 CC 16 CC 18 CC 20 CC 21 CC 22 CC 24 CC 26 CC 29 CC 32	CC 19	CC 2 CC 5 CC 11 CC 1? CC 13 CC ɔ CC 7 CC CC 25 CC 27 CC 28 CC 30 CC 31
17	Capsa c n	CC 1 CC 2 CC 5 CC 6 CC 8 CC 9 CC 12 CC 14 CC 1ɔ CC 21 CC 23 CC 25 CC 27 CC 30	CC 17 CC 18	CC 3 CC 4 CC 7 CC 10 CC 11 CC 13 CC 16 CC 9 CC 20 CC 22 CC 24 CC ?6 CC 28 CC 29 CC 31 CC 32
18	Oleores n	CC 3 CC 6 CC 8 CC 9 CC 10 CC 14 CC 15 CC 17 CC 18 CC 19 CC 20 CC 21 CC 23 CC 25 CC 27 CC 29 CC 30	CC 12 CC 31	CC 1 CC 2 CC 4 CC ɔ CC 7 CC 11 CC 13 CC 16 CC 22 CC 24 CC 26 CC 28 CC 32
19	Ascorb c ac d	CC 2 CC 5 CC 6 CC 9 CC 10 CC 12 CC 6 CC 18 CC 9 CC 20 CC 21 CC 25 CC 29		CC 1 CC CC 4 CC 7 CC 8 CC 1 CC 13 CC 14 CC 15 CC 17 CC 22 CC 23 CC 24 CC 26 CC 27 CC 28 CC 30 CC 3 CC 32

Table 11 Range mean phenotypic genotypic and environmental variances phenotypic and genotypic coefficients of variation for different characters in *C chinense*

Sl No	Character	Range	Mean + SE_m	σp^2	σg	σe^2	PCV (%)	GCV (%)
1	Plant height (cm)	61 33 135 3	98 69+ 4 00	393 08	345 01	48 07	20 09	18 82
2	Primary branches per plant	3 33 8 67	5 44 + 0 75	2 77	1 09	1 68	30 5[illegible]	19 17
3	Plant spread (cm)	248 71 454 48	515 39+15 1	2439 53	175 20	686 32	15 6[illegible]	1 78
4	Days to first flowering	54 67 85 00	70 18+1 54	38 53	1 44	7 09	8 85	7 99
5	Pollen viability (%)	3 27 86 9	62 8 +0 94	281 71	279 08	2 63	26 7	6 60
6	Days to maturity	22 00 37 33	31 04+0 66	14 92	13 62	1 30	12 44	1 89
7	Fruits per plant	18 99 637 44	168 85+9 54	23132 99	22860 03	272 96	90 08	89 54
8	Fruit length (cm)	3 60 8 5	5 75+0 5	1 08	1 01	0 07	18 07	17 51
9	Pedicel length (cm)	2 50 5 50	3 53+0 07	0 52	0 50	0 02	20 37	20 07
10	Fruit girth (cm)	5 27 10 37	8 45+0 099	2 26	2 23	0 03	17 79	17 67
11	Fruit weight (g)	1 22 8 65	5 02+0 15	2 81	2 75	0 06	33 41	5 03
12	Seeds per fruit	5 67 57 67	32 14+1 21	149 20	144 79	4 41	38 01	7 44
13	1000 seed weight (g)	2 83 5 21	4 12+0 09	0 37	0 34	0 03	14 74	14 23
14	Yield per plant (g)	51 31 1649 72	445 96+18 14	158932 00	157944 40	987 60	89 39	89 12
15	Yield per harvest (g)	19 78 278 51	95 78+4 76	4540 33	4272 44	67 89	68 82	68 28
16	Number of harvests	2 0 6 94	4 18+0 08	1 84	1 82	0 02	32 48	32 30
17	Capsaicin (%)	20 5 74	2 49+0 02	0 47	0 46	0 01	27 57	27 52
18	Oleoresin (%)	4 92 24 25	12 44±0 47	20 13	19 45	0 68	36 07	5 46
19	Ascorbic acid (mg per 100 g)	61 83 156 3	98 07+0 52	280 15	279 32	0 81	17 07	17 04
20	Mosaic incidence (Vulnerability Index)	40 63 67 90	55 18+2 30	42 96	27 13	15 83	11 88	9 44

Fig. 1 Phenotypic and genotypic coefficient of variation for 20 characters in *C. chinense*



X1-Plant height
X2-Primary branches per plant
X3-Plant spread
X4-Days to first flowering
X5-Pollen viability
X6-Days to maturity
X7-Fruits per plant
X8-Fruit length
X9-Pedicel length
X10-Fruit girth
X11-Fruit weight
X12-Seeds per plant
X13-1000 seed weight
X14-Yield per plant
X15-Yield per harvest
X16-Number of harvests
X17-Capsaicin
X18-Oleoresin
X19-Ascorbic acid
X20-Mosaic incidence

4.2.3 Heritability and genetic advance

Heritability and genetic advance for different characters are presented in Table 12 (Fig. 2).

High heritability coupled with high genetic advance was observed for most of the characters, except primary branches per plant, days to first flowering and mosaic incidence.

Heritability estimates were high for most of the characters studied *viz*., ascorbic acid (99.71), capsaicin (99.62), yield per plant (99.38) and pollen viability (99.07). Primary branches per plant recorded the lowest but a moderate heritability (39.35).

Genetic advance was highest for fruits per plant (183.37), followed by yield per plant (183.01) and the lowest for days to first flowering (14.87) and mosaic incidence (15.45). High heritability combined with high genetic advance was observed for fruits per plant and yield.

4.2.4 Correlation analysis

The phenotypic, genotypic and environmental correlation coefficients were estimated for 20 characters (Tables 13, 14 and 15).

(A) Phenotypic correlation

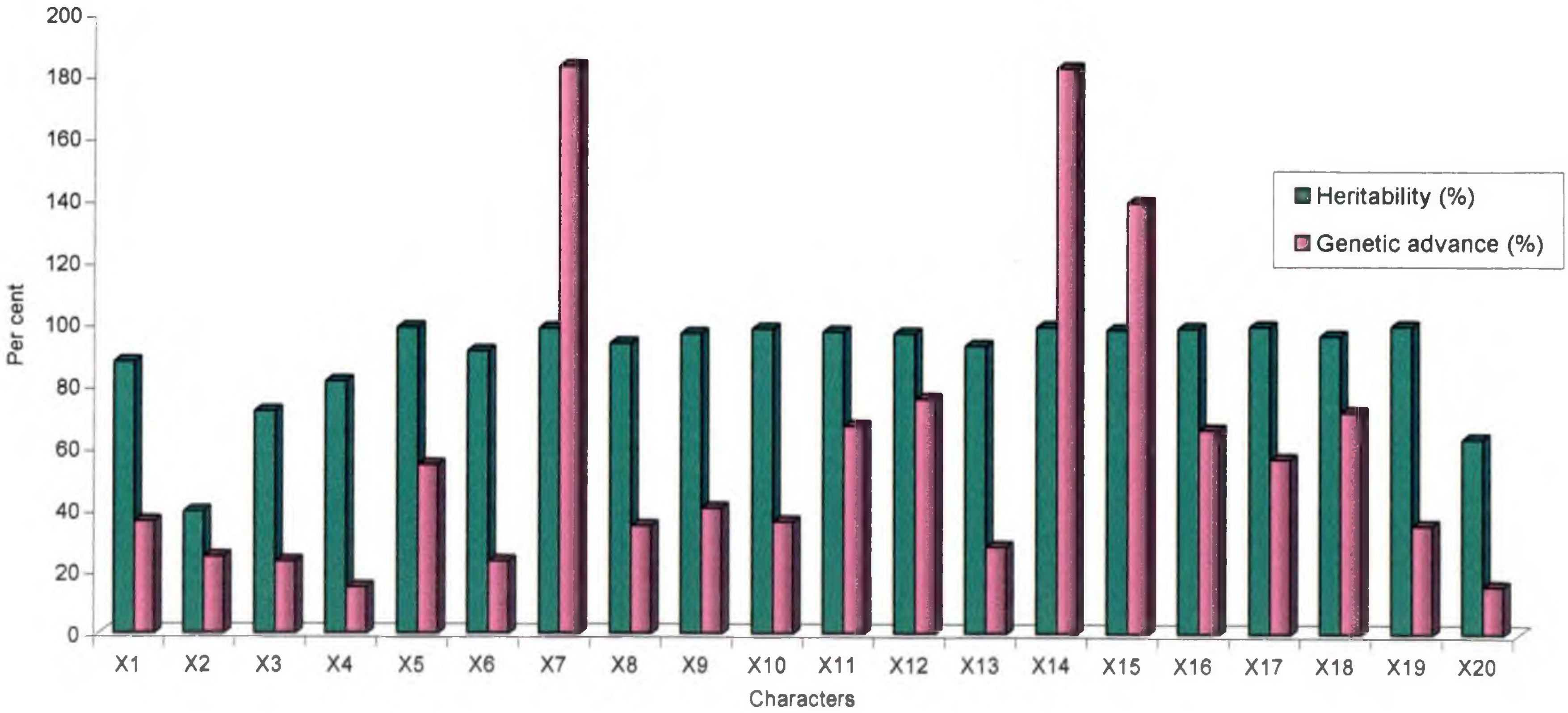
(i) Correlation between yield and other characters

Yield per plant recorded high positive correlation with plant height (0.4401), pollen viability (0.5759), fruits per plant (0.9300), fruit weight (0.4513),

Table 12. Heritability and genetic advance for different characters in *C. chinense*

Sl. No.	Characters	Heritability (%)	Genetic advance (%)
1	Plant height	87.77	36.32
2	Primary branches per plant	39.35	24.77
3	Plant spread	71.87	23.18
4	Days to first flowering	81.60	14.87
5	Pollen viability	99.07	54.53
6	Days to maturity	91.32	23.41
7	Fruits per plant	98.82	183.37
8	Fruit length	93.95	34.97
9	Pedicel length	97.04	40.72
10	Fruit girth	98.68	36.17
11	Fruit weight	97.75	67.28
12	Seeds per plant	97.04	75.99
13	1000-seed weight	93.16	28.29
14	Yield per plant	99.38	183.01
15	Yield per harvest	98.44	139.55
16	Number of harvests	98.89	66.16
17	Capsaicin	99.62	56.58
18	Oleoresin	96.65	71.81
19	Ascorbic acid	99.71	35.05
20	Mosaic incidence	63.15	15.45

Fig. 2 Heritability and genetic advance for 20 characters in *C. chinense*



X1-Plant height
X2-Primary branches per plant
X3-Plant spread
X4-Days to first flowering
X5-Pollen viability

X6-Days to maturity
X7-Fruits per plant
X8-Fruit length
X9-Pedicel length
X10-Fruit girth

X11- Fruit weight
X12-Seeds per plant
X13-1000 seed weight
X14-Yield per plant
X15-Yield per harvest

X16-Number of harvests
X17-Capsaicin
X18-Oleoresin
X19-Ascorbic acid
X20-Mosaic incidence

seeds per fruit (0.4798), number of harvests (0.7304) and ascorbic acid (0.2756). Days to first flowering and mosaic incidence were negatively correlated with yield (-0.5488 and -0.3531 respectively).

(ii) Correlation among the yield component characters

Plant height was positively correlated with plant spread (0.5282), fruits per plant (0.4256), fruit length (0.3862), number of harvests (0.2833) and ascorbic acid content (0.3204) and negatively correlated with days to first flowering (-0.3255).

Fruit girth and fruit weight were negatively correlated with primary branches per plant (-0.3391 and -0.3531 respectively), while capsaicin (0.4058) and mosaic incidence (0.3072) were positively correlated with primary branches per plant.

Fruit length observed high positive correlation with plant spread (0.3080). Days to first flowering recorded negative correlation with most of the characters, the highest being with fruits per plant (-0.5963).

Pollen viability exhibited high positive correlation with several characters like fruits per plant (0.5800), fruit length (0.3460), seeds per fruit (0.2691), number of harvests (0.4827), capsaicin (0.3051), oleoresin (0.3307) and ascorbic acid (0.4774).

Days to maturity was negatively correlated with days to first flowering (-0.2636). Fruits per plant was positively correlated with seeds per fruit (0.3240) and negatively correlated with mosaic incidence (-0.3667).

Table 13. Phenotypic correlation coefficients among yield and its components

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20
Plant height (X1)	1.0000																			
Primary branches per plant (X2)	0.0494	1.0000																		
Plant spread (X3)	0.5282**	-0.0479	1.0000																	
Days to first flowering (X4)	-0.3255*	0.1937	0.0229	1.0000																
Pollen viability (X5)	0.2127	0.0029	0.2301	-0.2630	1.0000															
Days to maturity (X6)	0.2222	-0.0121	-0.1536	-0.2636	0.0674	1.0000														
Fruits per plant (X7)	0.4256**	-0.0212	0.0778	-0.5963**	0.5800**	0.2020	1.0000													
Fruit length (X8)	0.3862*	-0.0827	0.3080	-0.1765	0.3460*	0.1775	0.1414	1.0000												
Pedicel length (X9)	0.2150	-0.0758	0.1903	0.0384	-0.1068	-0.1280	0.0650	0.0446	1.0000											
Fruit girth (X10)	-0.0803	-0.3391*	0.1488	-0.0005	0.0637	-0.0767	-0.0103	0.0241	-0.1490	1.0000										
Fruit weight (X11)	0.1928	-0.3531*	0.1330	-0.0898	0.1252	0.1126	0.2430	0.1634	0.1466	0.6862**	1.0000									
Seeds per fruit (X12)	0.0382	-0.2300	0.1366	-0.1669	0.2691	-0.1513	0.3240*	0.0652	-0.1097	0.4553**	0.4151*	1.0000								
1000-seed weight (X13)	-0.2057	-0.1978	0.0381	0.2441	0.2137	-0.1961	-0.0045	-0.2203	-0.3117	0.2137	0.1374	0.0292	1.0000							
Yield per plant (X14)	0.4401**	-0.1410	0.2082	-0.5488**	0.5759**	0.1652	0.9300**	0.1592	0.0920	0.2440	0.4513**	0.4798**	0.0725	1.0000						
Yield per harvest (X15)	0.5176**	-0.0161	0.2900	-0.5145**	0.5611**	0.2138	0.8637**	0.1840	0.0528	0.2468	0.4076*	0.3985*	0.0503	0.9409**	1.0000					
Number of harvests (X16)	0.2833	-0.2675	0.1537	-0.2919	0.4827**	-0.0341	0.6804**	0.1665	0.3676*	0.2427	0.4517**	0.4608**	0.0054	0.7304**	0.5294**	1.0000				
Capsaicin (X17)	-0.0654	0.4058*	0.0781	0.1471	0.3051	-0.0152	0.0004	0.1551	-0.2990	-0.2485	-0.3551*	-0.0772	0.0139	-0.0684	-0.0257	-0.1345	1.0000			
Oleoresin (X18)	0.2029	0.1731	0.0745	-0.0085	0.3307*	0.2118	0.2042	0.2989	0.1056	-0.0770	0.0924	-0.0990	-0.0219	0.1741	0.2381	0.1250	0.4255**	1.0000		
Ascorbic acid (X19)	0.3204*	-0.0449	0.2651	-0.1914	0.4774**	0.1013	0.2670	0.4292**	0.0423	0.0059	0.2458	0.0965	-0.1111	0.2756	0.3101	0.1241	-0.1637	0.1238	1.0000	
Mosaic incidence (X20)	0.0032	0.3072	-0.0410	0.1558	-0.1717	-0.1644	-0.3667*	0.1123	-0.1621	-0.0939	-0.2076	-0.2430	-0.0229	-0.3531*	-0.2369	-0.4308**	0.2037	0.105	-0.1305	1.0000

* Significant at 5 per cent level ** Significant at 1 per cent level

Fruit length was positively correlated with oleoresin (0.2989) and ascorbic acid contents (0.4292). Pedicel length observed high negative correlation with 1000-seed weight (-0.3117) and capsaicin (-0.2990).

Fruit girth observed high positive correlation with fruit weight (0.6862), seeds per fruit (0.4553) and negatively correlated with capsaicin (-0.2485).

Seeds per fruit was positively correlated with fruit weight (0.4151), whereas capsaicin was negatively correlated with fruit weight (-0.3551).

Mosaic incidence observed high negative correlation with number of harvests (-0.4308).

A high positive correlation was observed between capsaicin and oleoresin contents (0.4255).

(B) Genotypic correlation

(i) Correlation between yield and other characters

High positive correlation was observed between yield per plant and plant height (0.4604), pollen viability (0.5808), fruits per plant (0.9323), fruit weight (0.4614), seeds per fruit (0.4876), yield per harvest (0.9425) and number of harvests (0.7356), whereas days to first flowering and mosaic incidence exhibited a high negative correlation (-0.6131 and -0.4581 respectively). Yield per harvest was positively correlated with plant spread (0.3426).

Table 14. Genotypic correlation coefficients among yield and its components

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20
Plant height (X1)	1.0000																			
Primary branches per plant (X2)	0.0594	1.0000																		
Plant spread (X3)	0.6222	-0.0307	1.0000																	
Days to first flowering (X4)	-0.3803	0.3746	0.0659	1.0000																
Pollen viability (X5)	0.2269	0.0027	0.2795	-0.2943	1.0000															
Days to maturity (X6)	0.2346	-0.0533	-0.2163	-0.3092	0.0717	1.0000														
Fruits per plant (X7)	0.4471	-0.0622	0.0830	-0.6651	0.5869	0.2144	1.0000													
Fruit length (X8)	0.4048	-0.1639	0.3772	-0.1925	0.3590	0.1797	0.1484	1.0000												
Pedicel length (X9)	0.2282	-0.1003	0.2217	0.0555	-0.1046	-0.1409	0.0679	0.0511	1.0000											
Fruit girth (X10)	-0.0839	-0.5248	0.1898	0.0091	0.0667	-0.0755	-0.0077	0.0194	-0.1541	1.0000										
Fruit weight (X11)	0.2192	-0.5483	0.1444	-0.1034	0.1324	0.1193	0.2503	0.1646	0.1452	0.6990	1.0000									
Seeds per fruit (X12)	0.0470	-0.3590	0.1757	-0.2050	0.2760	-0.1622	0.3313	0.0658	-0.1176	0.4637	0.4220	1.0000								
1000-seed weight (X13)	-0.2271	-0.2712	0.0199	0.2721	0.2199	-0.2163	-0.0082	-0.2293	-0.3289	0.2265	0.1382	0.0399	1.0000							
Yield per plant (X14)	0.4604	-0.2443	0.2459	-0.6131	0.5808	0.1726	0.9323	0.1626	0.0957	0.2479	0.4614	0.4876	0.0774	1.0000						
Yield per harvest (X15)	0.5391	-0.0655	0.3426	-0.5814	0.5690	0.2250	0.8667	0.1900	0.0575	0.2519	0.4206	0.4062	0.0565	0.9425	1.0000					
Number of harvests (X16)	0.3070	-0.4118	0.1819	-0.3233	0.4872	-0.0404	0.6881	0.1711	0.3743	0.2485	0.4594	0.4684	0.0060	0.7356	0.5395	1.0000				
Capsaicin (X17)	-0.0667	0.6510	0.0980	0.1637	0.3072	-0.0159	0.0003	0.1586	-0.3022	-0.2528	-0.3604	-0.0789	0.0123	-0.0692	-0.0269	-0.1353	1.0000			
Oleoresin (X18)	0.2136	0.2930	0.1084	-0.0153	0.3364	0.2222	0.2131	0.3136	0.1054	-0.0778	0.0941	-0.1062	-0.0316	0.1792	0.2463	0.1255	0.4341	1.0000		
Ascorbic acid (X19)	0.3369	-0.0718	0.3056	-0.2123	0.4803	0.1060	0.2688	0.4420	0.0436	0.0060	0.2498	0.1006	-0.1149	0.2764	0.3122	0.1252	-0.1639	0.1281	1.0000	
Mosaic incidence (X20)	-0.0260	0.4916	-0.0485	0.2672	-0.2044	-0.1788	-0.4701	0.1119	-0.2086	-0.1215	-0.2976	-0.3007	-0.0377	-0.4581	-0.3170	-0.5557	0.2558	0.1272	-0.1631	1.0000

(ii) Correlation among the yield component characters

Plant height had high positive correlation with plant spread (0.6222), fruits per plant (0.4471), fruit length (0.4048) and ascorbic acid content (0.3369) and negatively correlated with days to first flowering (-0.3803).

Primary branches per plant exhibited high positive correlation with capsaicin (0.6510), mosaic incidence (0.4916) and days to first flowering (0.3746), whereas fruit girth (-0.5248), fruit weight (-0.5483) and seeds per fruit (-0.3590) were negatively correlated.

Fruit length and ascorbic acid were positively correlated with plant spread (0.3772 and 0.3056 respectively). Days to first flowering exhibited high negative correlation with fruits per plant (-0.6651), days to maturity (-0.3092) and pollen viability (-0.2943).

Pollen viability observed high positive correlation with several characters like fruits per plant (0.5869), fruit length (0.3590), seeds per fruit (0.2760), capsaicin (0.3072), oleoresin (0.3364) and ascorbic acid (0.4803) contents and negative correlation with mosaic incidence (-0.2044).

Fruits per plant had high positive correlation with seeds per fruit (0.3313) and negative correlation with mosaic incidence (-0.4701). Oleoresin and ascorbic acid exhibited high positive correlation with fruit length (0.3136 and 0.4420 respectively), whereas 1000-seed weight and capsaicin were negatively correlated with pedicel length (-0.3289 and -0.3022 respectively).

Table 15. Environmental correlation coefficients among yield and its components

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20
Plant height (X1)	1.0000																			
Primary branches per plant (X2)	0.0531	1.0000																		
Plant spread (X3)	0.1837	-0.0764	1.0000																	
Days to first flowering (X4)	-0.0248	-0.0555	-0.1210	1.0000																
Pollen viability (X5)	0.0316	0.0157	-0.1121	0.0394	1.0000															
Days to maturity (X6)	0.1183	0.0863	0.1384	0.0260	-0.0264	1.0000														
Fruits per plant (X7)	0.2433	0.2082	0.1349	0.0209	-0.0704	-0.0524	1.0000													
Fruit length (X8)	0.2165	0.0884	-0.0148	-0.0751	-0.0150	0.1520	-0.0607	1.0000												
Pedicel length (X9)	0.0732	-0.1028	0.0560	-0.1479	-0.2589	0.0921	-0.0774	-0.0994	1.0000											
Fruit girth (X10)	-0.0538	-0.1345	-0.1810	-0.1771	-0.2044	-0.1511	-0.2183	0.1897	0.0873	1.0000										
Fruit weight (X11)	-0.1959	-0.1115	0.1501	0.0399	-0.3558	-0.0024	-0.1868	0.1527	0.2025	-0.0199	1.0000									
Seeds per fruit (X12)	-0.0862	-0.0609	-0.1108	0.2105	-0.0914	0.0283	-0.0260	0.0562	0.1493	0.0781	0.1614	1.0000								
1000-seed weight (X13)	-0.0035	-0.1648	0.1569	0.0612	0.0975	0.0444	0.1198	-0.0898	0.0228	-0.1181	0.1407	-0.1959	1.0000							
Yield per plant (X14)	0.3653	0.1915	0.0100	0.0987	-0.0438	0.0356	0.7132	0.1097	-0.1494	-0.1616	-0.2926	0.0704	-0.0974	1.0000						
Yield per harvest (X15)	0.3770	0.2528	0.0267	0.1217	-0.0647	0.0146	0.6547	0.0401	-0.1618	-0.1015	-0.2657	0.0671	-0.1160	0.8840	1.0000					
Number of harvests (X16)	-0.0745	-0.1291	0.0067	-0.0336	0.0512	0.1382	0.0167	0.0610	0.0525	-0.2341	0.0012	0.1045	-0.0135	0.1352	-0.2197	1.0000				
Capsaicin (X17)	-0.1403	-0.0377	-0.1452	-0.0170	-0.0256	-0.0051	0.0119	0.1108	-0.1825	0.2947	0.0663	0.0376	0.1227	0.0800	0.1102	-0.0393	1.0000			
Oleoresin (X18)	0.0972	-0.0535	-0.1635	0.0653	0.0858	0.0554	-0.2053	0.0023	0.1097	-0.0448	0.0355	0.1224	0.1676	-0.1051	-0.0935	0.1194	0.0355	1.0000		
Ascorbic acid (X19)	0.2771	0.0036	0.2229	0.0067	0.0145	0.0142	0.0365	0.1066	-0.0728	-0.0032	-0.0956	-0.2664	-0.0242	0.0990	0.1134	-0.0380	-0.1054	-0.1941	1.0000	
Mosaic incidence (X20)	0.1062	0.1314	-0.0258	-0.1383	-0.1714	-0.1601	0.0709	0.1747	0.0113	0.0286	0.2885	-0.0731	0.0380	0.2034	0.1716	0.1305	0.0217	0.0509	-0.0313	1.0000

Fruit girth had high positive correlation with fruit weight (0.6990), seeds per fruit (0.4637) and negatively correlated with capsaicin content (-0.2528).

Fruit weight also had a negative correlation with capsaicin (-0.3604) along with mosaic incidence (-0.2976), but positively correlated with seeds per fruit (0.4220). Seeds per fruit exhibited high negative correlation with mosaic incidence (-0.3007).

Number of harvests had a more or less similar trend of correlation as that of yield per plant.

Capsaicin had high positive correlation with oleoresin (0.4341).

(C) Environmental correlation

Environmental correlation coefficients were found to be negligible among yield and its component characters, except for the correlation between fruits per plant and yield per plant (0.7132).

4.2.5 Path Analysis

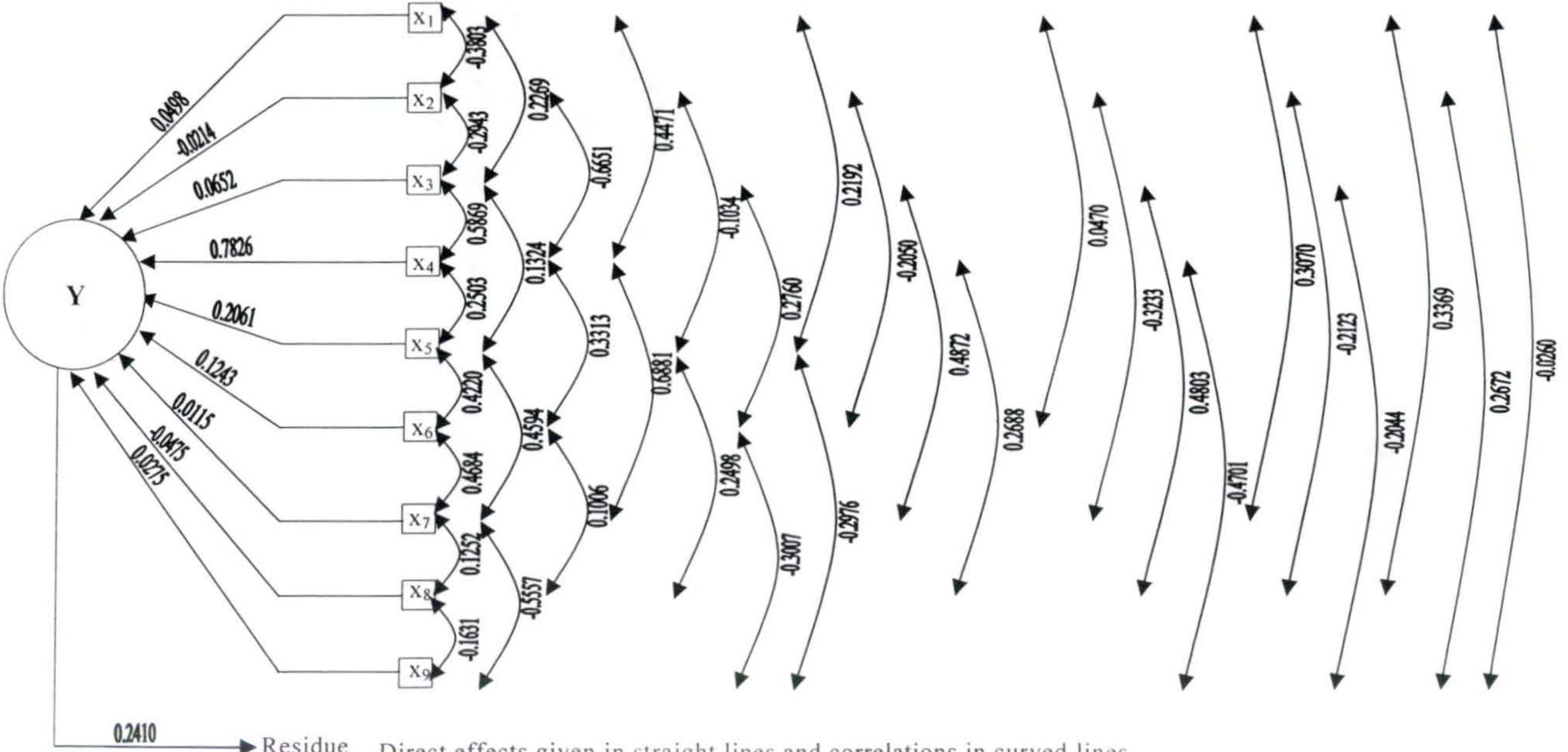
In path coefficient analysis, the genotypic correlation coefficients among yield and its component characters were partitioned into direct and indirect contribution of each character to fruit yield (Table 16 and Fig. 3). Plant height, days to first flowering, pollen viability, fruits per plant, fruit weight, seeds per fruit, number of harvests, ascorbic acid and mosaic incidence were selected for path coefficient analysis.

Table 16. Direct and indirect effect of selected yield components on fruit yield in *C. chinense*

Character	Plant height	Days to first flowering	Pollen viability	Fruits per plant	Fruit weight	Seeds per fruit	Number of harvests	Ascorbic acid	Mosaic incidence	Correlation with yield
Plant height	**0.0498**	0.0081	0.0148	0.3499	0.0452	0.0058	0.0035	-0.0160	-0.0007	0.4604
Days to first flowering	-0.0189	**-0.0214**	-0.0192	-0.5205	-0.0213	-0.0255	-0.0037	0.0101	0.0073	-0.6131
Pollen viability	0.0113	0.0063	**0.0652**	0.4593	0.0273	0.0343	0.0056	-0.0228	-0.0056	0.5808
Fruits per plant	0.0222	0.0143	0.0382	**0.7826**	0.0516	0.0412	0.0079	-0.0128	-0.0129	0.9323
Fruit weight	0.0109	0.0022	0.0086	0.1959	**0.2061**	0.0525	0.0053	-0.0119	-0.0082	0.4614
Seeds per fruit	0.0023	0.0044	0.0180	0.2593	0.0870	**0.1243**	0.0054	-0.0048	-0.0083	0.4876
Number of harvests	0.0153	0.0069	0.0317	0.5385	0.0947	0.0582	**0.0115**	-0.0059	-0.0153	0.7356
Ascorbic acid	0.0168	0.0045	0.0313	0.2104	0.0515	0.0125	0.0014	**-0.0475**	-0.0045	0.2764
Mosaic incidence	-0.0013	-0.0057	-0.0133	-0.3679	-0.0613	-0.0374	-0.0064	0.0077	**0.0275**	-0.4581

Residue = 0.2410
Direct effects- diagonal elements
Indirect effects- off diagonal elements

Fig. 3 Path diagram showing direct and indirect effects of the components on yield



Direct effects given in straight lines and correlations in curved lines

Y – Yield per plant
X_1 – Plant height
X_2 – Days to first flowering
X_3 – Pollen viability
X_4 – Fruits per plant
X_5 – Fruit weight
X_6 – Seeds per fruit
X_7 – Number of harvests
X_8 – Ascorbic acid
X_9 – Mosaic incidence

Fruits per plant exhibited the highest positive direct effect on fruit yield (0.7826), followed by fruit weight (0.2061) and seeds per fruit (0.1243). The direct effects of plant height, pollen viability, number of harvests and mosaic incidence were negligible, whereas days to first flowering and ascorbic acid exerted small and negative direct effects on yield.

Indirect effects through fruits per plant were consistently high signifying the importance of that character. Thus in the case of plant height, pollen viability and number of harvests, high positive correlation with yield was mainly due to their positive indirect effects through fruits per plant (0.3499, 0.4593 and 0.5385 respectively). Similarly, high negative correlation of days to first flowering and mosaic incidence on yield was due to high negative indirect effects through fruits per plant (-0.5205 and -0.3679 respectively). In the case of fruit weight and seeds per fruit, the correlation was mainly built by the direct as well as indirect effect *via* fruits per plant.

4.2.6 Selection Index

A discriminant function analysis was carried out for isolating superior genotypes. Selection index involving characters *viz*., plant height (X_1), days to first flowering (X_2), pollen viability (X_3), fruits per plant (X_4), fruit weight (X_5), seeds per fruit (X_6), yield per plant (X_7), number of harvests (X_8), ascorbic acid (X_9) and mosaic incidence (X_{10}) were selected for the analysis.

The selection index worked out was as follows :

$$I = 0.6548872\ X_1 - 0.8016408\ X_2 + 1.396126\ X_3 + 0.8978062\ X_4 + 3.657391\ X_5$$

$$+ 0.7279018\ X_6 + 0.9976921\ X_7 + 2.350527\ X_8 + 0.9246957\ X_9 - 0.4314854\ X_{10}.$$

The scores obtained for the accession based on the selection index were given in Table 17.

Based on selection index, CC 23 (7471.67) ranked first, followed by CC 13 (6805.48) and CC 7 (4955.16) (Plates 8, 9 and 10). The minimum scores were obtained for CC 32 (762.16) and CC 24 (781.35).

4.2.7 Mahalanobi's D^2 analysis

Following Mahalanobi's D^2 statistic, the 32 accessions of *C. chinense* were subjected to cluster analysis, based on ten characters *viz*., plant height, days to first flowering, pollen viability, fruits per plant, fruit weight, seeds per fruit, yield per plant, number of harvests, ascorbic acid and mosaic incidence.

The 32 accessions fell under six clusters. The clustering pattern is furnished in Table 18. Cluster I was the largest with 21 accessions, followed by cluster II with 6 accessions and cluster III with two accessions. Clusters IV, V and VI had one accession each.

The cluster means of the ten characters are presented in Table 19. Cluster IV consisted of taller accession (CC 5) which was late in flowering, whereas cluster V (CC 13) comprised of early flowering accession, which had more number of harvests and low mosaic incidence. Cluster III (CC 2 and

Table 17. Selection indices arranged in descending order

Rank	Accessions	Selection index
1	CC 23	7471.67
2	CC 13	6805.48
3	CC 7	4955.16
4	CC 2	4248.36
5	CC 15	3926.26
6	CC 27	3756.06
7	CC 12	3504.63
8	CC 30	3408.03
9	CC 28	3367.46
10	CC 31	3098.68
11	CC 3	2643.41
12	CC 5	2573.48
13	CC 11	2416.41
14	CC 16	2333.01
15	CC 1	2186.01
16	CC 4	2055.50
17	CC 22	2010.79
18	CC 8	1731.02
19	CC 19	1537.20
20	CC 29	1512.32
21	CC 20	1494.36
22	CC 17	1441.58
23	CC 25	1130.55
24	CC 14	1102.03
25	CC 6	1035.57
26	CC 21	1031.92
27	CC 10	941.39
28	CC 9	909.99
29	CC 18	883.80
30	CC 26	804.73
31	CC 24	781.35
32	CC 32	762.16

Plate 8

Plate 9

Plate 10

Table 18. Clustering pattern of accessions

Cluster No.	Number of accessions	Accessions
I	21	CC 14, CC 6, CC 9, CC 21, CC 18, CC 10, CC 25, CC 26, CC 17, CC 24, CC 32, CC 19, CC 20, CC 29, CC 4, CC 1, CC 8, CC 22, CC 11, CC 3, CC 16
II	6	CC 28, CC 30, CC 15, CC 31, CC 27, CC 12
III	2	CC 2, CC 7
IV	1	CC 5
V	1	CC 13
VI	1	CC 23

Table 18 Clustering pattern of accessions

Cluster No	Number of accessions	Accessions
I	21	CC 14 CC 6 CC 9 CC 21 CC 18 CC 10 CC 25 CC 26 CC 17 CC 24 CC 32 CC 19 CC 20 CC 29 CC 4 CC 1 CC 8 CC 22 CC 11 CC 3 CC 16
II	6	CC 28 CC 30 CC 15 CC 31 CC 27 CC 12
III	2	CC 2 CC 7
IV	1	CC 5
V	1	CC 13
VI	1	CC 23

Table 19 Cluster means of ten biometric characters

Cluster	Plant height (cm)	Days to first flowering	Pollen viability (%)	Fruits per plant	Fruit weight (g)	Seeds per fruit	Yield per plant (g)	Number of harvests	Ascorbic acid (mg/100g)	Mosaic incidence (V I)
I	92 51	71 68	56 53	96 75	4 33	27 89	212 62	3 42	94 17	56 28
II	110 72	69 56	76 67	223 81	6 18	38 89	710 21	5 54	105 04	56 25
III	114 00	65 35	80 40	285 11	7 51	45 84	989 64	4 72	115 27	51 89
IV	116 00	77 00	42 80	201 00	6 50	28 33	479 80	6 45	94 53	51 67
V	105 00	54 67	79 93	620 00	5 18	41 67	1435 60	6 94	102 70	40 63
VI	102 00	60 67	79 30	637 44	5 88	47 67	1649 72	5 93	102 70	50 15

CC 7) had the h ghest pollen vıabıl ty fruıt weıght and ascorbıc acıd content Yıeld per plant fruıts per plant and seeds per fruıt were hıghest ın cluster VI (CC 23)

The average nter and ntracluster d stances are presented n Table 20 The cluster dıagram ıs shown ın Fıg 4

The ıntracluster dıstance was on the ıncrease wıth ıncreasıng cluster sıze Cluster I had the hıghest ıntracluster dıstance (229 93) followed by clusters II and III (217 55 and 188 74 respect vely)

The h ghest ntercluster d stance was observed between clusters I and VI (1965 74) followed by clusters I and V (1640 10) and clusters IV and VI (1606 19) The genet c dıstance (D) between clusters I II and IV were largest wıth cluster VI The mınımum ntercluster dıstance was observed between clusters V and VI (339 74) ınd cat ng a close relatıonsh p among the access ons ncluded

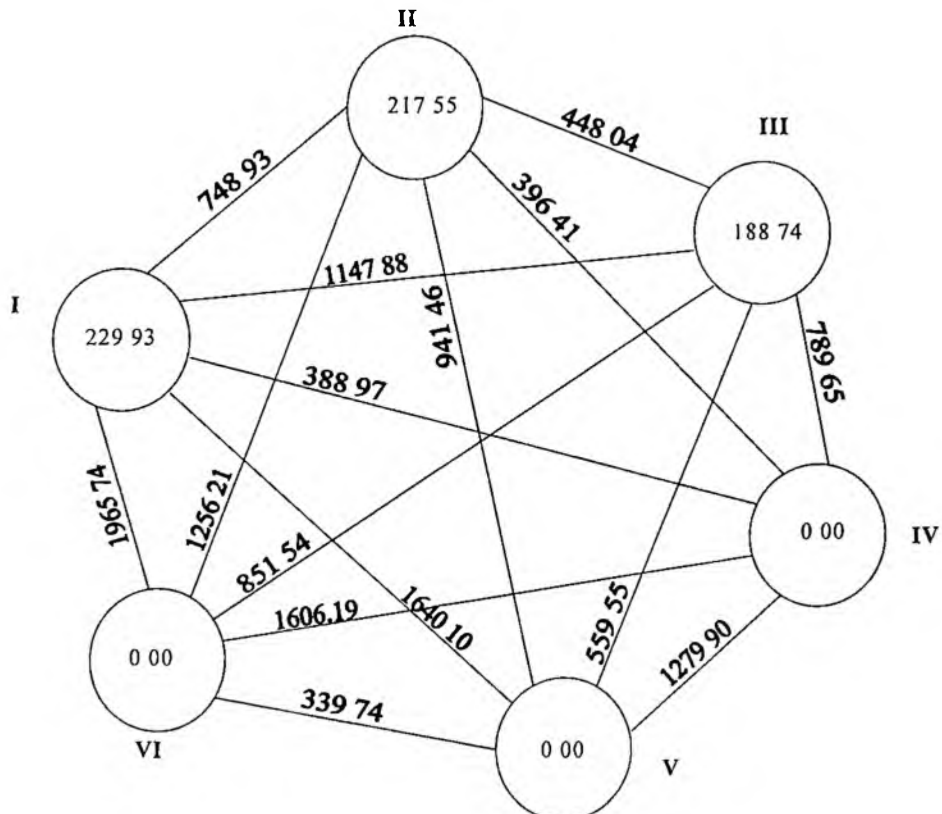
Table 20 Average inter and intracluster distances

Cluster	I	II	III	IV	V	VI
I	229 93	748 93	1147 88	388 97	1640 10	1965 74
II		217 55	448 04	396 41	941 46	1256 21
III			188 74	789 65	559 55	851 54
IV				0 00	1279 90	1606 9
V					0 00	339 74
VI						0 00

Diagonal elements ntracluster values

Off d agonal elements ntercluster values

Fig 4 Cluster diagram



The values in circles indicate intracluster D values and others indicate intercluster D values

Discussion

5 DISCUSSION

The genus *Capsicum* is noted for its richness in diversity However the exploration of this diversity is mainly restricted to the most widely cultivated species *C annuum* *C chinense* characterized by its perennial habit and highly pungent fruit is cultivated in the homesteads of Kerala The two recognized varieties of *C chinense viz* Scotch Bonnet and Habanero are known for their extreme pungency

Kerala is blessed with diverse climatic and soil conditions which have helped in the development of different landraces of crops having high variability These landraces the products of natural selection maintain genetic heterogenity in balance over time (Sharma 1994) The exploitation of this heterogenity can help in the improvement of the crop

The genetic improvement of any crop aims at increasing the production potential and quality by altering the genetic makeup of the existing varieties To achieve this goal a plant breeder requires information on certain genetic parameters like variability heritability genetic advance and association between characters For the development of superior varieties selection is the fundamental process which utilizes the available variability in a crop

Hence a study was undertaken to collect and catalogue the available landraces of *C chinense* for various morphological characters and to assess the magnitude of genetic variability for identifying superior genotypes based on yield quality and pest and disease resistance

5 1 Genetic cataloguing

Genetic cataloguing based on standard descriptors helps to easily describe the morphological features of a genotype and thus helps exchange of information about new accessions in a more clear way

Thirty two accessions of *C chinense* upon cataloguing showed distinct variations among each other with respect to vegetative inflorescence fruit and seed characters The accessions had either erect or compact growth habit with green to purple stem and leaves Flowers per axil were either two or three with a prominent annular constriction at calyx Fruit colour and fruit shape showed wide variation among the accessions There are reports on high variability for morphological characters in *C annuum* (Indira 1994) in *C frutescens* (Sheela 1998) and in *C chinense* (Cherian 2000)

5 2 Variability

An insight into the magnitude of variability present in a crop species is of utmost importance as it provides a basis for effective selection The observed variability in the population is the sum total of the variations that arise due to genotypic and environmental effects Hence a knowledge on the nature and magnitude of genetic variation contributing to gain under selection is essential

In the present investigation analysis of variance revealed highly significant differences among the thirty two accessions for all the characters studied namely plant height primary branches per plant plant spread days to first flowering pollen viability days to maturity fruits per plant fruit length pedicel length fruit girth fruit weight seeds per fruit 1000 seed weight yıeld per plant y eld per harvest number of harvests capsa c n oleoresın ascorbıc acıd and mosaıc ınc dence Such var atıon nd cated the scope for ımprovıng the populatıon for these characters as reported earlıer by H remath and Mathapatı (1977) Gopalakrıshnan *et al* (1987) and Kumar *et al* (1993) ın ch ll

In respect of vegetatıve characters ample varıabılıty was observed as evıdent from the w de range obtaıned for plant he ght and plant spread Among the accessıons evaluated CC 27 was the most vıgorous regıster ng the hıghest values for plant he ght and CC 7 for plant spread Consıderable varıabıl ty was reported by Gopalakr shnan *et al* (1987) for plant l e ght a d Sahoo *et al* (1990) for plant spread Pr mary branches per plant recorded a low range of var at on compared to other characters as reported by Sahoo *et al* (1990) n chıll

The accessıon CC 13 was the earlıest to flower It also had the maxımum harvests and hıgh fruıt yıelds In the present study days to f rst flowerıng varıed from 54 67 to 83 00 Pollen vıab l ty showed a wıde range of varıatıon among the accessıons Sımılar results were also reported by Pradeepkumar (1990) Days to matur ty recorded a narrow r nge of va o Most of the access ons attaıned fru t maturıty around 31 days after fr t set Cherıan (2000) reported a s mılar range for days to maturıty ın *C ch nense*

Pedıcel length ın the present study ranged from 2 50 to 5 50 cm Pedıcel ın ch llı ıs non edıble and fruıts wıth short pedıcel ıs desırable Consıderable varıatıon for the character was also reported by Ranı (1996a) and Cherıan (2000)

Among the accessions maximum fruit weight was observed in CC 2 Other accessions with better fruit weight were CC 27 and CC 28 Both fruit length and fruit girth contributed to better fruit weight in CC 2 In the present study fruit length ranged from 3 60 to 8 33 cm Similarly fruit girth also varied from 5 27 to 10 37cm suggesting ample variability and scope for improvement of fruit size in *C chinense*

Fruits per plant and yield per plant exhibited high variability Among the accessions evaluated fruits per plant and yield were maximum in CC 23 (Nemom Thiruvananthapuram) followed by CC 13 (Vithura Thiruvananthapuram) and CC 7 (Vithura Thiruvananthapuram) The high yield in CC 23 may be attributed to the high fruits per plant pollen viability and more harvests CC 13 was characterized by least mosaic incidence and earliness resulting in more number of harvests and finally yield The accession CC 7 apart from being better for most of the fruit characters like fruit length fruit girth and fruit weight it also registered high values for plant height and plant spread indicating a vigorous nature This confirms the fact that fruit yield is a complex trait and is the ultimate expression of many component characters

Seeds per fruit exhibited a wide range of variation from 5 67 to 57 67 whereas 1000 seed weight had a narrow range as indicated by a low phenotypic and genotypic variances Wide variability in seeds per fruit was observed by Arya and Sain (1976) and Vijayalakshmi *et al* (1989) Sahoo *et al* (1990) reported a low range of variation in 100 seed weight Varieties with high fruit seed weight and fruit seed number are preferred not only to increase crop production but also to meet the needs of the seed industry and farmers

Capsa cın the pungent prıncıple of chıllı ıs cons dered to be one of the most ımportant qualıty characters In the present study wıde varıatıon was observed between the accessıons for capsaıcın content Th s varıat on could probably be due to the presence of gene modıfyıng factors for pungency and the ratıo of placental tıssue to seed and perıcarp Varıetal varıat on n capsaıcın contents n chıllı was also reported by Pradeepkumar (1990) Sheela (1998) Cherıan (2000) and Sreelathakumary (2000) All the access ons evaluated ın the present study had h gh capsa cın content (>1 per cent) wh ch are part cularly valued for the r pungency and for the manufacture of h gh capsa cın oleores n In thıs context the access ons CC 9 and CC 27 wh ch produced yellow fruıts at mature stage w ll be more econom cal for capsa c n extract on as there wıll not be any ınterference of red pıgments

Oleores n represents the total flavour extract of ground spıces and cons sts of fixed o l capsa cın pıgments sugars and resın They are now beıng extensıvely used ın processed foods and also pharmaceut cal products (Bajaj *et al* 1980) The results obta ned ın the current ınvest gatıon revealed consıderable varıat on among the accessıons for oleores n content Thıs ıs n agreement wıth the results obtaıned by Pradeepkumar (1990) Cherıan (2000) and Sreelathakumary (2000) The hıgh pungency oleoresın obta ned from the yellow fruıted accessıons namely CC 9 and CC 27 can be of h gh value ın the pharmaceutıcal and cosmetıc ndustrıes where hıgh pungency and low coloı r are des rable

The nutrıt ve value of chıllı s largely determ ned by the content of ascorb c acıd S gn f'cant varıatıon ın ascorbıc acıd content between access ons was noted n the present study Such wıde var at on vas also reported by Rani (1994) and Todorova *et al* (1997) Accessions with high ascorbic acid content are suitable for vegetable purposes

Mosaic is a serious disease affecting chilli and is a major constraint in chilli cultivation in Kerala Significant differences were observed among the accessions for mosaic incidence which clearly indicated that the level of resistance or susceptibility to the disease varied with the accession Out of the 32 accessions evaluated 26 were moderately resistant and the remaining six were found to be susceptible to the disease Screening for chilli mosaic resistance was also done by Thakur *et al* (1985) Anandam (1992) Kalloo (1994) and Fatima (1999) The accessions which were found to be moderately resistant in the present study may be used as resistant donors for imparting disease resistance to otherwise desirable genotypes

High coefficients of variation (phenotypic [PCV] and genotypic [GCV]) were observed for fruits per plant yield per plant and fruit weight Similar results were also reported by Nair *et al* (1984) Jabeen *et al* (1999) and Cherian (2000) The high PCV and GCV observed for these characters are evident from their high variability which in turn offers good scope for selection The lowest PCV and GCV was exhibited by days to first flowering which was in conformity with the findings of Cherian (2000) The GCV was very near to PCV for most of the characters indicating a highly significant effect of genotype on phenotypic expression with very little effect of environment

5 3 Heritability and genetic advance

The total variability existing in a population is a sum of heritable and non heritable components and it is necessary to partition these components since the magnitude of heritable variability is an important aspect of genetic constitution of breeding material

High values of heritability were observed for most of the characters studied Higher magnitude of heritability (>90 %) was registered for yield per plant fruits per plant fruit length fruit girth fruit weight seeds per fruit 1000 seed weight pollen viability days to maturity number of harvests capsaicin oleoresin and ascorbic acid contents Similar findings were also reported by Rajput *et al* (1981) for fruits per plant and fruit yield Nair *et al* (1984) for capsaicin Bhagyalakshmi *et al* (1990) and Kumar *et al* (1993) for ascorbic acid and Singh *et al* (1994) for fruit characters High heritability estimates indicate the presence of large number of fixable additive factors and hence these traits can be improved by selection

High heritability estimates does not necessarily mean a high genetic advance for a particular character The effectiveness of selection depends upon the heritability and genetic advance of the character selected The present investigation revealed high heritability coupled with high genetic advance for several biometric characters including fruits per plant yield per plant fruit weight fruit girth and fruit length Jabeen *et al* (1998) also observed high heritability and genetic advance for several yield characters

High her tability coupled with low genetic advance attributable to non additive gene act on was noticed for days to first flowering Similar results were reported by Na r *et al* (1984) and V jayalakshm *et al* (1989)

On the bas s of the present study t can be concluded that s multaneo s selection based on multiple characters hav ng high est mates of her tab l ty and genetic advance might be of appreciable use in this crop

5 4 Correlation studies

Correlation prov des nformat on on the nature and extent of relationship between all pairs of characters A study of correlat on among yield and its components w ll be of great value in planning and evaluat ng breeding programmes

In the present study both at phenotypic and genotyp c levels the characters *viz* plant he ght pollen viability fruits per plant fru t we ght seeds per fruit and number of harvests showed strong pos tive association with yield per plant Days to first flowering and mosaic incidence were negatively correlated w th yield

The very high pos t ve assoc ation of fru ts per plant with y eld indicated that fru ts per plant was the pr mary yield attr bute n ch ll Similar reports were also suggested by Sundaram and Irulappan (1998) and Cher an (2000)

The present investigat on revealed that plant he ght was pos t vely correlated with plant spread and yield Ramakumar *et al* (1981) reported a strong correlation between plant spread and plant height Al yu *et al* (2000) supported the assoc at on between plant height and y eld Prod ct on of increased vegetative growth like plant spread and plant height might lead to larger canopy of the plant resulting in increased fruits per plant and finally yield

Positive association of fruit weight and seeds per fruit with yield was in agreement with the findings of Rani (1996b) and Mishra *et al* (1998) High correlation observed between number of harvests and yield was in conformity with that of Sheela (1998)

The study revealed a strong positive association between pollen viability and yield This can be explained as when pollen viability increases it increases the availability of viable pollen for pollination and fruit set thereby leading to an increased fruit set fruits per plant and finally yield This was supported by high correlation of pollen viability with fruits per plant which in turn was correlated with yield

The high negative correlation between days to first flowering and yield was supported by the findings of Warade *et al* (1996) and Sreelathakumary (2000) Hence any selection aimed for earliness will be useful for improving yield and yield associated characters

Capsaicin was found to be positively correlated with primary branches per plant pollen viability and oleoresin and negatively with pedicel length and fruit weight Hence selection based on these characters may be done to improve capsaicin and a simultaneous improvement in oleoresin contents A negative correlation of capsaicin with fruit weight was also reported by Jiang *et al* (1987) and Rani (1995) Aiming at capsaicin improvement selection of small fruited accessions will reduce the fruit yield leading to decrease capsaicin output per unit area Hence medium weight fruited accessions with fairly better capsaicin content may be selected Similarly ascorbic acid was also correlated with yield and yield components

Mosaic incidence exhibited high negative correlation with yield This might be due to its negative association with other yield contributing factors like pollen viability fruits per plant fruit weight seeds per fruit and number of harvests Moreover late flowering accessions were more affected by the disease which also showed reduced pollen viability Mosaic induced pollen sterility leading to reduced fruit set and fruits per plant was reported by Jayarajan and Ramakrsihnan (1961)

On the basis of the present study it is evident that selection based on earliness increased plant height pollen viability fruit weight fruits per plant seeds per fruit and number of harvests along with mosaic resistance may be done for yield improvement

5 5 Path coefficient analysis

Yield is a complex quantitative character governed by a large number of genes and is greatly influenced by environmental factors The present investigation of path coefficient analysis provided information on the nature of association of several characters contributing to yield by means of untangling the direct and indirect contribution of various characters in building up a complex correlation As evidenced from correlation studies path coefficient analysis also signifies the importance of the character fruits per plant which exhibited the highest direct and indirect effects on fruit yield Similar results were also reported by Cherian (2000) and Munshi *et al* (2000)

Fruit weight and seeds per fruit also exh bited direct positive effects on yield The direct effects of plant height pollen viability number of harvests nosa c nc dence days to first flower ng and ascorbic acid content were small and negl gible but their nd rect effects through fru ts per plant were consistently high This was n conform ty with the f ndings of Sundaram and Ranganathan (1978)

5 6 Selection index

Select on ndex prov des information on y eld components and thus aids n indirect select on for the mprovement of y eld It involves discriminant function analysis which is meant for solating superior genotypes based on the phenotyp c and genotyp c correlations Ident fication of super or genotypes of *C ch nense* based on d scr minant function analys s was done by Cherian (2000) A model nvolving the same set of ten characters wh ch was used for path coefficient analysis was selected for rank ng the accessions On rank ng the scores obtained the accession CC 23 (Nemom Thiruvananthapuram) ranked f rst followed by CC 13 (V thura Th ruvananthapuram) and CC 7 (V thura Th ruvananthapuram) These accessions w th high yield quality and mosaic res stance may be recommended as elite types after refinement and mult locational testing

5 7 Mahalanobi s D^2 analysis

Breeding crop plants adopt ng hybrid zation as a tool is one of the most i nportant crop improvement methods The success of hybrid zat on programme is ma nly dependent on the genetic d versity of the parents chosen for the purpose Crosses between genetically diverse parents are likely to produce high heterot c effects Mahalanob s D^2 stat stic s one of the potent techniques for measuring genetic divergence at both ntra and ntercluster levels and thus prov des a bas s for selection of genet cally d vergent parents n hybridizat on programmes Genetic d vergence in ch ll was assessed by Mehra (1978) Sundaram *et al* (1980) Gill *et al* (1982) Varalakshmi and Har babu (1991) Ind ra (1994) and Roy and Sharma (1996)

In the present study based on Mahalanob s D^2 stat stic the 32 accessions were grouped into six gene constellat ons The maximum number of accessions (21) were included in cluster I followed by cluster II (s x) and cluster III (two) Clusters IV V and VI had one access on each The pattern of clustering closely followed the ranking obtained from selection ndex

Considering the cluster means for the var ous characters stud ed clusters III V and VI were superior for most of the biometric characters whereas clusters I and IV were generally poor Cluster II was found to be ntermediate For crop improvement programmes intercrossing among accessions w th outstanding mean performance for these characters would be effect ve

The study revealed maximum d vergence between clusters I and VI followed by clusters I and V as shown by the r h gh nterclt ster d stances Clusters V and VI w th least d vergence showed a close relationsh p between the accessions CC 13 and CC 23 The intracluster distance was nax m m for cluster I which had the maximum number of accessions On the basis of the present study the accessions of clusters V and VI may be used as base mater als for hybr d zation with selected accessions of cluster I n order to obtain des rable segregants w th h gh y eld potent al

The present nvest gation on 32 *C chinense* accessions showed w de variation for almost all the characters studied High heritab l ty coupled with high genetic advance was observed for most of the bio netr c characters which indicates the scope for effective selection Correlation and path coefficient analysis revealed that fruits per plant s the primary y eld component The accessions CC 23 (Nemom Thiruvananthapuram) CC 13 (Vithura Th ruvananthapuram) and CC 7 (Vithura Thiruvananthapuram) were found to be promising with regard to yield quality and mosa c resistance The same may be used for further improvement programmes

Summary

6 SUMMARY

The present investigation on Genetic cataloguing of hot chilli (*Capsicum chinense* Jacq.) was conducted at the vegetable research plot of the Department of Olericulture, College of Agriculture, Vellayani during September 2000 to May 2001.

The study envisaged genetic cataloguing of the available germplasm in *C. chinense*, assessment of genetic variability, divergence, association among the characters including the direct and indirect effects of various characters on yield and formulation of a selection index for identifying suitable lines based on yield, quality and pest and disease resistance.

The experimental material consisted of 32 accessions collected from different parts of Kerala. The experiment was laid out in a randomised block design with three replications. The accessions were genetically catalogued based on the descriptor list for *Capsicum* (IBPGR, 1995). The results revealed distinct variations among the accessions with respect to vegetative, inflorescence, fruit and seed characters.

Significant differences were observed among the accessions for all the characters studied *viz.*, plant height, primary branches per plant, plant spread, days to first flowering, pollen viability, days to maturity, fruits per plant, fruit length, pedicel length, fruit girth, fruit weight, seeds per fruit, 1000 seed weight, yield per plant, yield per harvest, number of harvests, capsaicin, oleoresin, ascorbic acid and mosaic incidence.

The highest yield was observed in CC 23 (Nemom Thiruvananthapuram 1649 72 g) wh ch also recorded the maximum fru ts per plant (637 44) CC 13 (V th ra Th ruva anthapura n) was the earl est to flower (54 67 days) w th max mum number of harvests (6 94) and least vulnerab l ty ndex for mosaic (40 63) Among the access ons CC 27 was the tallest (133 33 cm) The maximum plant spread was exhibited by CC 7 wh ch also recorded the highest ascorbic acid content (136 33 mg per 100 g) CC 2 had the maximum fruit weight (8 63 g) The highest capsaicin (3 74 per cent) and oleoresin (24 25 per cent) contents were recorded by CC 16 Out of the 32 accessions evaluated for mosa c resistance 26 were moderately res stant and the remaining six were susceptible to the d sease

High coefficients of variation (phenotypic [PCV] and genotypic [GCV]) were recorded for fruits per plant y eld per plant and fruit we ght The lowest PCV and GCV were exh bited by days to first flowering

H gh her tability coupled w th h gh genetic advance was observed for y eld per plant fruit per plant fru t we ght fru t girth and fru t length nd cat ng scope for improvement of these characters through select on

Correlation studies revealed that at both phenotypic and genotyp c levels characters like plant height pollen v ab lity fru ts per plant fruit weight seeds per fruit y eld per harvest and number of harvests were positively correlated with yield Days to first flowering and mosaic inc dence were negatively correlated w th yield

Path coeffic ent analysis nd cated that fruits per plant exerted the max mum pos tive direct effect (0 7826) on y eld followed by fruit weight

(0 2061) and seeds per fru t (0 1243) The nd rect effects through fru ts per plant vere co ıs stently h gh s gn fy ng the mportance of that characters

A select on ındex was worked out us ng ten characters *v z* plant he ght days to first flower ng pollen vıabılıty fruıts per plant fru t we ght seeds per fruıt yıeld per plant number of harvests ascorb c ac d content and mosa c nc dence Based o ı tl e dex scores obta ned CC 23 (Ne nom Th ruvananthapuram) ranked f rst followed by CC 13 (V thura Th ruvananthapuram) and CC 7 (V thura Th ruvanantl apuram)

The 32 access ons were grouped nto s x clusters based on Mahalanobı s D^2 statıst c Cluster I was the largest whıch contaıned 21 access ons followed by cluster II wıth sıx and cluster III wıth two access ons Clusters IV V and VI had one accessıon each W th regard to the cluster means clusters V (CC 13) and VI (CC 23) performed better for most of the characters taken The max mum ntercluster d stance was observed between clusters I and VI (1965 74) followed by clusters I and V (1640 10) Cluster I had the h ghest ntracluster d stance (229 93)

Co npar son among the access ons for varıous bıometrıc characters revealed that CC 23 CC 13 and CC 7 were found to be prom s ng based on the r super or ty n y eld qual ty and mosa c res stance and l ence they may be ut l zed for further crop nprovement

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GENETIC CATALOGUING OF HOT CHILLI (*Capsicum chinense* Jacq.)

BY

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ABSTRACT OF THE THESIS
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ABSTRACT

The research project Genetic cataloguing of hot chilli (*Capsicum chinense* Jacq) was carried out in the vegetable research plot of the Department of Olericulture College of Agriculture Vellayani during September 2000 to May 2001 The objective of the study was to catalogue the accessions based on the IBPGR descriptor for *Capsicum* and to estimate the genetic parameters for different traits in the germplasm for identifying superior lines based on yield quality and pest and disease resistance

Thirty two accessions of *C chinense* collected from various sources upon cataloguing po nted out wide var at on for several morpholog cal characters Analys s of variance revealed significant d fference among the access ons for all the characters stud ed namely plant height primary branches per plant plant spread days to first flowering pollen viability days to maturity fruits per plant fruit length pedicel length fruit girth fruit weight seeds per fruit 1000 seed weight yield per plant yield per harvest number of harvests capsaicin oleoresin ascorbic acid and mosaic incidence

Among the accessions CC 23 recorded the maximum yield (1649 72 g) as well as fruits per plant (637 44) CC 13 was the earliest to flower (54 67 days) with the maximum number of harvests (6 94) and least vulnerability ndex for mosa c (40 63) Fruits per plant recorded the maximum phenotypic

aı d genotyp c coeffic ents of var atıon followed by y eld per plant and fru t we ght

H gh herıtabılıty coupled wıth hıgh genetıc advance was observed for fru ts per plant y eld per plant fruıt weıght fruıt gırth and fruıt length

Correlatıon studıes and path coeffıcıent analysıs revealed that fruıts per plant ıs the prımary yıeld component as evıdenced from ıts hıgh posıtıve correlat on as well as hıgh dırect and ndırect effects on yıeld

In the d scr mınant functıon analysıs CC 23 (Nemom Thıruvananthapuram) ranked first followed by CC 13 (Vıthura Thıruvananthapuram) and CC 7 (Vıthura Thıruvananthapuram)

Based on the analysıs for genet c d vergence the 32 accessıons were grouped nto s x clusters w th the maxımum ıntercluster d stance observed between clusters I and VI

On the basıs of the present study the accessıons CC 23 CC 13 and CC 7 were found to be prom sıng w th regard to yıeld qualıty and mosaıc res stance a ıd the sa ı e may be ut l zed for further ıııprovement