QUALITY CHARACTERIZATION OF HOT CHILLI (*Capsicum chinense* Jacq.) GENOTYPES IN RAINY AND SUMMER SEASONS

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DECLARATION

I hereby declare that this thesis entitled "**Quality characterization of hot chilli (*Capsicum chinense* Jacq.) genotypes in rainy and summer seasons**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "**Quality characterization of hot chilli (*Capsicum chinense* Jacq.) genotypes in rainy and summer seasons**" is a record of research work done independently by Ms. Robi. R. (2001-12-09) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Dedicated to

Achan and Amma

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LIST OF ABBREVIATIONS

%	–	Per cent
°C	–	Degree Celsius
°E	–	Degree East
µg	–	Micro gram
°N	–	Degree North
CD	–	Critical difference
cm	–	Centimetre
cv.	–	Cultivar
d.f.	–	Degrees of freedom
et al.	–	And others
Fig.	–	Figure
g	–	Gram
h	–	Hour
i.e.	–	That is
M_1	–	Turning stage
M_2	–	Red ripe stage
M_3	–	Withering stage
mg	–	Milligram
ml	–	Millilitre
mm	–	Millimetre
nm	–	Nanometer
no.	–	Number
NS	–	Not significant
SE	–	Standard error
spp.	–	Species
viz.	–	Namely

Introduction

1. INTRODUCTION

Chilli is an indispensable condiment as well as vegetable in every household. India is the largest producer, consumer and exporter of chillies. They are consumed in green, red as well as sun-dried conditions and are valued for its pungency, taste, aroma and the appealing colour that it imparts to food. The fruit is a rich source of vitamin and C. It is a strategic raw material in several of our speciality products of both traditional and modern menus.

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*.

Hot chilli (*Capsicum chinense*) is one of the species grown in the homesteads of Kerala having a wide range of variability. It is characterized by its typical flavour and aroma and noted for its high oleoresin and pungency. The plant is perennial in habit and bears two to five flowers per node as against solitary bearing in most of the *C. annuum*. Recently this crop is being exported to Maldives in large scale from Thiruvananthapuram airport where it has got much demand because of its unique flavour and taste. It is known that this hot chilli is being largely used for the preparation of tuna fish, one of the most favourite dishes of the people of Maldives.

The important quality attributes of chilli are oleoresin, capsaicin, carotenoid and ascorbic acid. The chilli oleoresin offers many advantages over dry spice powder. They find application in food, pharmaceutical and cosmetic industries. Many advanced countries are shifting towards the spice oleoresin rather than using whole or powdered forms. The pungent

principle, capsaicin in chilies has significant physiological action and is widely used by the pharmaceutical industry. Natural fruit colour is one of the most important attributes of chillies used in processed foods in place of synthetic colour. Carotenoids like capsanthin and capsorubin are responsible for the red colour of fruit. Since many countries including India are applying more and more restrictions on the use of artificial colours, chilli colour may have a good demand as a substitute in food industry. The green chilli fruits are valuable on account of their richness in ascorbic acid.

As India possess tremendous genetic variability in hot chilli, evaluation on yield and quality attributes deserves priority. By generating detailed information about the quality of various hot chilli genotypes, it would be possible to identify superior ones with yield and quality. This will fetch more income to the farmers which in turn may help the industries.

The quality characters of hot chilli is influenced by the season. Finding out the best season of cultivation for maximum yield and quality would be helpful for farmers to grow hot chilli profitably. This may also help in deciding the suitable crop rotation in a farming system.

The harvesting stage may vary with the purpose for which hot chilli fruits are used. The quality may also vary with the harvesting stage. Fixing the correct maturity stage would be helpful in increasing the yield and quality at lower cost.

Considering all these aspects, the present study was taken up in *C. chinense* with the following objectives:

1. To study the variability.
2. To study the influence of season.
3. To study the influence of maturity stages on quality.
4. To study the incidence of diseases in the field.

Review of Literature

2. REVIEW OF LITERATURE

Capsicum chinense is an economically important species of vegetable chilli originated in the New World (Smith and Heiser, 1957). This species is noted for the highly pungent and red or yellow coloured fruits with distinctive flavour. The long duration and ability to yield under shade, renders it as an ideal crop in homesteads. They are grown in western hemisphere, tropical South America, Caribbean 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).

Though *C. chinense* is grown predominantly in the shady homesteads of Kerala, considerable variability is reported in respect of yield and quality attributes (Manju, 2001). The oleoresin and capsaicin recovery, carotenoid and ascorbic acid content are more relevant in terms of value addition and are influenced by season and stage of maturity.

The available literature on these aspects relevant to the present study is reviewed under the following subheads.

2.1 Genetic variability, heritability, genetic advance, correlation studies and path co-efficient analysis.

2.2 Influence of season on yield and quality.

2.3 Influence of maturity stages on quality.

2.4 Incidence of diseases.

2.1 GENETIC VARIABILITY, HERITABILITY, GENETIC ADVANCE, CORRELATION STUDIES AND PATH COEFFICIENT ANALYSIS

2.1.1 Genetic Variability

Variability either naturally existing or created artificially forms the basis for any crop improvement programme. Many workers have reported considerable variability for a number of characters in chilli.

2.1.1.1 Yield Characters

Considerable variation for several characters in *C. chinense* was reported by Cherian (2000), Sreelathakumary (2000) and Manju (2001). In *C. annuum*, genetic variability for several characters was observed by Arya and Saini (1976), Singh and Singh (1979), Rajput *et al*. (1983), Ahmed *et al*. (1990), Nandi (1992), Kumar *et al*. (1993) and Nandadevi and Hosmani (2003). In *C. frutescens,* variability was reported by Sheela (1998) and Sreelathakumary and Rajamony (2003a).

High genotypic coefficient of variation (GCV) in chilli for fruit length, fruit girth and fruit weight was reported by Das and Chaudhary (1999), Fatima (1999), Sreelathakumary (2000) and Mishra *et al*. (2001). Gupta and Yadav (1984) observed high phenotypic and genotypic coefficient of variation for fruit girth. High values of genotypic coefficient of variation in chilli was reported by Arya and Saini (1976), Rajput *et al*. (1983), Nandi (1992) and Sarma and Roy (1995). In *C. chinense*, high phenotypic and genotypic coefficient of variation were observed for fruits per plant, yield per plant and fruit weight by Cherian (2000) and Manju (2001).

2.1.1.2 Quality Characters

Wide range of variation for capsaicin content in *Capsicum* spp. was reported by Mini (1997) and Sreelathakumary (2000) and it was 1.1 to 2.2

per cent and 0.65 to 1.06 per cent respectively. Large variation was reported by Pradeepkumar (1990) and Rani (1994) in *C. annuum* and Cherian (2000) and Manju (2001) in *C. chinense*.

Considerable variation for oleoresin content was observed in *Capsicum* spp. by Pradeepkumar (1990), Indira (1994), Mini (1997) and Sreelathakuamary (2000). In *C. chinense*, Cherian (2000) recorded a range of 4.92 to 24.25 per cent.

Reddy *et al*. (1999) reported significant difference in colour values in chilli varieties. Variation in carotenoid content was observed among the genotypes of *Capsicum* spp. by Sreelathakumary (2000).

Bajaj *et al*. (1980) observed an ascorbic acid range of 53.77 to 221.86 mg per 100 g fresh fruit. In *C. annuum* wide range of variation was reported by Maurya *et al*. (1984) and Rani (1994). In *C. chinense*, Manju (2001) reported a wide range of 61.83 to 136.33 mg per 100 g fresh weight.

2.1.2 Heritability and Genetic Advance

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

2.1.2.1 Yield Characters

Several workers reported high heritability coupled with genetic advance for fruit yield in chilli (Singh and Singh, 1976; Arya and Saini, 1977; Rajput *et al*., 1983; Ramakumar *et al*., 1981; Sahoo *et al*., 1990; Kumar *et al*., 1993; Munshi and Behera, 2000; Gogoi and Gautam, 2002; Rathod *et al*., 2002). Nair *et al*. (1984) observed higher magnitude of heritability for fruit weight, fruit girth, yield per plant and dry chilli recovery in *C. annuum*. In *C. chinense* a narrow sense of heritability was reported for days to first flowering, days to maturity and plant height

(Vallego and Costa, 1987). High heritability and genetic advance were observed for fruit girth, fruit weight, fruit number per plant and fruit yield per plant by Cherian (2000) and Manju (2001).

2.1.2.2 Quality Characters

High heritability and genetic advance for capsaicin was observed by Nair *et al*. (1984). 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). Acharyya *et al*. (2002) observed high heritability for capsaicin and ascorbic acid content.

2.1.3 Correlation

A thorough knowledge of the relationship between yield and its component would facilitate effective selection for simultaneous improvement of one or many yield contributing characters.

2.1.3.1 Yield Characters

The capsaicin content is positively correlated with age, length, width, ascorbic acid and dry matter of fruit but negatively correlated with moisture content (Awasthi and Singh, 1979). A negative correlation of capsaicin with fruit weight was reported by Jiang *et al*. (1987) and Rani (1995). Mini (1997) reported a positive correlation of oleoresin with fruits per plant and negative correlation with earliness. In *C. chinense*, a high positive correlation of oleoresin with fruit length was observed by Manju (2001). A high positive correlation observed between oleoresin and capsaicin content.

2.1.4 Path Coefficient Analysis

Sundaram and Ranganathan (1978) reported that fruits per plant exerted the maximum positive direct effect on yield. The indirect effects

and other characters through fruits per plant were consistently high. Fruits per plant and fruit weight were reported to be the primary yield determinants in chilli (Rao and Chhonkar, 1981, Depestre *et al*., 1989; Pawade *et al*., 1995; Das and Choudhary, 1999; Munshi *et al*., 2000). Fatima (1999) found that fruit weight exhibited the highest positive direct effect on yield. In pepper (*C. annuum*), total dry weight exerted the maximum direct effect on yield followed by leaf area index, fruits and seeds per fruit (Aliyu *et al*., 2000). The direct effects of average fruit weight, number of fruits per plant and crop duration were high and positive (Jose and Khader, 2002). Fruits per plant, fruit length and plant height had shown positive direct effect on yield of *C. frutescens* (Sreelathakumary and Rajamony, 2003b).

2.2 INFLUENCE OF SEASON ON YIELD AND QUALITY

Crop productivity relies greatly on external factors which include weather conditions prevailing during the critical phases of growth as well as the internal physiological factors.

2.2.1 Yield Characters

Seasonal influence on economic characters in brinjal (*Solanum melongena* L.) were studied by Nandpuri *et al*. (1976). Twenty varieties from diverse sources were studied during spring and autumn seasons and observed that varieties gave higher yield per plant and number of marketable fruits per plant during autumn than spring season. El-Aidy (1990) reported that cucumber yields were different in their response to the planting date. Best results were obtained from planting during winter (October 1st) and early summer (February 2nd). The weather conditions seriously affected flowering of pepper and tomato with malformed ovaries and production of non viable pollen (Rylski *et al*., 1994).

Mini (1997) evaluated nine chilli genotypes for yield of fruit, earliness and oleoresin recovery in three seasons namely summer, rainy and winter and at three different harvest maturity. The genotypes tried were CA 653, Arka Lohit, Ujwala and KTPL-19 under *C. annuum*; CA 640 and CA 645 under *C. chinense*; CA 671 and CA 648 under *C. frutescens*; CA 670 under *C. baccatum*. She observed that chilli genotypes produced maximum fruits and yield during summer, minimum fruits from winter and minimum yield from rainy seasons. CA 645 had maximum fruit yield per plant followed by Ujwala. Lowest fruit yield was observed in CA 648 irrespective of season. Among them Ujwala was the earliest to flower and set fruit and CA 645 was the late. Seasonal influence showed that the genotypes were generally late in winter.

According to Estrada *et al*. (1999), seasonal changes from June to October had no significant effect on fresh or dry weight of chilli fruits.

Lohithaswa *et al*. (2000) examined chilli genotypes and their F_1 for fruit yield and its components in three environmental conditions *i.e.*, at Bangalore under rainfed in Kharif 1995, at Hebbal under irrigated in summer 1996 and at Hiriyar under rainfed in Kharif 1996. Highly significant variation due to genotypes and environment was observed for all the characters *viz*. days to initiation of flowering, plant height, number of secondary branches, average fruit weight, fruit index (fruit length x fruit diameter), Bartlet index for earliness, number of fruits per plant and dry fruit yield per plant. Genotype x environment interaction was significant for all the characters except days to initiation of flowering.

The impact of soil moisture stress on yield of chilli (*C. annuum*) was assessed by Mahendran and Bandara (2000) and they noted that long term moisture stress during the late vegetative period caused highest yield reduction.

The effect of weather conditions on the dry matter yield in fruits of four hot pepper cultivars *i.e.*, Bronowicka Ostra, Cyklon, Orkan and Tajfun was investigated during 1998 and 1999 in Poland by Buczkowska *et al*. (2001). A higher dry matter yield was recorded in 1999 (22.6 kg per 100 m^2) than in 1998 (10.2 kg per 100 m^2) due to much better weather conditions in 1999.

Nine genotypes of chilli (*C. annuum*) were compared for fruit characters during the rabi season of 1994-95 and 1995-96 and the results indicated slightly higher values of phenotypic coefficient of variation than genotypic coefficient of variation indicating the negligible effect of the environment on the fruit characters (Mishra *et al*., 2001).

2.2.2 Quality Characters

In chilli, the quality characters *viz*., capsaicin, oleoresin, carotenoids and ascorbic acid content may be influenced by season and weather conditions.

Claus (1961) stated that the percentage of capsaicin in the fruits varied greatly depending on species, geographical origin of the sample and climatic condition. Ohta (1962) reported that higher night temperature was responsible for the higher capsaicin content. Laul *et al*. (1970) determined that the total colouring matter of dried chillies showed an increasing trend with the advancement of the season and number of picking. A better understanding of agronomic and environment factors which affect certain biochemical processes such as capsaicinoid and carotenoid synthesis was warranted (Margoczi *et al*., 1989). Bosland (1993) and Menon (1995) found that harvesting conditions, post harvest operations etc. determined the initial colour in chillies.

According to Estrada *et al*. (1999), the pattern of capsaicinoid accumulation was the same during the different months, but there was a

considerable increase in capsaicinoid levels in August and September in all the growth stages studied.

Mini *et al*. (1999) noted significant difference among genotypes and season for oleoresin yield. The genotypes grown during winter season had maximum oleoresin (27.24 per cent) followed by summer (23.76 per cent) and rainy season (19.13 per cent). Considering the yield and oleoresin together, summer is the best season for total oleoresin yield per unit area. The poor oleoresin content in summer was compensated by the higher yield.

Effect of soil moisture stress at different growth stages on ascorbic acid, capsaicin and β-carotene contents of chilli (*C. annuum*) were studied by Mahendran and Bandara (2000). Long term moisture deficits during the late vegetative, flowering, pod setting, pod maturity and fruit ripening stages delayed ascorbic acid synthesis. A similar trend was observed in the recovery of ascorbic acid. Moisture stress increased the pungency of the fruits, whereas irrigation decreased pungency. Moisture stress at the late vegetative stage caused reduced quality compared with the other growth stages. The more flavour is marked at 30 ^{0}C than at 21-24^{0}C, as well as under water stress (Siviero and Centola, 2001).

2.3 INFLUENCE OF MATURITY STAGES ON QUALITY

The quality characters in chilli *viz*., capsaicin, oleoresin, carotenoids and ascorbic acid are influenced by nutritional, environmental and physiological factors among which the physiological growth stage of the fruit is most significant.

2.3.1 Capsaicin

The pungent principle in chilli, capsaicin ($C_{18}H_{27}O_3N$) is a substituted benzylamide derivative. *Capsicum* sp. synthesize and

accumulate capsaicin specifically in capsaicinoid secreting organs localized in the placenta and the interlocular septum of fruits (Ohta, 1963; Iwai *et al*., 1979).

The capsaicin content is positively correlated with age of fruit (Awasthi and Singh, 1979). Iwai *et al.* (1979) reported that accumulation of capsaicin occurs over a relatively short period during the later stages of fruit development.

Ahmed *et al*. (1987) tabulated the capsaicin content at three different stages *viz*., green, ripe and sun dried fruits of twelve *C. annuum* varieties. They reported that capsaicin content increased in the order green fruit < ripe fruit< sundried fruit. Mini (1997) analysed nine chilli genotypes grown during summer season harvested at three maturity stages *viz*., turning stage, full ripe stage and withering stage and observed that chilli fruits were least pungent at turning stage (14.7 mg per g) and the pungency showed an increasing trend as the harvesting was progressed from turning to full ripe and withering stage. But the fruits harvested at full ripe and withering stage were on par in pungency in varieties Ujwala and KTPL-19.

The capsaicinoid concentration of developing (20 to 100 days after flowering) fruits of *C. annuum* and *C. frutescens–C. chinense* complex cultivars were determined by Minami *et al.* (1998). They detected three capsaicinoids namely capsaicin, dihydrocapsaicin and nondihydrocapsaicin. Intercultivar and inter specific differences in capsaicinoids concentration were observed as early as 20 days after flowering. Capsaicinoid concentration was highest between 20 and 40 days after flowering.

Estrada *et al*. (2000) studied changes in capsaicin with fruit development in *C. annuum* and observed that capsaicinoid increases with fruit development. Gnayfeed *et al*. (2001) conducted a work to investigate changes in capsaicin as a function of ripening in four of the most

important cultivars of *C. annuum* in Hungary. The results indicated that capsaicin was at a low level in mature green fruits and the onset of climacteric ripening caused their content to grow. Capsaicinoid reached their maximum level at the colour break or red stage and then decreased.

Jha *et al*. (2001) investigated the capsaicin content in developing fruits of ten chilli (*C. annuum*) cultivars and recorded highest capsaicin level at mature stage than at immature, intermediate mature and ripened stage in all cultivars.

The changes in quality of hot pepper fruits by harvest maturity was studied by Jecheon *et al*. (2001). The highest capsaicinoid content was found in fruits harvested at the initial colouring stage, followed by those in reddening and greening stage. Narayanan *et al*. (1979) reported that the capsaicin content increased steadily from green fruit stage to dry pod stage.

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

Kweon *et al*. (2002), analysed hot pepper (*C. annuum*) cultivars during different ripening stages and showed that the capsaicin content was highest at the third ripening stage.

2.3.2 Oleoresin

Oleoresin consists of fixed oil, capsaicin, pigments, sugars and resin (Bajaj *et al*., 1980).

Indian chilli could be extracted to produce a product equivalent to oleoresin red pepper which had limited demand in food industries.

According to Singh *et al*. (2001) acetone was the best solvent for chilli oleoresin extraction and the optimum time of extraction was five hours.

Influence of three stages of harvest maturity in three seasons on oleoresin yield was studied in nine different chilli (*Capsicum* spp.) genotypes by Mini (1997). The results indicated that the cultivars belonging to *C. annuum* had high oleoresin yield when fruits were harvested at turning stage and CA 670 (*C. baccatum*) had the lowest oleoresin yield. At full ripe stage, Arka Lohit and KTPL-19 had highest oleoresin recovery irrespective of season. When harvesting was delayed to withering stage, Arka Lohit, CA 670, CA645 and Ujwala were higher in Oleoresin recovery. In general, cultivars had high oleoresin during summer at turning stage (26.4 per cent). But when harvesting was delayed to full ripe or withering stage, highest oleoresin yield (26.5 per cent and 26.2 per cent) were observed during winter season.

A study was conducted in twenty five accessions of bird pepper (*C. frutescens*) at two maturity sages *viz.,* fully mature but green and red ripe stage and reported that the oleoresin content was more in red ripe fruits than in mature green fruits (Sheela *et al*., 2001). The oleoresin content ranged from 4.5 to 14.25 per cent in mature green stage to 8.75 to 24.45 per cent in red ripe stage.

2.3.3 Carotenoids

Vinkler (1971) determined the total carotenoids, capsanthin and capsorubin in fruits of *C. annuum* var. *annuum*. He found that capsanthin formed 45 to 80 per cent of the total carotenoids and capsorubin ranged from 6 to 19 per cent. Gregory *et al*. (1987) reported that red bell peppers contained total carotenoids of 280 µg per g. Deli *et al*. (1992) identified thirty four carotenoids from the chromatograms. Soohyun *et al*. (1998) identified carotenoids including capsanthin estimated to a total concentration of 65 mg per 100 g of fresh weight.

Cholnoky (1939) on analysing several varieties of paprika for two yearly harvests found that the total colour was higher for the first harvest than for the second. Lease and Lease (1956) reported that the degree of harvest maturity of fruits affected the colour stability of dried ground capsicum. The initial colour of chilli fruits picked at withering stage was superior to that picked at full ripe but succulent.

According to Benedek (1972) the chilli fruits harvested at red ripe stage continued to live and its colouring matter content increased. He found that mature but still unripe chilli fruits when harvested became red later on, however, it contained less colouring matter than fruits harvested red ripe.

Quantitative analysis of the carotenoid pigments of five *Capsicum* cultivars at four stages of maturation were done by Rahman and Buckle (1980). From immature, mature, half ripened and fully ripened capsicum fruits, upto twelve, twelve, twenty nine and twenty six individual pigments were isolated and identified. Conrad *et al*. (1987) graded fruits of *C. frutescens* into six colour classes ranging from green to red. Deli *et al*. (1992) investigated the changes in carotenoid pigments of paprika fruits at six stages of ripening.

Mini (1997) pointed out that chilli genotypes exhibited highest colour values at withering stage, moderate at full ripe stage and lowest at turning stage. When the harvesting was done at turning stage, KTPL-19 had the highest colour value. CA 645 produced the lowest colour value during the full ripe and withering stage. Saga and Ogawa (1995) found that carotenoid content increased rapidly between seven and ten weeks after flowering.

In accord with the advance in ripening, carotenoids were being formed even at the over ripening stage. Carotenoids were at a low level in

mature green fruits and the onset of climacteric ripening caused their content to grow (Gnayfeed *et al*., 2001).

2.3.4 Ascorbic acid

Ascorbic acid was purified for the first time from capsicums in 1928 by Albert- Szent- Gyorgi (Paul and Bosland, 1993). The fruits of most *Capsicum* spp. contain high amounts of ascorbic acid upto 340 mg per 100 g when in fresh state (Anu and Peter, 2000).

A high content of ascorbic acid was observed in red chillies than in the green chillies (Mishra and Khatai, 1969). The highest ascorbic acid content was reported in the variety Abohar- 12 at green stage of fruit maturity and in variety NP-46 at turning red and red stage (Saimbhi *et al*., 1972).

Bajaj *et al*. (1977) pointed out that the ascorbic acid content on fresh weight basis in the 'turning red' stage was more than that of 'green' stage of all varieties throughout the season. Its content in the 'red' stage of all the varieties was slightly less than that of 'turning red' stage upto three weeks, later on the 'red' stage contained more of it that found at 'green' and 'turning red' stage, with the exception in case of Jwala variety, which had maximum during 'turning red' stage.

Awasthi and Singh (1979) recorded the highest content of ascorbic acid at 35 to 49 days after fruit set in the developing fruits of all the varieties studied. Its content had high positive correlation with age of fruit, except in varieties KT 1 and KT 2. Ascorbic acid content was maximum in green fruit and decreased as the development of fruit enhanced (Lehninger, 1982; Murugan, 2001).

The maximum ascorbic acid was estimated from the green and red fruits of the variety Manipuri (190.2 mg and 171.0 mg respectively) while

minimum was from the green and red fruits of Pant C-1 (166.48 mg and 152.57 mg respectively). Its content in all the varieties decreased slightly when the fruits passed from the green to red stage (Maurya *et al*., 1984). Mary and Balakrishnan (1990) reported a higher ascorbic acid content in red ripe chillies compared to green chillies. Lakshmi *et al*. (1992) detected a higher ascorbic acid content in ripe fruits than in green fruits of *C. frutescens*.

Howlader *et al*. (1996) assessed the ascorbic acid content at various stages of fruit development of three local chilli (*C. annuum*) morphotypes *i.e.*, long (C-19-1, P-3), medium long (Baramasi) and round. They observed that its content increased with advancing maturity and qualitatively the fruits reached their peak stage after ripening.

Lalithakumari *et al.* (1999) analysed eleven chilli cultivars to determine the ascorbic acid content at different maturity stages *i.e.*, at ten days intervals from 10 days after anthesis to 80 days after anthesis. Its content at 10 days after anthesis was found to be negligible and at 20 days after anthesis it was 42.8 mg per 100 g. As the fruit growth progressed, ascorbic acid content in them increased upto 70 days after anthesis (fully matured and red ripened) followed by a decline by 80 days after anthesis (drying process begins). Gnayfeed *et al*. (2001) observed that the ascorbic acid reached their maximum level at the colour break or red stage and then declined.

Ascorbic acid content was assessed in developing fruits of ten chilli (*C. annuum*) cultivars and four pattern of accumulation were observed. The greatest accumulation was found in (1) S-Angar, DCI, 85-3 and Local-1 at maturity (2) 85-8, 85-9 and Local-2 at ripening (3) 85-1 and 85-2 at intermediate maturity or colour break and (4) NP-46-A at the immature stage (Jha *et al*., 2001).

Jecheon *et al*. (2001) reported highest ascorbic acid content in the reddening fruits followed by the initial colouring fruits and green fruits, while consumption of ascorbic acid was higher in fruits at the green stage than those of the colouring and reddening stage. Pepper (*C. annuum*) cultivars Caccavielo and Elisa showed significant differences for ascorbic acid at two ripening stages (Roura *et al*., 2001).

The bird pepper (*C. frutescens*) accessions exhibited significant variation in ascorbic acid content at both stages of maturity *viz*., fully mature but green and red ripe stage. It ranged from 21.0 to 77.6 mg per 100 g in mature fruits and 31.5 to 135.75 per 100 g in red ripe fruits. Among the accessions its content was highest in CF 15 and CF 10 at the two maturity stages (Sheela *et al*., 2001).

The ascorbic acid content of *C. annuum* fruits from two cultivars ('P-14' and 'Florinis') were determined at the immature, commercially mature and physiologically mature stages of ripening. Its content in fruits of 'P-14' increased with ripening, while in fruits of 'Florinis' it showed an increase only at the commercially mature stage of ripening (Niklis *et al*., 2002).

2.4 INCIDENCE OF DISEASES

Chilli is affected by a conglomeration of parasitic and non parasitic disease causing considerable economic loss. Among the diseases reported, bacterial wilt and leaf curl complex become increasingly important in recent years. Most of the reported resistant sources are becoming susceptible with the rapid development of new pathogenic races.

2.4.1 Bacterial Wilt

Bacterial wilt caused by *Ralstonia solanacearum* is one of the most devastating disease in tropical and subtropical regions of the world. The

characteristic symptom of the disease is the drooping of leaves followed by wilting of plant. The vascular system becomes discoloured and there will be brown decay of the pith.

The disease is favoured by high soil moisture which helps in dispersal of bacteria and increases the size of lenticels. A warm and wet soil is conducive to invasion of tissues and development of the disease (Singh, 1975).

The bacterium invades the host through wounds usually below ground. It was found that relatively high soil temperature and soil moisture favoured the disease. It was also reported that the organism spread through irrigation water and rain water (Nair and Menon, 1983).

The disease is very difficult to manage because of its wide host range, the exceptional ability of the pathogen to survive in the roots of non-host plants and in the soil, susceptibility of all the commercial cultivars and non-feasibility of chemical control. Recently great emphasis on alternative control measures such as biological and cultural control have been laid (Ho, 1988).

The resistance of 53 *C. annuum* accessions to bacterial wilt was studied in Kerala from 1996 to 1998 (Fatima and Joseph, 2001). Of the 53 accessions, 15 were resistant (less than 20 per cent infection), 16 were moderately resistant (20 to 40 per cent), 13 were moderately susceptible (40 to 60 per cent) and nine were highly susceptible (more than 60 per cent).

2.4.2 Leaf Curl

Leaf curl disease seems to be a major hurdle in commercial cultivation of chilli. The symptoms of disease are downward curling, dark green colour and oval to round shaped leaves, pronounced vein-thickening and leafy outgrowths or enations on the under surface of leaves. In severe

cases, axillary buds were stimulated to produce small cluster of leaves. Flower and fruit formation were also reduced (Nair and Menon, 1983).

Chilli leaf curl is a complex disease caused by separate or combined infection of mites, thrips and viruses (Tewari, 1983 and Nawalagatti *et al*., 1999).

The virus causing leaf curl in chillies is commonly referred to as chilli leaf curl virus or tobacco leaf curl viruses. Pepper mottle virus was reported to be involved in the leaf curl disease complex (Peter, 1998).

The causal agents of leaf curl were reported to be *Scirtothrips dorsalis* (thrips) and *Polyphagotarsonemus latus* (mite) by Amin (1979), Mallapur (2000) and Reddy *et al*. (2000).

Several factors (viruliferous insect population, temperature, humidity, wind direction and velocity, sunshine, rainfall and precipitations) either singly or in combinations contribute to the wide spread incidence of leaf curl disease. Under South Indian condition, maximum temperature and rainfall have been found to be more important (Murugesan *et al*., 1977). For the management of disease, several insecticides have been used to control the vectors (Rataul and Butter, 1976; Mishra, 1984).

Materials and Methods

3. MATERIALS AND METHODS

The present investigation was carried out in the Department of Olericulture, College of Agriculture, Vellayani during the period from June 2002 to May 2003. The area is situated at 8.5^0 N latitude, 76.9^0 E longitude at an altitude of 29.0 m above mean sea level. Experimental site has a lateritic red loam soil with a pH of 5.2. The area enjoys a warm humid tropical climate.

The study consisted of the following experiments.

3.1 Evaluation of *Capsicum chinense* genotypes

3.2 Influence of harvest maturity on quality

3.1 EVALUATION OF *C. CHINENSE* GENOTYPES

3.1.1 Experimental Materials and Methods

Ten selected superior genotypes obtained from the preliminary germplasm evaluation trial of *C. chinense* by Manju (2001) were utilized for the study. The details of the genotypes and their sources are presented in Table 1.

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

Sl. No.	Accession number	Source
1	CC 23	Nemom, Thiruvananthapuram
2	CC 13	Vithura, Thiruvananthapuram
3	CC 7	Vithura, Thiruvananthapuram
4	CC 2	Anchal, Kollam
5	CC 15	Vilavoorkal, Thiruvananthapuram
6	CC 30	Nemom, Thiruvananthapuram
7	CC 28	Pothenkode, Thiruvananthapuram
8	CC 31	Nemom, Thiruvananthapuram
9	CC 3	Neyyattinkara, Thiruvananthapuram
10	CC 11	Vithura, Thiruvananthapuram

All the genotypes were evaluated in two seasons *viz*., S_1- rainy (June- November) and S_2–summer (December-May). Each experiment was laid out in the following manner.

Design	:	RBD
Replications	:	3
Treatments	:	10
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, 2002).

3.1.2 Observations

Five plants were randomly selected per genotype 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 genotype in each replication.

Observations on the following characters were recorded from both the experiments during rainy and summer seasons.

3.1.2.1 Plant Characters

(a) Plant height (cm)

Measured from the ground level to the tip of the plant at the time of final harvest.

(b) Primary branches per plant

Branches arising from the main stem were counted.

3.1.2.2 Flowering Characters

(a) Days to first flowering

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

(b) Days to harvest

Number of days from transplanting to first harvest in 50 per cent of plants in each genotype was observed and average worked out.

3.1.2.3 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) Fruit girth (cm)

Measured using twine and metre scale at the maximum width of the fruit.

(d) Fruit weight (g)

Average of five fruits weight.

(e) Pedicel length (cm)

Distance between the point of attachment of pedicel with the stem and the fruit.

(f) Pedicel-fruit ratio

Ratio between pedicel length and fruit length.

(g) Yield per plant (g)

Weight of fruits harvested from each plant was recorded.

(h) Driage (%)

$$\frac{\text{Weight of dried fruit}}{\text{Weight of fresh fruit}} \times 100$$

3.1.2.4 Quality Characters

(a) Capsaicin (%)

Capsaicin content of different genotypes were determined by Folin-Dennis method. The pungent principle reacts with Folin-Dennis reagent to give a blue coloured complex which is estimated colorimetrically (Mathew *et al*., 1971).

Reagents

(i) Folin-Dennis reagent

Refluxed 750 ml distilled water, 100 g sodium tungstate, 20 g phosphomolybdic acid and 50 ml phosphoric acid for two hours. Cooled and diluted to 1000 ml with distilled water.

(ii) 25 % aqueous sodium carbonate solution

(iii) Acetone

Procedure

The fruits harvested at red ripe stage were dried in a hot air oven at 50^0C and powdered finely in a mixer grinder. Five hundred mg each of the sample was weighed into test tubes. Added 10 ml acetone to it 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^{-1}) 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 Manickam, 1992).

Procedure

Chilli fruits harvested at red ripe stage were dried in a hot air oven at 50^0C, 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) Carotenoids (%)

Carotenoids present in the fruits of selected genotypes were extracted using acetone and its optical density measured at 450 nm.

Procedure

One hundred milligrams of fresh fruit was cut into small pieces and homogenized in a blender with acetone. The homogenate was transferred into a volumetric flask and made up to 25 ml and kept overnight in dark. The optical density was measured at 450 nm (Jensen, 1978). The carotenoid present in the extract was calculated using the formula:

$$C = \frac{D \times f \times V \times 100}{2500}$$

Where, C – total amount of carotenoids in per cent

D – Absorbance at 450 nm in a 1 cm cell

F – Dilution factor

V – Volume of the original extract in ml

2500 – Average extinction coefficient of the pigments

(d) 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_1 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 % oxalic acid) and titrated as above against the dye solution to a pink colour (V_2 ml). Ascorbic acid content of the sample was calculated using the formula :

$$\text{Amount of ascorbic acid /100 g sample} = \frac{0.5 \times V_2 \times 100}{V_1 \times 5 \times \text{weight of sample}} \times 100$$

3.1.2.5 Reaction towards major pests and diseases

No scoring was done for pests since there was no major pest incidence in the crop. Bacterial wilt was the serious disease during rainy season and the number of affected plants were recorded. Chilli leaf curl virus disease was the serious problem during summer season and hence scoring based on visual observations was done for leaf curl disease.

(a) Incidence of bacterial wilt

Daily observation of plants was done for incidence of bacterial wilt (Plate 1) and recorded the number of plants wilted per plot.

(b) Scoring for chilli leaf curl virus

The scoring was based on a scale 0 to 4 proposed by Rajamony *et al*. (1990) in melons with slight modifications. This was done according to the characteristic symptom of each observational plant (Table 2 and plates 2 to 5).

Table 2. Scoring for chilli leaf curl virus disease

Score	Symptoms
0	No symptoms
1	Slight curling of terminal leaves
2	Curling of terminal and adjacent lower leaves
3	Curling and appearance of blisters on leaves
4	Severe curling and puckering of leaves, stunted appearance of plants

The individual plant score was utilized to work out the "severity index" or "vulnerability index" so as to measure the degree of resistance. The index was calculated using an equation adopted by Silbernagel and Jafri (1974) for measuring the degree of resistance in snap bean (*Phaseolus vulgaris*) to beet curly top virus and modified later by Bos (1982):

$$\text{Vulnerability Index (V.I)} = \frac{0n_0 + 1n_1 + 2n_2 + 3n_3 + 4n_4}{n_t (n_c - 1)} \times 100$$

Where,

n_0, n_1, ----, n_4 = number of plants in the category 0,1, ---, 4 respectively

n_t = total number of plants

n_c = total number of categories = 5

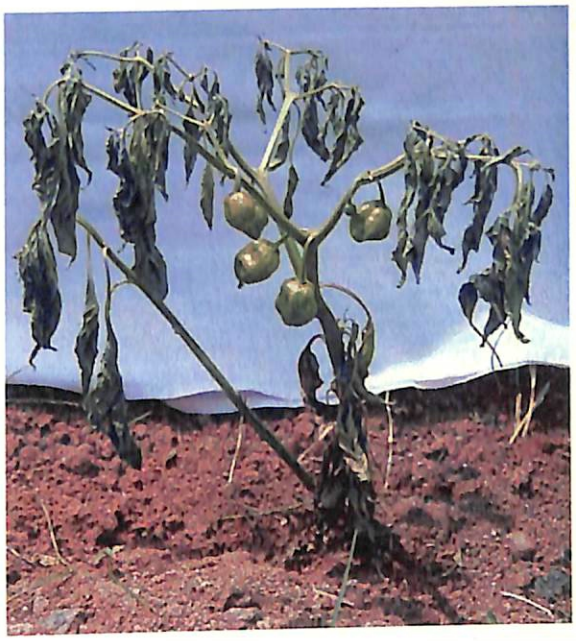


Plate 1 Bacterial wilt affected plant

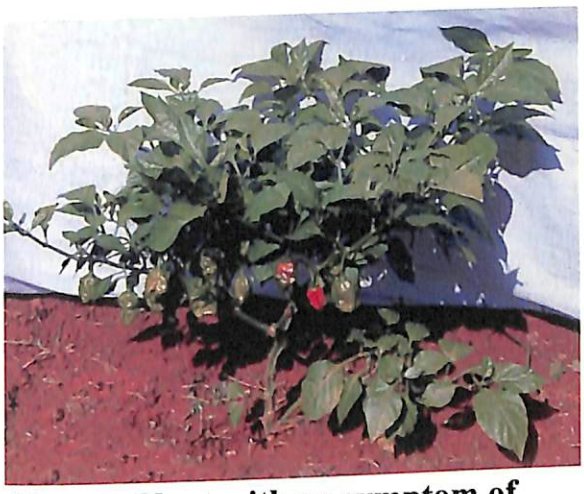


Plate 2 Plant with no symptom of leaf curl disease (Score 0)

Plate 3 Plant with slight symptoms of leaf curl disease (Score 1)

Plate 4 Plant with moderate symptoms of leaf curl disease (Score 3)

Plate 5 Plant with severe symptoms of leaf curl disease (Score 4)

The genotypes were classified according to vulnerability index as

V.I	Category
0.0	Resistant (R)
1.00- 25.00	Tolerant (T)
25.01-50.0	Susceptible (S)
>50.00	Highly susceptible (HS)

3.1.3 Statistical Analysis

The collected data were subjected to the analysis of variance to test the significant difference among the genotypes under rainy and summer seasons for various traits as per Panse and Sukhatme (1967). Pooled analysis was done to test the significant difference among different seasons.

Data are analysed for the following in rainy season.

3.1.3.1 Mean

The mean ($\overline{X}_i$) of the characters X_i was worked out.

3.1.3.2 Variability

Variability components (phenotypic and genotypic) for different characters was estimated as suggested by Kempthorne (1977).

(a) Variance and Covariance

The variance and covariance components were calculated as per the following formulae :

For the character X_i,

$$\text{Environmental variance, } \sigma_{ei}^2 = MSE$$

$$\text{Genotypic variance, } \sigma_{gi}^2 = \frac{MST - MSE}{R}$$

$$\text{Phenotypic variance, } \sigma_{pi}^2 = \sigma_{gi}^2 + \sigma_{ei}^2$$

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_i and X_j,

$$\text{Environmental covariance, } \sigma_{eij} = MSPE$$

$$\text{Genotypic covariance, } \sigma_{gij} = \frac{MSPT - MSPE}{r}$$

$$\text{Phenotypic variance, } \sigma_{pij} = \sigma_{gij} + \sigma_{eij}$$

where, MSPT and MSPE are respectively, the mean sum of products between the i^{th} and j^{th} characters for genotype and environment respectively from Analysis of Covariance (ANCOVA).

(b) Coefficient of Variation

Variability that existed in the population for various characters were apportioned using the estimates of coefficient of variation (Singh and Choudhary, 1985).

For the character X_i,

$$\text{Phenotypic coefficient of variation, PCV} = \frac{\sigma_{pi}}{\overline{X}_i} \times 100$$

$$\text{Genotypic coefficient of variation, GCV} = \frac{\sigma_{gi}}{\overline{X}_i} \times 100$$

$$\text{Environmental coefficient of variation, ECV} = \frac{\sigma_{ei}}{\overline{X}_i} \times 100$$

where, σ_{pi}, σ_{gi} and σ_{ei} are respectively the phenotypic, genotypic and environmental standard deviations with respect to each character.

3.1.3.3 Heritability

Hanson *et al*. (1956) proposed the mathematical relationship of variance estimates on computation of heritability, which is usually expressed as percentage :

$$\text{Heritability (broad sense), } H^2 = \frac{\sigma_{gi}^2}{\sigma_{pi}^2} \times 100$$

3.1.3.4 Genetic Advance

Genetic advance as percentage over mean was calculated as per the formula given by Lush (1949) and Johnson *et al*. (1955) :

$$\text{Genetic advance, GA} = \frac{kH^2 \sigma_{pi}}{\overline{X}_i} \times 100$$

where, H^2 - heritability in broad sense.

σ_{pi} - phenotypic standard deviation

k - selection differential which is 2.06 in case of 5 % selection in large samples (Miller *et al*., 1958 and Allard, 1960).

3.1.3.5 Correlation Analysis

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

3.1.3.6 Path Analysis

The direct and indirect effects of yield contributing factors were estimated through path analysis technique (Wright, 1954).

3.2 INFLUENCE OF HARVEST MATURITY ON QUALITY OF *C. CHINENSE* GENOTYPES

3.2.1 Experimental Materials and Methods

Fruits were harvested at three different stages of maturity (Plate 6) from the ten *C. chinense* genotypes, raised during the two seasons *viz*., rainy and summer.

The three maturity stages were:

M_1 (Turning stage) : Stage when mature fruit just starts changing its colour to intermediate stage.

M_2 (Red ripe stage) : Stage when the fruit becomes fully ripe, but firm and succulent in nature.

M_3 (Withering stage) : Stage when the fully ripe fruit has become shrivelled in appearance.

Colour changes of the fruits of different genotypes used in the study to judge the above maturity stages were shown in Table 3.

M_1

M_2

M_3

Plate 6 Stages of harvest maturity

Table 3. Colour changes of fruits in different genotypes of *C. chinense*

Sl. No.	Genotypes	Maturity stages		
		M_1	M_2	M_3
1	CC 23	Green	Orange	Red
2	CC 13	Purple	Orange red	Red
3	CC 7	Green	Orange	Red
4	CC 2	Green	Orange red	Red
5	CC 15	Green	Orange red	Red
6	CC 30	Green	Orange red	Red
7	CC 28	Green	Orange red	Reddish orange
8	CC 31	Green	Orange red	Red
9	CC 3	Green	Brown	Reddish orange
10	CC 11	Green	Orange red	Red

The experiment formed two factorial RBD, one with 10 genotypes and 2 seasons and another with 10 genotypes and 3 maturity stages each with 3 replications.

3.2.2 Observations

Dried fruits at three stages of maturity were powdered and evaluated for the following characters as in previous case

(a) Capsaicin (Folin – Dennis method)

(b) Oleoresin (Soxhlet method)

Fresh fruits at three stages of maturity were evaluated as in previous case for

(c) Carotenoids

(d) Ascorbic acid (2,6 – dichlorophenol indophenol dye method)

3.2.3 Statistical Analysis

The data were subjected to analysis of variance to test the significant difference among the genotypes. Pooled analysis was done to test the significant difference among different seasons and different maturity stages.

Results

4. RESULTS

The experiment entitled 'Quality characterization of hot chilli (*Capsicum chinense* Jacq.) genotypes in rainy and summer seasons' was carried out in the Department of Olericulture, College of Agriculture, Vellayani during the period 2001-2003.

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

4.1 Variability

4.2 Influence of season

4.3 Influence of maturity stages on quality

4.4 Incidence of diseases

4.1 VARIABILITY

Analysis of variance showed significant difference among genotype for all the characters studied in rainy season (Table 4 and Plate 7). The variability parameters like range, mean, genotypic and phenotypic variances, coefficients of variation at genotypic and phenotypic levels, heritability in broad sense, genetic advance and genetic advance as percentage of mean were estimated in rainy season and presented in Table 5 and 6.

4.1.1 Phenotypic and genotypic variance

High phenotypic and genotypic variance were observed for fruits per plant and yield per plant. Wide variation was observed in phenotypic and genotypic variance among the characters. Maximum values of phenotypic variance (86477.56) and genotypic variance (84966.56) was observed for

Table 4 Analysis of variance for different characters of genotypes in rainy season (Mean squres)

Source	d.f.	Plant height	Primary branches per plant	Days to first flowering	Days to harvest	Fruits per plant	Fruit length	Fruit girth	Fruit weight	Pedicle length
Replication	2	27.31	0.19	1.43	0.93	147.00	0.05	0.02	0.07	0.02
Genotype	9	352.18**	6.95**	121.47**	158.67**	75348.66**	5.10**	5.12**	6.99**	1.13**
Error	18	14.87	0.27	3.88	5.19	141.5	0.01	0.03	2.40	0.02

Source	d.f.	Pedicel-fruit ratio	Yield per plant	Driage	Capsaicin	Oleoresin	Carotenoid	Ascorbic acid	Bacterial wilt incidence
Replication	2	0.002*	1293	1.68**	0.002	0.09	0.00009	0.98	0.18
Genotype	9	0.07**	256410.5**	27.39**	0.95**	50.47**	0.02**	514.21*	6.66**
Error	18	0.0006	1511.11	0.04	0.002	0.08	0.0003	6.19	0.25

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

CC 23

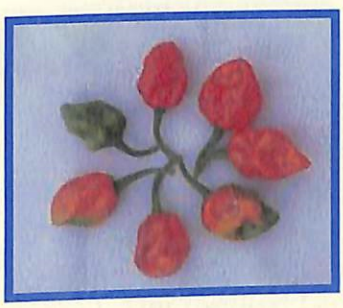
CC 13

CC 7

CC 2

CC 15

CC 30



CC 28

CC 31

CC 3

CC 11

Plate 7. Variability in fruit characters of *C. chinense*

yield per plant. Carotenoids exhibited least phenotypic variance (0.005) and genotypic variance (0.005). For all the characters, genotypic variance makes up the major portion of phenotypic variance with very little effect of environment.

4.1.2 Phenotypic and genotypic coefficients of variation

Phenotypic and genotypic coefficients of variation (PCV and GCV respectively) observed were high for most of the characters (Fig.1). Fruits per plant had the highest PCV (47.67) and GCV (47.53) followed by oleoresin content (35.15 and 35.07 respectively) and the lowest PCV and GCV were exhibited by days to harvest (8.91 and 8.49 respectively).

4.1.3 Heritability and genetic advance

Heritability and genetic advance for different characters were presented in Table 6 and Fig. 2. High heritability coupled with high genetic advance was observed for most of the characters except plant height and days to harvest.

Heritability estimates were high for most of the characters *viz*., driage (99.59), oleoresin (99.51), capsaicin (99.45), fruits per plant (99.44) and carotenoids (99.38). Plant height exhibited lowest (88.20) heritability.

Genetic advance was highest for yield per plant (595.2) and lowest for carotenoid (0.15).

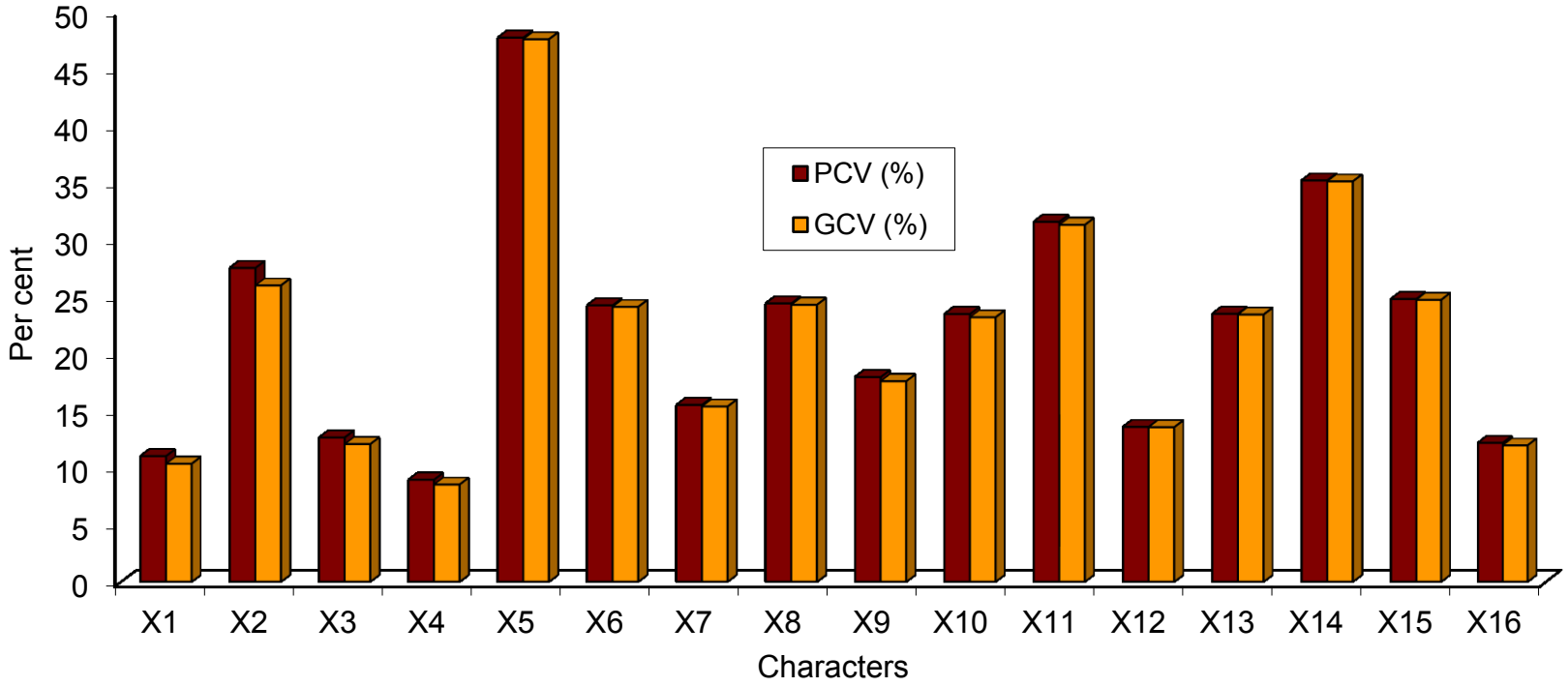
Genetic advance as per cent of mean ranged from 16.67 for days to harvest to 97.64 for fruits per plant.

4.1.4 Correlation

The phenotypic (r_p), genotypic (r_g) and environmental (r_e) correlation coefficients were estimated for 17 characters in rainy season (Table 7, 8 and 9).

Table 5 Range, mean, phenotypic, genotypic and environmental variances, phenotypic and genotypic coefficients of variation for different characters of genotypes in rainy season

Sl. No.	Characters	Range	Mean ± SE_m	σp^2	σg^2	σe^2	PCV (%)	GCV (%)
1	Plant height (cm)	87.79 – 120.13	102.87 ± 2.23	127.31	112.44	14.87	10.97	10.30
2	Primary branches per plant	3.73 – 8.93	5.75 ± 0.30	2.49	2.23	0.26	27.47	25.94
3	Days to first flowering	45.00 – 64.00	52.07 ± 1.37	43.07	39.20	3.87	12.60	12.02
4	Days to harvest	72.00 – 96.67	84.23 ± 1.32	56.35	51.16	5.19	8.91	8.49
5	Fruits per plant	152.87 – 675.87	333.10 ± 6.87	25210.56	25069.06	141.50	47.67	47.53
6	Fruit length (cm)	3.49 – 8.43	5.41 ± 0.08	1.71	1.69	0.02	24.19	24.06
7	Fruit girth (cm)	5.48 – 10.31	8.50 ± 0.10	1.73	1.70	0.03	15.46	15.32
8	Fruit weight (g)	3.52 – 8.52	6.29 ± 0.089	2.35	2.32	0.02	24.36	24.24
9	Pedicel length (cm)	2.75 – 4.35	3.479 ± 0.07	0.39	0.37	0.01	17.90	17.54
10	Pedicel-fruit ratio	0.49 – 0.96	0.67 ± 0.04	0.02	0.02	0.0006	23.43	23.14
11	Yield per plant (g)	397.33 – 1319.33	932.83 ± 22.44	86477.56	84966.56	1511.11	31.52	31.25
12	Driage (%)	18.93 – 29.53	22.36 ± 0.11	9.16	9.12	0.036	13.53	13.50
13	Capsaicin	1.32 – 3.18	2.41 ± 0.02	0.32	0.32	0.001	23.45	23.38
14	Oleoresin	7.53 – 19.43	11.69 ± 0.165	16.88	16.79	0.08	35.15	35.07
15	Carotenoid	0.176 – 0.411	0.289 ± 0.003	0.005	0.005	0.00003	24.75	24.67
16	Ascorbic acid	95.23 – 136.45	109.25 ± 1.44	175.53	169.34	6.19	12.13	11.91

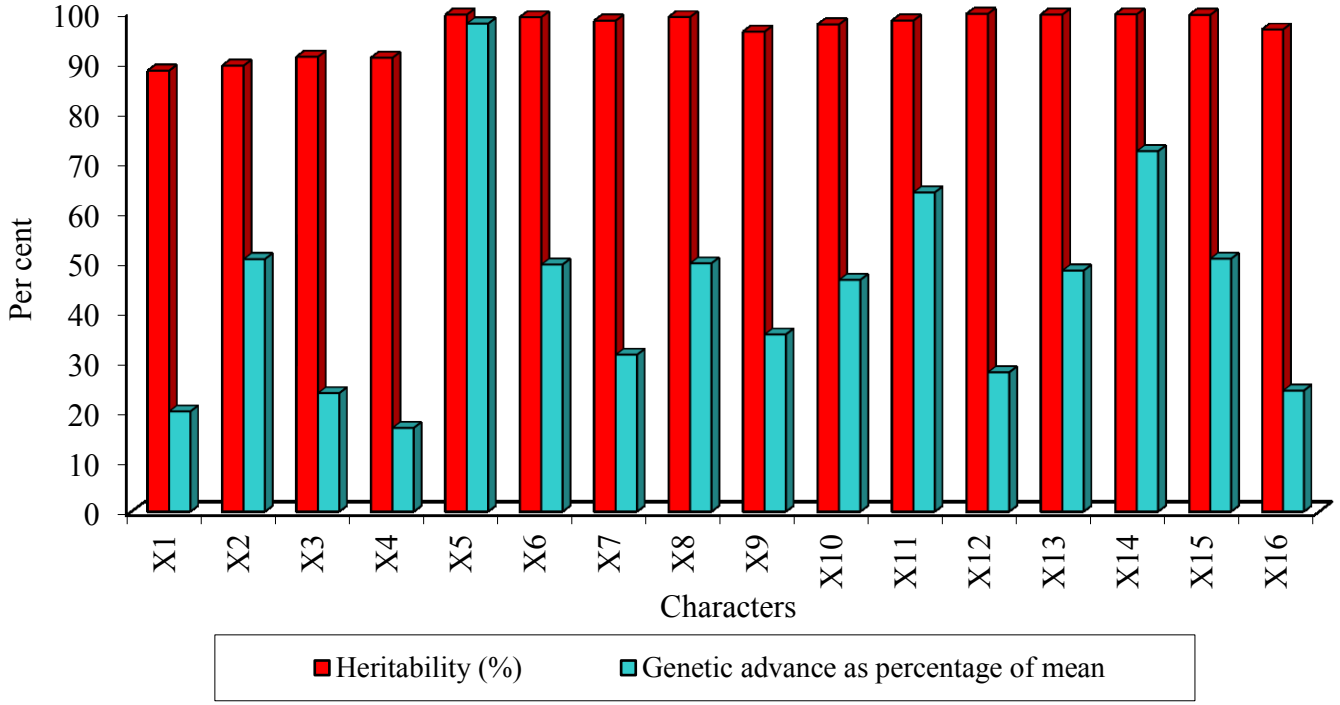


X1 Plant height
X2 Primary branches per plant
X3 Days to first flowering
X4 Days to harvest
X5 Fruits per plant
X6 Fruit length
X7 Fruit girth
X8 Fruit weight
X9 Pedicel length
X10 Pedicel-fruit ratio
X11 Yield per plant
X12 Driage
X13 Capsaicin
X14 Oleoresin
X15 Carotenoid
X16 Ascorbic acid

Fig. 1 Phenotypic and genotypic coefficients of variation for different characters in *C. chinense*

Table 6 Heritability, genetic advance and genetic advance as percentage of mean for different characters of genotypes in rainy season

Sl. No.	Characters	Heritability (%)	Genetic advance	Genetic advance as % of mean
1	Plant height	88.2	20.53	19.96
2	Primary branches per plant	89.20	2.90	50.43
3	Days to first flowering	90.99	12.30	23.62
4	Days to harvest	90.79	14.04	16.67
5	Fruits per plant	99.44	325.25	97.64
6	Fruit length	98.93	2.67	49.35
7	Fruit girth	98.23	2.66	31.29
8	Fruit weight	98.97	3.12	49.60
9	Pedicel length	96.03	1.23	35.35
10	Pedicel-fruit ratio	97.47	0.31	46.27
11	Yield per plant	98.25	595.20	63.80
12	Driage	99.59	6.21	27.77
13	Capsaicin	99.45	1.16	48.13
14	Oleoresin	99.51	8.42	72.07
15	Carotenoid	99.38	0.15	50.52
16	Ascorbic acid	96.47	26.33	24.10



X1 Plant height
X2 Primary branches per plant
X3 Days to first flowering
X4 Days to harvest
X5 Fruits per plant
X6 Fruit length
X7 Fruit girth
X8 Fruit weight
X9 Pedicel length
X10 Pedicel-fruit ratio
X11 Yield per plant
X12 Driage
X13 Capsaicin
X14 Oleoresin
X15 Carotenoid
X16 Ascorbic acid

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

4.1.4.1 Phenotypic correlation

(i) Correlation between yield and other characters

Yield per plant recorded high positive correlation with fruits per plant (0.7183). Days to first flowering (-0.8847), days to harvest (-0.8383) and incidence of bacterial wilt (-0.4619) were negatively correlated with yield.

(ii) Correlation among the yield component characters

Plant height was positively correlated with ascorbic acid content (0.4856). Primary branches per plant was positively correlated (0.6772) with ascorbic acid content.

Days to first flowering was positively correlated with days to harvest (0.8629) and negatively correlated with fruits per plant (-0.5747) and yield per plant (-0.8847). Days to harvest had negative correlation with fruits per plant (-0.4992).

Fruits per plant showed positive correlation with pedicel-fruit ratio (0.4780) and negative correlation with fruit girth (-0.7239), fruit weight (-0.5640) and incidence of bacterial wilt (-0.4558).

Fruit length was negatively correlated with pedicel-fruit ratio (-0.6627). Fruit girth was negatively correlated with driage (-0.6362) and positively correlated with fruit weight (0.8335). Fruit weight had negative correlation with capsaicin content (-0.5303). Pedicel length was positively correlated with driage per cent (0.5889).

4.1.4.2 Genotypic correlation

(i) Correlation between yield and other characters

Yield per plant was positively correlated with fruits per plant (0.7172) and negatively correlated with days to first flowering (-0.9234) and days to harvest (-0.874).

Table 7 Phenotypic correlation coefficient for characters of genotypes in rainy season

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_1	1.00																
X_2	0.2817	1.00															
X_3	-0.1416	0.0318	1.00														
X_4	-0.3106	0.0032	0.8629**	1.00													
X_5	0.4003	0.4002	-0.5747**	-0.4992*	1.00												
X_6	-0.3233	0.0206	0.1956	0.1506	-0.4238	1.00											
X_7	-0.4019	-0.4216	-0.0122	0.0215	-0.7239**	0.0986	1.00										
X_8	-0.1156	-0.3767	-0.2146	-0.2890	-0.5640**	0.1417	0.8335**	1.00									
X_9	0.0044	0.4362	0.0474	-0.2041	0.0449	0.4146	-0.1660	-0.0444	1.00								
X_{10}	0.3108	0.4126	-0.0751	-0.2282	0.4780*	-0.6627**	-0.3458	-0.3053	0.3786	1.00							
X_{11}	0.2754	-0.0365	-0.8847**	-0.8383**	0.7183**	-0.4216	-0.1559	0.0965	-0.1744	0.2088	1.00						
X_{12}	0.2148	0.0377	0.1777	0.0022	-0.3051	0.1317	0.2640	0.2671	0.5889**	0.2504	-0.3479	1.00					
X_{13}	0.2356	0.2529	0.2302	0.1759	0.3140	0.3405	-0.6362**	-0.5303**	0.1390	-0.2212	-0.0809	-0.0847	1.00				
X_{14}	-0.2346	-0.2357	0.2779	0.4172	-0.2508	-0.1462	0.2373	0.2008	-0.4304	-0.2728	-0.1452	-0.0805	0.2162	1.00			
X_{15}	0.3435	0.0196	0.1647	0.3712	-0.1022	0.0531	0.0025	0.0273	-0.2930	-0.3333	-0.2406	0.2763	0.2858	0.4162	1.00		
X_{16}	0.4856*	0.6772**	-0.0583	-0.0854	0.2436	-0.2075	-0.0362	-0.0043	0.0018	0.1486	0.1307	0.0794	0.1787	0.0621	0.3184	1.00	
X_{17}	-0.2428	-0.3516	0.3365	0.3192	-0.4558*	0.3285	0.0620	0.0533	0.0349	-0.1772	-0.4619*	0.0288	-0.3117	-0.3186	-0.0795	-0.3742**	1.00

* Significant at 5 per cent level

** Significant at 1 per cent level

X_1 Plant height
X_2 Primary branches per plant
X_3 Days to first flowering
X_4 Days to harvest
X_5 Fruits per plant
X_6 Fruit length
X_7 Fruit girth
X_8 Fruit weight
X_9 Pedicel length
X_{10} Pedicel fruit ratio
X_{11} Yield per plant
X_{12} Driage
X_{13} Capsaicin
X_{14} Oleoresin
X_{15} Carotenoid
X_{16} Ascorbic acid
X_{17} Bacterial wilt incidence

(ii) Correlation among the yield components

Plant height showed positive correlation with ascorbic acid content (0.5435). Primary branches per plant was positively correlated with pedicel length (0.4548) and ascorbic acid content (0.7318) and it was negatively correlated with fruit girth (-0.4856).

Days to first flowering had positive correlation with days to harvest (0.8754) and negative correlation with fruits per plant (-0.5978). Days to harvest was positively correlated with oleoresin content (0.4396) and negatively correlated with fruits per plant (-0.5170).

Fruits per plant had positive correlation with pedicel-fruit ratio (0.4909) and negative correlation with fruit length (-0.4304), fruit girth (-0.7341), fruit weight (-0.5680) and incidence of bacterial wilt (-0.4851).

Fruit length was negatively correlated with pedicel-fruit ratio (-0.6668). Fruit girth is positively correlated with fruit weight (0.8397) and negatively correlated with capsaicin content (-0.6463). Fruit weight was negatively correlated with capsaicin content (-0.5361).

Pedicel length was positively correlated with driage (0.5985) and negatively correlated with oleoresin content (-0.4379).

Ascorbic acid content was negatively correlated with incidence of bacterial wilt (-0.7410).

4.1.4.3 Environmental correlation

Environmental correlation coefficients were found to be negligible among yield and its component characters, except for the correlation between yield per plant and fruits per plant (0.9551), pedicel-fruit ratio with days to first flowering (0.4781), days to harvest (0.5979) and pedicel length (0.7732).

Table 8 Genotypic correlation coefficient for characters of genotypes in rainy season

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_1	1.00																
X_2	0.3173	1.00															
X_3	-0.1424	0.0225	1.00														
X_4	-0.3312	-0.0237	0.8754**	1.00													
X_5	0.4245	0.4347	-0.5978**	-0.5170**	1.00												
X_6	-0.3402	-0.0042	.2097	0.1701	-0.4304	1.00											
X_7	-0.4188	-0.4656*	-0.0215	0.0117	-0.7341**	0.0989	1.00										
X_8	-0.1272	-0.4137	-0.2366	-0.3120	-0.5680**	0.1398	0.8397**	1.00									
X_9	0.0080	0.4548*	0.0226	-0.2446	0.0489	0.4228	-0.1811	-0.0539	1.00								
X_{10}	0.3352	0.4157	-0.1040	-0.2733	0.4909*	-0.6668**	-0.3603	-0.3135	0.3660	1.00							
X_{11}	0.2892	-0.0277	-0.9234**	-0.8704**	0.7172**	-0.4332	-0.1619	0.0972	-0.1775	0.2219	1.00						
X_{12}	0.2205	0.0377	0.1855	-0.0011	-0.3059	0.1338	0.2702	0.2687	0.5985**	0.2509	-0.3513	1.00					
X_{13}	0.2556	0.2672	0.2356	0.1822	0.3154	0.3402	-0.6463**	-0.5361**	0.13750	-0.2259	-0.0820	-0.0841	1.00				
X_{14}	-0.2601	0.2489	0.2942	0.4396*	-0.2525	-0.1455	0.2458	0.2027	-0.4379	-0.2759	-0.1473	-0.0820	0.2192	1.00			
X_{15}	0.3679	0.0250	0.1712	0.3944	-0.1049	0.0541	0.0042	0.0287	-0.3006	-0.3384	-0.2468	0.2782	0.2867	0.4156	1.00		
X_{16}	0.5435**	0.7318**	-0.0965	-0.1134	0.2501	-0.2138	-0.0437	-0.0109	-0.0041	0.1501	0.1371	0.0822	0.1827	0.0648	0.3234	1.00	
X_{17}	-0.2627	-0.4118	0.3475	0.3333	-0.4851*	0.3486	0.0580	0.0443	0.0642	-0.1716	-0.4978*	0.0353	-0.3325	-0.3355	-0.0806	-0.7410**	1.00

* Significant at 5 per cent level

** Significant at 1 per cent level

X_1 Plant height
X_2 Primary branches per plant
X_3 Days to first flowering
X_4 Days to harvest
X_5 Fruits per plant
X_6 Fruit length
X_7 Fruit girth
X_8 Fruit weight
X_9 Pedicel length
X_{10} Pedicel fruit ratio
X_{11} Yield per plant
X_{12} Driage
X_{13} Capsaicin
X_{14} Oleoresin
X_{15} Carotenoid
X_{16} Ascorbic acid
X_{17} Bacterial wilt incidence

Table 9 Environmental correlation coefficient for characters of genotypes in rainy season

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_1	1.00																
X_2	0.0005	1.00															
X_3	-0.1351	0.1163	1.00														
X_4	-0.1349	0.2454	0.7379**	1.00													
X_5	0.0991	-0.3759	-0.2687	-0.3508	1.00												
X_6	-0.1505	-0.4874*	-0.1089	-0.3383	0.3923	1.00											
X_7	-0.2600	0.3263	0.2027	0.2592	0.1586	0.0834	1.00										
X_8	0.0969	0.3614	0.3280	0.2185	-0.0753	0.3222	0.4147	1.00									
X_9	-0.0434	0.2326	0.4402	0.4019	-0.1913	0.1208	0.3701	0.4023	1.00								
X_{10}	-0.0028	0.4767*	0.4781*	0.5979**	-0.4498*	-0.4808*	0.3172	0.1675	0.7732**	1.00							
X_{11}	0.1311	-0.2443	-0.2911	-0.4043	0.9551	0.3969	0.1830	0.0435	-0.0727	-0.3935	1.00						
X_{12}	0.3697	0.1016	0.0575	0.1683	-0.1316	-0.1816	-0.3789	0.0629	.2844	0.3137	-0.0536	1.00					
X_{13}	-0.1566	0.0500	0.2741	0.1247	0.0555	0.3957	0.2592	0.2106	0.3155	0.1032	0.0208	-0.2143	1.00				
X_{14}	0.3873	-0.0532	-0.0980	-0.0336	0.0696	-0.2559	-0.6109	-0.0550	-0.1656	-0.0905	0.0432	0.2688	-0.3497	1.00			
X_{15}	0.3230	-0.1508	0.0813	-0.1416	0.3420	-0.0662	-0.1527	-0.1501	0.0422	-0.0208	0.3118	-0.0940	0.1442	0.5338**	1.00		
X_{16}	-0.2505	-0.0264	0.5689**	0.3631	-0.0955	0.0695	0.2540	0.3324	0.1527	0.1009	-0.1127	-0.0973	-0.0164	-0.1057	0.0632	1.00	
X_{17}	-0.0780	0.1736	0.2307	0.1847	0.1606	-0.0256	0.1770	0.3606	-0.3998	-0.3279	0.1634	-0.2362	0.1403	-0.0315	-0.1301	0.2913	1.00

* Significant at 5 per cent level

** Significant at 1 per cent level

X_1 Plant height
X_2 Primary branches per plant
X_3 Days to first flowering
X_4 Days to harvest
X_5 Fruits per plant
X_6 Fruit length
X_7 Fruit girth
X_8 Fruit weight
X_9 Pedicel length
X_{10} Pedicel fruit ratio
X_{11} Yield per plant
X_{12} Driage
X_{13} Capsaicin
X_{14} Oleoresin
X_{15} Carotenoid
X_{16} Ascorbic acid
X_{17} Bacterial wilt incidence

4.1.5 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 10 and Figure 3). Plant height, fruits per plant, fruit length, pedicel-fruit ratio, driage, carotenoid and incidence of bacterial wilt were selected for path coefficient analysis.

Fruits per plant exhibited the highest positive direct effect on fruit yield (1.0453) followed by driage (0.5801) and plant height (0.1470). Bacterial wilt incidence had negligible direct effect. Pedicel fruit ratio (-1.2968), fruit length (-0.8499) and carotenoid (-0.7422) exerted high and negative direct effect on yield.

Indirect effects through fruits per plant were consistently high signifying the importance of that character. Thus in the case of plant height and fruit- pedicel ratio, high positive correlation with yield was mainly due to their positive direct effects through fruits per plant (0.4437 and 0.5131 respectively). Similarly high negative correlation of fruit length, driage and bacterial wilt was due to high negative indirect effects through fruits per plant (-0.4499, -0.3197 and –0.5071 respectively).

4.2 INFLUENCE OF SEASON

General analysis of variance showed significant difference among genotypes for all the characters studied in two seasons *viz*., rainy and summer (Table 4 and 11).

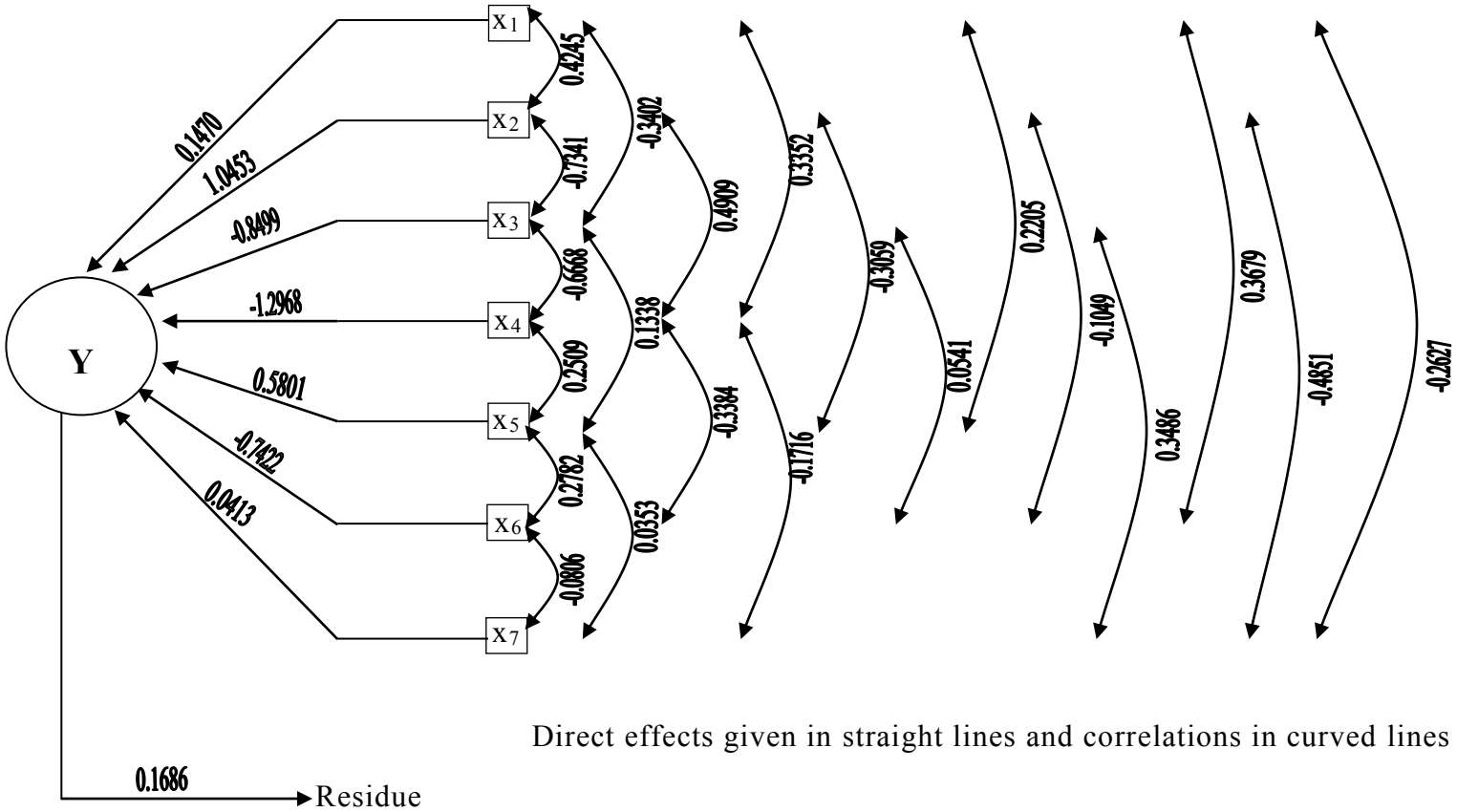
Pooled analysis was carried out for the characters *viz*., primary branches per plant, days to first flowering, days to harvest, fruit length, fruit girth, pedicel length, pedicel-fruit ratio, fruits per plant and yield per plant (Table 12). The characters fruit weight and disease incidence were

Table 10 Direct and indirect effect of selected yield components on fruit yield of *C. chinense*

Characters	Plant height	Fruits per plant	Fruit length	Pedicel-fruit ratio	Driage	Carotenoid	Bacterial wilt incidence	Correlation with yield
Plant height	**0.1470**	0.4437	0.2891	-0.4347	0.1279	-0.2730	-0.0109	0.2892
Fruits per plant	0.0624	**1.0453**	0.3658	-0.6366	-0.1775	0.0779	-0.0200	0.7172
Fruit length	-0.0500	-0.4499	**-0.8499**	0.8647	0.0776	-0.0402	0.0144	-0.4332
Pedicel-fruit ratio	0.0493	0.5131	0.5667	**-1.2968**	0.1456	0.2512	-0.0071	0.2219
Driage	0.0324	-0.3197	-0.1137	-0.3254	**0.5801**	-0.2065	0.0015	-0.3513
Carotenoid	0.0541	-0.1096	-0.0460	0.4388	0.1614	**-0.7422**	-0.0033	-0.2468
Bacterial wilt incidence	-0.0386	-0.5071	-0.2963	0.2225	0.0205	0.0598	**0.0413**	-0.7410

Residue = 0.1686
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_4 – Pedicel-fruit ratio
X_1 – Plant height	X_5 – Driage
X_2 – Fruits per plant	X_6 – Carotenoid
X_3 – Fruit length	X_7 – Bacterial wilt incidence

Table 11 Analysis of variance for different characters of genotypes in summer season (Mean squares)

Source	d.f.	Plant height	Primary branches per plant	Days to first flowering	Days to harvest	Fruits per plant	Fruit length	Fruit girth	Fruit weight	Pedicle length
Replication	2	2.06	0.53	1.19	4.23	595.19	0.006	0.02	0.039	0.004
Genotype	9	326.67**	4.09**	85.66**	142.16**	55174.8**	4.12**	4.75**	6.21**	2.35**
Error	18	1.97	0.35	2.82	3.09	170.79	0.01	0.02	0.02	0.02

Source	d.f.	Pedicel-fruit ratio	Yield per plant	Driage	Capsaicin	Oleoresin	Carotenoid	Ascorbic acid	Bacterial wilt incidence	Leaf curl incidence of
Replication	2	0.0003	3718.5**	0.94	0.00009	0.13	0.00003	5.45	0.87	18.91
Genotype	9	0.06**	251620.8**	6.18**	0.95**	46.95**	0.01**	585.87**	5.48**	1374.94**
Error	18	0.0005	202.72	0.39	0.001	0.06	0.00001	3.99	0.37	8.82

** Significant at 1 per cent level

Table 12 Pooled analysis of variance for different characters of genotypes over season

Source	d. f	Primary branches per plant	Days to first flowering	Days to harvest	Fruits per plant	Fruit length	Fruit girth	Pedicel length	Pedicel-fruit ratio	Yield per plant
Season	1	13.07**	2788.02**	2244.81**	113604.5**	0.96**	0.01	1.06	0.001	567452**
Genotype	9	10.71**	133.00	188.98	129107.7**	9.11**	9.79**	3.15**	0.13**	497577.4**
Interaction (Season x genotype)	9	0.33	74.13	111.85	1415.67	0.112	0.08	0.33	0.001	10453.33
Pooled error	36	0.56	74.13	111.85	1415.67	0.112	0.06	0.33	0.001	10453.33

** Significant at 1 per cent level

not pooled because of heterogeneity in values in two seasons and the characters plant height and driage were not pooled because they were not affected by the season. Pooled analysis of quality characters were presented in Table 17.

4.2.1 Plant characters

4.2.1.1 Plant height

Significant variation among genotypes for plant height was observed in both the seasons.

During rainy season, the genotype CC 3 recorded maximum plant height of 120.13 cm. The genotypes CC 7 (117.53 cm) and CC 30 (113.93 cm) were on par with CC 3. Minimum plant height was observed in CC 31 (87.79 cm). In summer season, CC 7 recorded maximum plant height of 115 cm. The genotype CC 3 (113.80 cm) was on par with CC 31. The minimum plant height was recorded in CC 11 (86.60 cm). Plant height was more in rainy season as compared to summer season. Overall mean for plant height during rainy season was 102.87 cm and for summer season it was 96.88 cm (Table 13).

4.2.1.2 Primary branches per plant

Significant difference was observed among genotypes and seasons for primary branches per plant (Table 13). In rainy and summer season, genotype CC 3 had maximum number of primary branches per plant (8.93 and 6.93 respectively) and CC 30 had the minimum (3.73 and 3.13 respectively). The number of primary branches per plant was more in rainy season than summer season. Overall mean for primary branches per plant was 5.75 during rainy season and 4.82 during summer season.

In general the genotype CC 3 had more number (7.93) of primary branches per plant and CC 30 had less number (3.43).

4.2.2 Flowering characters

4.2.2.1 Days to first flowering

Significant variation was observed among seasons for days to first flowering (Table 13). During rainy season CC 13 was the earliest to flower (45 days) which was on par with CC 30 (47 days). The genotype CC 2 was the latest (64 days) to flower. In summer season also CC 13 was the earliest to flower (54 days) and CC 28 was the latest (72 days). Genotypes were late in summer than rainy season. The overall mean for days to flowering was 52.07 during rainy and 65.7 during summer season.

In general CC 13 was the earliest genotype (49.5 days) and CC 11 was the latest (66.17 days) for flowering.

4.2.2.2 Days to harvest

Significant difference for days to harvest among seasons was observed (Table 13). CC 30 was the earliest to harvest (72) in rainy season and CC 2 was the latest (96.67 days). In summer season, CC 30 was the earliest (83.67) to harvest and CC 28 was the latest (107.07 days). The genotypes took more days to harvest in summer (96.47 days) than in rainy season (84.23 days).

In general CC 30 was the earliest (77.83 days) and CC 2 and CC 28 were the latest (95.67) to harvest.

4.2.3 Fruit and Yield characters

4.2.3.1 Fruits per plant

Significant variation for fruits per plant was observed among genotypes and seasons (Table 14). Maximum number of fruits per plant was recorded from the genotype CC 3 in both rainy and summer seasons (675.87 and 526.27 respectively). CC 11 had minimum fruits from both seasons (152.87 and 82.47 respectively). In summer season low number of

Table 13 Mean performance of genotypes for plant and flowering characters

Genotype	Plant height (cm)			Primary branches per plant			Days to first flowering			Days to harvest		
	Rainy	Summer	Mean	Rainy	Summer	Mean	Rainy	Summer	Mean	Rainy	Summer	Mean
CC 23	98.93	93.00	95.97	5.67	4.53	5.1	52.00	62.00	57.00	86.33	93.67	90.00
CC 13	101	95.33	98.17	4.2	3.53	3.87	45.00	54.00	49.50	83.33	91.67	87.50
CC 7	117.53	115.00	116.27	6.87	5.73	6.3	56.00	66.67	61.33	89.33	98.33	93.83
CC 2	96.53	91.07	93.8	4.33	3.67	4.0	64.00	64.33	64.17	96.67	94.67	95.67
CC 15	103.47	95.40	99.44	5.4	4.87	5.13	48.33	65.67	57.00	79.00	94.00	86.50
CC 30	113.93	103.07	108.5	3.73	3.13	3.43	47.00	63.00	55.00	72.00	83.67	77.83
CC 28	95.40	88.73	92.07	5.8	5.4	5.6	48.67	72.00	60.33	83.67	107.67	95.67
CC 31	87.79	86.79	87.29	6.67	5.67	6.17	48.00	70.67	59.33	79.67	106.00	92.83
CC 3	120.13	113.80	116.97	8.93	6.93	7.93	50.33	67.67	59.00	79.67	97.00	88.33
CC 11	94.00	86.60	90.3	5.93	4.73	5.33	61.33	71.00	66.17	92.67	98.00	95.33
Mean	102.87	96.88	99.88	5.75	4.82	5.29	52.07	65.70	58.89	84.23	96.47	90.35
SE	2.23	0.81	-	0.3	0.34	0.31	1.14	0.97	3.51	1.32	1.01	4.32
CD (0.05)	6.62	2.41	-	0.89	1.01	0.87	3.38	2.89	NS	3.91	3.01	NS
SE (season)	-			0.14			1.57			1.93		
CD (0.05) (season)	-			0.39			4.51			5.54		

fruits per plant was recorded as compared to rainy season. The overall mean for fruits per plant for rainy season was 333.10 and summer season was 246.07.

Highest number of fruits per plant was from the genotype CC 3 (601.07) (Plate 8) and lowest was from CC 11 (117.67).

4.2.3.2 Fruit length

Significant variation in fruit length was observed among genotypes and seasons (Table 14). Maximum fruit length was for the fruits of genotype CC 11 in rainy and summer season (8.43 and 8.31 cm respectively). Minimum fruit length was for CC 23 (3.49 and 3.76 respectively) in both seasons. In general, fruit length was slightly more in summer (5.66 cm) as compared to rainy season (5.41 cm).

The fruit length was more for CC 11 (8.37 cm) and minimum for CC 23 (3.6 cm).

4.2.3.3 Fruit girth

Significant difference for fruit girth was observed among genotypes (Table 14). Genotype CC 15 recorded maximum fruit girth of 10.31 and 10.01 cm respectively for rainy and summer seasons. Minimum fruit girth was observed in CC 3 (5.48 and 5.63 cm respectively) in both seasons. A slight reduction in fruit girth was recorded for fruits during rainy season (8.51 cm) than summer season (8.53 cm).

Among the genotypes, CC 3 had minimum fruit girth of 5.55 cm and CC 15 had maximum of 10.16 cm.

4.2.3.4 Fruit weight

During rainy and summer seasons CC 15 had maximum fruit weight (8.52 and 8.5 g respectively) and CC 3 had minimum fruit weight (3.52 and

3.83 g respectively). In general, fruit weight was slightly higher in summer (6.41 g) than rainy season (6.28g) (Table 14).

4.2.3.5 Pedicel length

Significant variation was observed for pedicel length among genotypes in two seasons (Table 14). In rainy season, CC 15 recorded maximum pedicel length of 4.35 cm, which was on par with CC 3 (4.3 cm) and CC 11 (4.16 cm). In summer season also CC 15 had maximum pedicel length of 5.5 cm. Lowest pedicel length was observed in CC 13 in rainy and summer seasons (2.75 and 2.97 cm respectively). A slight increase in pedicel length was observed in fruits from summer season than rainy season. Overall mean for pedicel length was 3.75 cm in summer and 3.48 cm in rainy season.

The genotype CC 15 had maximum pedicel length of 5.1 cm and CC 13 had minimum (2.86 cm).

4.2.3.6 Pedicel-fruit ratio

Significant difference was observed among genotypes of *C. chinense* for pedicel-fruit ratio (Table 14). The maximum ratio was recorded by the genotype CC 3 in rainy and summer seasons (0.96 and 0.88 respectively) and minimum by CC 11 (0.49 and 0.50 respectively). Overall mean for pedicel-fruit ratio for both seasons were almost same (0.66 and 0.67 respectively).

The genotype CC 3 had maximum ratio of 0.92 and CC 11 had minimum of 0.49.

4.2.3.7 Yield per plant

Significant difference for yield per plant was observed among genotypes and seasons (Table 14). CC 30 had the highest yield (1319.33 g)

Table 14 Mean performance of genotypes for fruit and yield characters

Genotype	Fruits per plant			Fruit length (cm)			Fruit girth (cm)			Fruit weight (g)		
	Rainy	Summer	Mean	Rainy	Summer	Mean	Rainy	Summer	Mean	Rainy	Summer	Mean
CC 23	353.53	253.73	303.63	3.49	3.76	3.63	8.50	8.82	8.66	5.75	6.07	5.91
CC 13	492.80	400.40	446.60	5.37	5.72	5.54	7.87	7.53	7.70	4.89	5.03	4.96
CC 7	225.13	200.27	212.70	5.33	5.93	5.63	9.29	9.45	9.37	7.07	7.27	7.17
CC 2	181.20	103.60	142.40	4.45	4.59	4.52	8.84	8.80	8.82	5.73	5.87	5.80
CC 15	211.40	129.07	170.23	5.73	5.89	5.81	10.31	10.01	10.16	8.52	8.50	8.51
CC 30	353.27	254.73	304.00	5.10	5.61	5.35	8.59	8.86	8.72	7.73	7.77	7.75
CC 28	338.73	250.20	294.47	6.07	6.08	6.08	8.60	8.77	8.68	7.70	7.77	7.74
CC 31	346.20	260.00	303.10	5.66	5.61	5.64	9.69	9.55	9.62	6.67	6.50	6.59
CC 3	675.87	526.27	601.07	4.47	5.13	4.79	5.48	5.63	5.55	3.52	3.83	3.68
CC 11	152.87	82.47	117.67	8.43	8.31	8.37	7.87	7.89	7.88	5.31	5.47	5.39
Mean	333.10	246.07	289.59	5.41	5.66	5.54	8.51	8.53	8.52	6.29	6.41	6.35
SE ± M	6.87	7.55	15.36	0.08	0.06	0.14	0.10	0.08	0.09	0.09	0.09	-
CD (0.05) (0.05)	20.41	22.41	44.09	0.23	0.19	0.39	0.30	0.25	0.28	0.27	0.25	-
SE (season)	6.87			0.06			NS			-		
CD (0.05) (season)	19.72			0.18			NS			-		

Table 14 Continued

Genotype	Pedicel length (cm)			Pedicel-fruit ratio			Yield per plant (g)			Driage (%)		
	Rainy	Summer	Mean	Rainy	Summer	Mean	Rainy	Summer	Mean	Rainy	Summer	Mean
CC 23	2.90	3.12	3.01	0.84	0.83	0.83	959.33	783.33	871.33	18.93	20.77	19.85
CC 13	2.75	2.97	2.86	0.52	0.51	0.52	1184.33	1008.00	1096.17	20.43	20.83	20.63
CC 7	2.80	3.19	2.99	0.53	0.54	0.53	762.00	718.00	740.00	22.63	23.23	22.93
CC 2	3.19	3.23	3.21	0.72	0.70	0.71	544.67	302.00	423.33	24.33	25.13	24.73
CC 15	4.35	5.86	5.10	0.76	0.79	0.78	862.67	546.00	704.33	29.53	21.83	25.68
CC 30	3.33	3.59	3.46	0.65	0.64	0.65	1319.33	1020.67	1170.00	21.47	22.33	21.90
CC 28	3.31	3.33	3.32	0.54	0.54	0.54	1080.00	963.33	1021.67	19.83	20.37	20.10
CC 31	3.71	3.49	3.59	0.65	0.62	0.64	1095.30	845.33	970.33	20.60	22.27	21.44
CC 3	4.30	4.50	4.40	0.96	0.88	0.92	1123.33	966.67	1045.00	23.37	23.27	23.32
CC 11	4.16	4.17	4.17	0.49	0.50	0.49	397.33	230.00	313.67	22.51	22.80	22.66
Mean	3.48	3.75	3.62	0.67	0.66	0.67	932.83	738.33	835.58	22.36	22.28	22.32
SE ± M	0.07	0.08	0.24	0.01	0.01	0.01	22.44	8.22	41.74	0.11	0.36	-
CD (0.05) (0.05)	0.21	0.22	0.67	0.04	0.04	0.04	66.69	24.42	119.83	0.33	1.06	-
SE (season)	NS			NS			18.67			-		
CD (0.05) (season)	NS			NS			53.59			-		

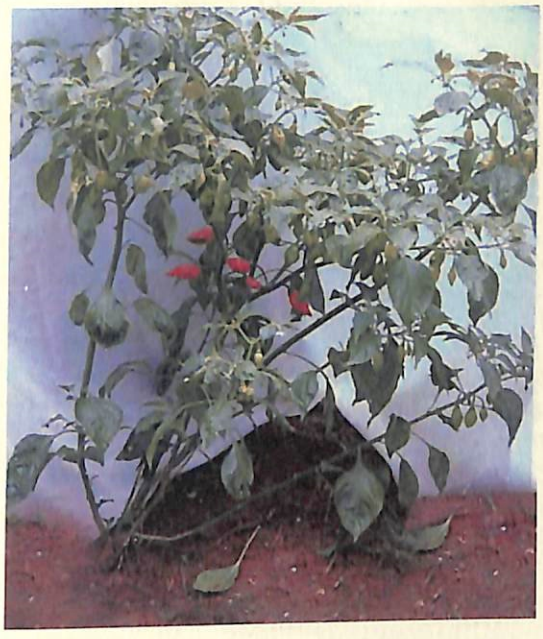


Plate 8 CC 3 – Genotype with maximum number of fruits per plant and maximum capsaicin content

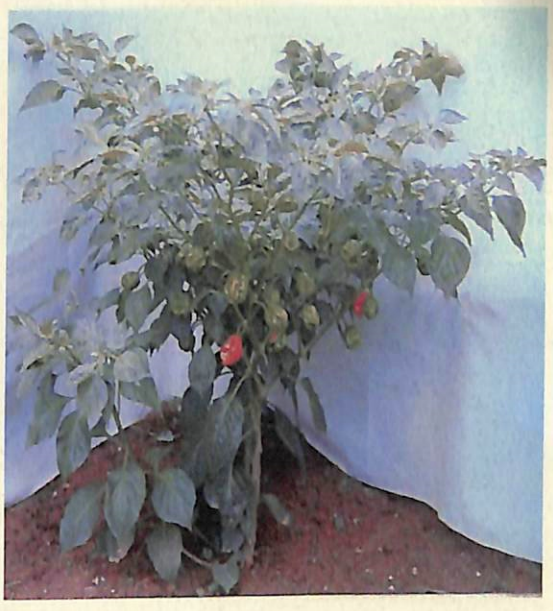


Plate 9 CC 30 – Genotype with maximum yield per plant

Plate 10 CC 28 – Genotype with maximum oleoresin content

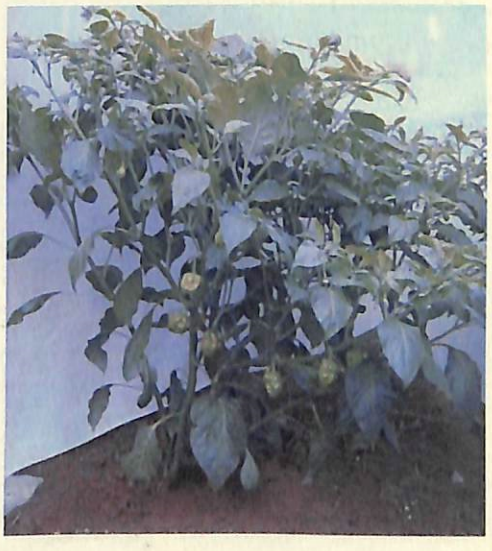


Plate 11 CC 7 – Genotype with maximum carotenoid and ascorbic acid content

and CC 11 had the lowest yield (397.33 g) in rainy season. During summer season, highest yield was obtained from CC 30 (1020.67 g) which was on par with CC 13 (1008 g). The lowest yield was from CC 11 (230 g). More yield was obtained during rainy season than summer season. Over all mean for yield per plant was 932.83 g for rainy and 738.33 g for summer season.

The genotype CC 30 was the highest yielder (Plate 9) which had 1170 g fruits per plant and CC 11 was the lowest with 313.67 g fruits per plant.

4.2.3.8 Driage

During rainy season, CC 15 had highest driage percentage (29.53) and CC 23 had lowest (18.93). In summer season CC 2 had maximum driage percentage of 25.13 and CC 28 had minimum of 20.37 per cent. In summer season a slight decrease in driage was recorded as compared to rainy season. The overall mean for driage in rainy season was 22.36 and in summer it was 22.28 per cent (Table 14).

4.2.4 Quality Characters

4.2.4.1 Capsaicin (%)

Maximum capsaicin was recorded from fruits of genotype CC 3 (3.18 and 3.58 per cent) and minimum from CC 23 (1.32 and 1.58 per cent) for rainy and summer season respectively (Table 15 and Fig. 4). In most of the genotypes capsaicin level increased in summer than rainy season. The overall mean for capsaicin was 2.41 for rainy and 2.57 for summer season.

In general, CC 3 (Plate 8) had the highest capsaicin content (3.38) and CC 23 had the lowest (1.45).

4.2.4.2 Oleoresin (%)

In rainy season, oleoresin content was highest in CC 2 (19.43 per cent) and lowest in CC 11 (7.53 per cent) (Table 15 and Fig. 4). During

Table 15 Mean performance of genotypes for capsaicin and oleoresin over season

Genotype	Capsaicin (%)			Oleoresin (%)		
	Rainy	Summer	Mean	Rainy	Summer	Mean
CC 23	1.32	1.58	1.45	8.47	10.07	9.27
CC 13	2.73	3.03	2.88	11.53	14.97	13.25
CC 7	2.52	2.72	2.62	13.37	17.57	15.47
CC 2	2.68	2.42	2.55	19.43	18.43	18.93
CC 15	1.61	1.98	1.80	9.07	11.53	10.30
CC 30	2.40	2.32	2.36	9.43	9.03	9.23
CC 28	2.57	2.56	2.57	17.93	21.53	19.73
CC 31	2.24	2.54	2.39	11.57	12.93	12.25
CC 3	3.18	3.58	3.38	8.53	12.03	10.28
CC 11	2.86	3.01	2.94	7.53	13.97	10.75
Mean	2.41	2.57	2.49	11.69	14.21	12.95
SE ± M	0.02	0.02	-	0.17	0.14	-
CD (0.05) (0.05)	0.07	0.06	-	0.49	0.42	-

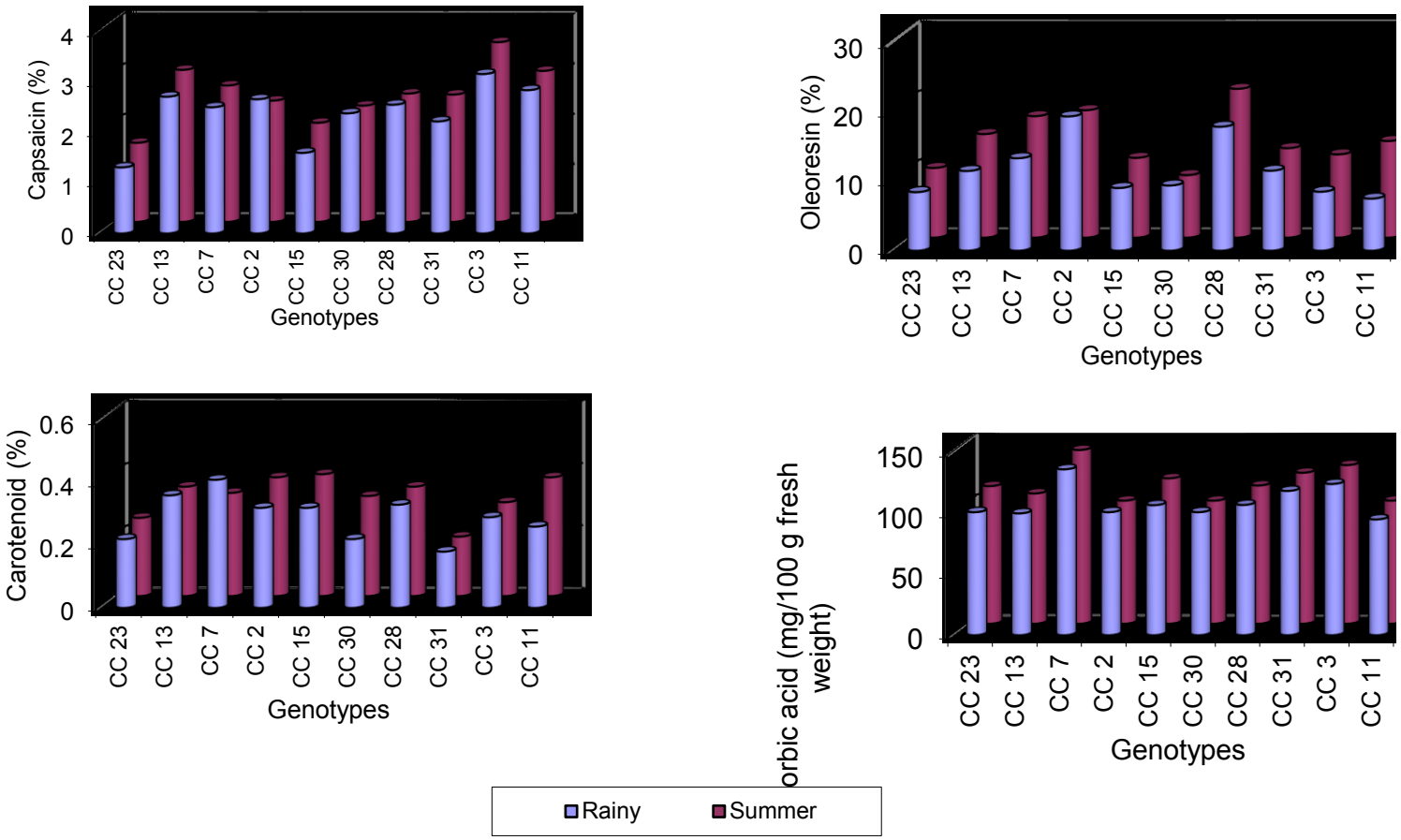


Fig.4 Seasonal influence on quality characters in *C. chinense*

summer season CC 28 had maximum oleoresin (21.53 per cent) and CC 30 had minimum (9.03 per cent). There was an increased oleoresin content in rainy season (Fig. 4). The overall mean for oleoresin content was 11.69 per cent for rainy and 14.12 per cent for summer season.

The genotype CC 28 had maximum oleoresin (19.73) (Plate 10) and CC 30 had minimum (9.23).

4.2.4.3 Carotenoids (%)

Highest carotenoids content was recorded by CC 7 with 0.41 per cent in rainy season and lowest by CC 31 with 0.18 (Table 16 and Fig. 4). During summer season, CC 15 had maximum carotenoid (0.39 per cent) which was on par with CC 2 and CC 11 each with 0.38 per cent. Minimum carotenoid content was recorded by CC 31 (0.19 per cent). Overall mean for carotenoid content was 0.29 per cent for rainy and 0.32 per cent for summer season.

Among genotypes, CC 7 (Plate 11) recorded maximum carotenoid content (0.37) which was on par with CC 13 and CC 15 each with 0.36 per cent. The minimum carotenoid content was recorded by CC 31 (0.19 per cent).

4.2.4.4 Ascorbic acid

In both rainy and summer seasons, highest ascorbic acid was recorded in CC 7 (136.45 and 142.86 mg per 100 g respectively). In rainy season, minimum ascorbic acid content was observed in CC 11 with 95.23 mg per 100 g fresh fruit. In summer season the genotypes CC 13, CC 2 and CC 11 recorded the lowest ascorbic acid content each with 101.18 mg per 100 g (Table 16 and Fig. 4). Its content increased in summer season as compared to rainy season. The overall mean for ascorbic acid content for rainy season was 109.25 mg per 100g of fresh fruit and for summer season was 115.44 (Fig. 4).

Table 16 Mean performance of genotypes for carotenoid and ascorbic acid over season

Genotype	Carotenoid (%)			Ascorbic acid (mg/100 g fresh weight)		
	Rainy	Summer	Mean	Rainy	Summer	Mean
CC 23	0.22	0.25	0.24	101.18	113.12	117.15
CC 13	0.36	0.35	0.36	100.18	107.12	103.65
CC 7	0.41	0.33	0.37	136.45	142.86	139.66
CC 2	0.32	0.38	0.35	101.18	101.18	101.18
CC 15	0.32	0.39	0.36	106.92	119.56	113.24
CC 30	0.22	0.32	0.27	101.18	101.18	101.18
CC 28	0.33	0.35	0.34	107.12	113.64	110.38
CC 31	0.18	0.19	0.19	118.68	124.15	121.42
CC 3	0.29	0.30	0.30	124.40	130.43	124.42
CC 11	0.26	0.38	0.32	95.23	101.18	98.21
Mean	0.29	0.32	0.31	109.25	115.44	112.35
SE ± M	0.003	0.002	-	1.44	1.15	-
CD (0.05) (0.05)	0.009	0.007	-	4.27	3.42	-

The highest ascorbic acid content was in genotype CC 7 (Plate 11) with 139.66 mg per 100g fresh fruit and lowest in CC 11 with 98.21.

4.3 INFLUENCE OF MATURITY STAGES ON QUALITY

Pooled analysis over different harvest maturity stages for the different quality characters are presented in Table 17. Mean performance of genotypes for quality characters over three different maturity stages are presented in Table 18, 19, 20 and 21 and Fig. 5 and 6.

4.3.1 Capsaicin (%)

In rainy season when fruits were harvested at turning stage (M_1) genotype CC 3 recorded maximum capsaicin content (3.02) and CC 23 recorded minimum (1.26). In summer season also CC 3 had the maximum capsaicin (3.32) and CC 23 had minimum (1.32).

At full ripe stage (M_2), CC 3 had the highest capsaicin content both in rainy and summer season (3.18 and 3.58 respectively) and CC 23 had the lowest capsaicin content (1.32 and 1.58 respectively).

When harvesting was done at withering stage (M_3), CC 3 had maximum capsaicin in both seasons (3.36 and 3.65 respectively) and CC 23 had minimum capsaicin (1.48 and 1.58 respectively).

Capsaicin content increased as the age of fruit increased and it was maximum in withering stage during the two seasons.

The interaction between season x maturity was significant for capsaicin content. Highest capsaicin was observed in summer season when fruits were harvested at withering stage. The interaction of genotypes with season and stages of maturity was also significant. Considering genotypes in relation to season and maturity stages, capsaicin was maximum for CC 3 (3.65) when harvested at withering stage during summer season.

Table 17 Pooled analysis of variance for quality characters over harvest maturity and over season

Source	d.f.	Capsaicin	Oleoresin	Carotenoid	Ascorbic acid
Genotype	9	5.42**	192.43**	0.05*	3234.92**
Maturity stage	2	1.58**	265.06**	1.70**	416.50**
Interaction (Genotype x maturity)	18	0.02**	5.74**	0.03**	22.40**
Season	1	1.35**	147.07**	2.02**	1582**
Interaction (season x genotype)	9	0.10**	13.79**	0.00**	101.36**
Season x Genotype x Maturity	18	0.01**	1.83**	0.00**	22.00**
Pooled error	118	0.001	0.07	0.00002	4.44

** Significant at 1 per cent level

Table 18 Mean performance of genotypes for capsaicin over maturity stages, per cent

Genotype	Rainy				Summer			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
CC 23	1.26	1.32	1.48	1.35	1.32	1.58	1.60	1.50
CC 13	2.54	2.73	2.80	2.69	2.96	3.03	3.20	3.06
CC 7	2.30	2.52	2.68	2.50	2.58	2.72	2.86	2.72
CC 2	2.12	2.68	2.50	2.43	2.28	2.42	2.54	2.41
CC 15	1.49	1.61	1.88	1.66	1.76	1.98	2.10	1.95
CC 30	2.18	2.40	2.44	2.34	2.20	2.32	2.38	2.30
CC 28	2.10	2.57	2.65	2.44	2.14	2.56	2.61	2.44
CC 31	2.06	2.24	2.38	2.23	2.36	2.54	2.60	2.50
CC 3	3.02	3.18	3.36	3.19	3.32	3.58	3.65	3.52
CC 11	2.65	2.86	2.95	2.82	2.83	3.01	3.12	2.99
Mean	2.17	2.41	2.51	2.36	2.37	2.57	2.67	2.54

	CD (0.05) values	SE values
Season (S)	0.01	0.00
Variety (V)	0.02	0.01
SV	0.03	0.01
Maturity (M)	0.01	0.00
SM	0.02	0.01
VM	0.04	0.01
SVM	0.05	0.02

4.3.2 Oleoresin (%)

The fruits from genotype CC 28 had maximum oleoresin (13.07 and 16.07 per cent) in rainy and summer season respectively when harvested at turning stage. During rainy season, CC 11 had minimum oleoresin per cent (5.97). The genotype CC30 recorded minimum oleoresin (7.07 per cent) in summer season.

At full ripe stage maximum oleoresin was recorded by CC 2 (19.43 per cent) in rainy season and by CC 28 (21.53 per cent) in summer season. The minimum oleoresin was recorded from CC 11 (7.53 per cent) in rainy season and from CC 30 (9.03 per cent) in summer season.

When fruits were harvested at withering stage, maximum oleoresin was obtained from CC 28 in both seasons with 20.5 and 22.33 per cent respectively. Minimum oleoresin was from CC 11 in rainy season (8.57 per cent) and from CC 23 in summer (11.07 per cent).

In both seasons, the oleoresin content was increased as the age of fruit increased.

Season × maturity interaction was significant for oleoresin content. Highest oleoresin was observed in summer season when fruits were harvested at withering stage. The interaction of genotypes with season and stages of harvest maturity was also significant. Considering genotypes with season and maturity stages, oleoresin was maximum for CC 28 when harvested at withering stage (22.33 per cent) during summer season.

4.3.3 Carotenoids (%)

At turning stage, CC 3 had highest carotenoid content (0.25 per cent each) and CC 31 had the lowest carotenoid content (0.13 per cent each) in both the seasons.

Table 19 Mean performance of genotypes for oleoresin over maturity stages, per cent

Genotype	Rainy				Summer			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
CC 23	8.10	8.47	8.97	8.51	8.53	10.07	11.07	9.89
CC 13	9.53	11.53	13.93	11.67	11.10	14.97	14.00	13.36
CC 7	10.03	13.37	15.07	12.82	12.53	17.57	18.93	16.34
CC 2	12.97	19.43	18.53	16.98	14.07	18.43	16.07	16.19
CC 15	7.53	9.07	10.97	9.19	8.93	11.53	12.97	11.14
CC 30	7.43	9.43	12.57	9.81	7.07	9.03	11.57	9.22
CC 28	13.07	17.93	20.50	17.17	16.07	21.53	22.33	19.98
CC 31	8.43	11.57	14.00	11.33	10.40	12.93	12.57	11.97
CC 3	7.50	8.53	10.53	8.86	10.03	12.03	12.60	11.56
CC 11	5.97	7.53	8.57	7.36	9.03	13.97	13.37	12.12
Mean	9.06	11.69	13.36	11.37	10.78	14.21	14.55	13.18

	CD (0.05) values	SE values
Season (S)	0.08	0.03
Variety (V)	0.18	0.06
SV	0.25	0.09
Maturity (M)	0.10	0.03
SM	0.14	0.05
VM	0.31	0.11
SVM	0.44	0.16

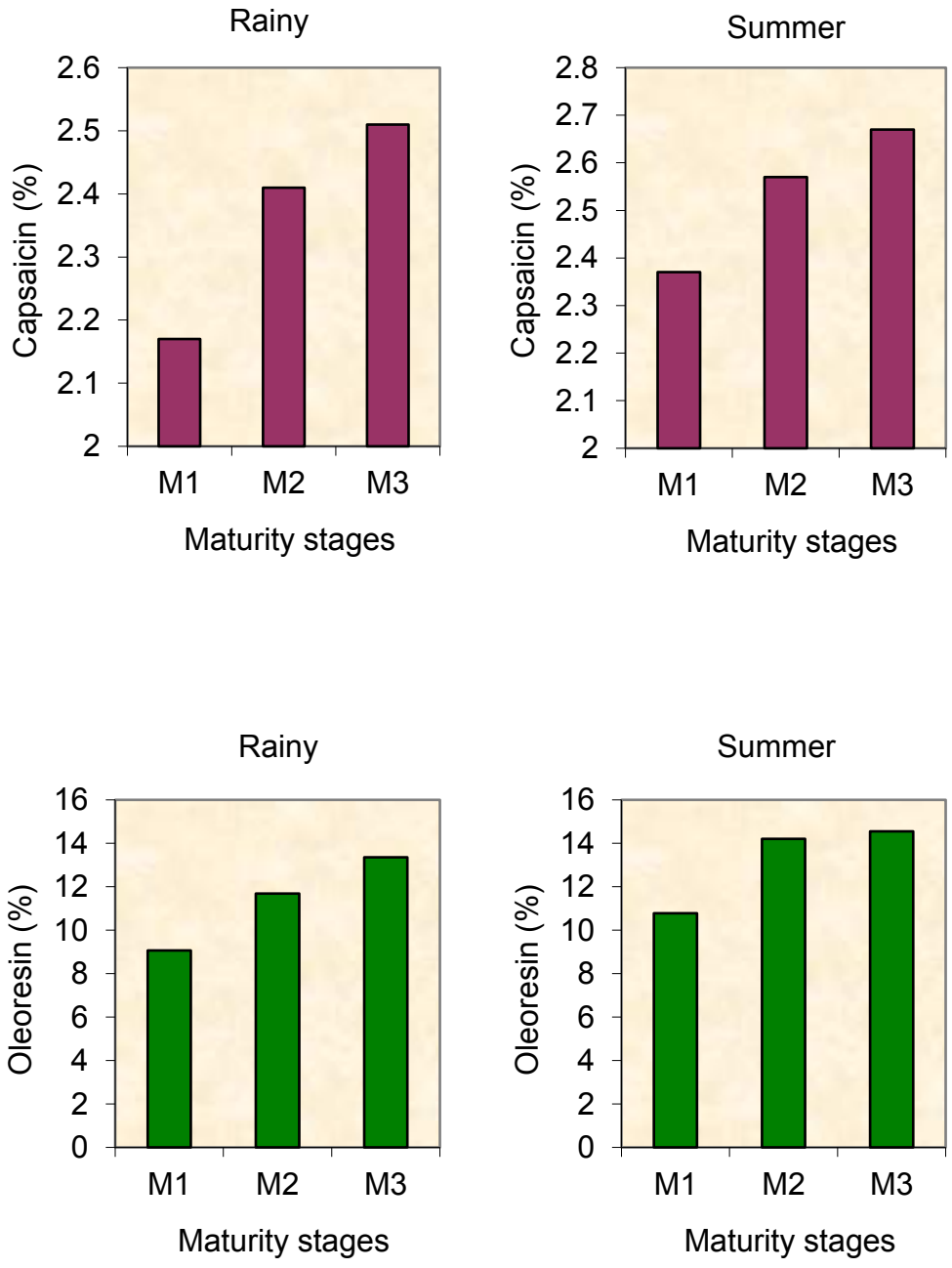


Fig. 5 Influence of harvest maturity on capsaicin

In red ripe stage, CC 7 had maximum carotenoids (0.41) in rainy season. In summer season, genotypes CC 2, CC 15 and CC 11 had maximum carotenoids with 0.38 per cent each. Genotype CC 31 had minimum carotenoids of 0.18 and 0.19 per cent in rainy and summer season respectively.

When harvesting was done at withering stage, CC 11 had maximum carotenoid content with 0.72 per cent in both the seasons. Genotypes CC 28 had minimum carotenoid (0.36 per cent) in rainy season. In summer season genotype CC 28 and CC 3 had minimum carotenoid content of 0.41 per cent.

Season x maturity interaction was significant for carotenoid content. Irrespective of season maximum carotenoid was observed in withering stage followed by red ripe and turning stage. Season x maturity x genotype interaction was also significant. Considering genotypes in relation to season and maturity stages, maximum colour was for CC 11.

4.3.4 Ascorbic acid (mg / 100 g)

When the chilli fruits were harvested at turning stage, genotype CC 7 had maximum ascorbic acid content of 130.12 and 136.70 mg per 100 g fresh weight in rainy and summer seasons. In rainy season, the minimum ascorbic acid content was from CC 11 (89.40) and in summer season from CC 2, CC 30 and CC 11 (95.23 each).

When harvested at red ripe stage, CC 7 had maximum ascorbic acid content of 136.45 and 142.86 respectively in rainy and summer seasons. CC 11 had minimum ascorbic content of 95.23 in rainy season and CC 2, CC 30 and CC 11 had minimum of 101.18 each in summer season.

In withering stage also CC 7 had maximum ascorbic content (136.59 and 142.61 mg/100g fresh weight) in rainy and summer season respectively.

Table 20 Mean performance of genotypes for carotenoid over maturity stages, per cent

Genotype	Rainy				Summer			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
CC 23	0.15	0.22	0.46	0.28	0.16	0.25	0.48	0.29
CC 13	0.16	0.36	0.60	0.37	0.14	0.35	0.58	0.36
CC 7	0.18	0.41	0.48	0.36	0.19	0.33	0.50	0.34
CC 2	0.14	0.32	0.43	0.29	0.14	0.38	0.48	0.34
CC 15	0.20	0.32	0.67	0.40	0.18	0.38	0.70	0.42
CC 30	0.21	0.22	0.41	0.28	0.22	0.32	0.46	0.33
CC 28	0.16	0.33	0.36	0.28	0.16	0.35	0.41	0.31
CC 31	0.13	0.18	0.42	0.24	0.13	0.19	0.44	0.25
CC 3	0.25	0.29	0.39	0.31	0.25	0.30	0.41	0.32
CC 11	0.15	0.26	0.72	0.38	0.14	0.38	0.72	0.42
Mean	0.17	0.29	0.49	0.32	0.17	0.32	0.52	0.34

	CD (0.05) values
Season (S)	0.001
Variety (V)	0.001
SV	0.001
Maturity (M)	0.001
SM	0.001
VM	0.01
SVM	0.01

Table 21 Mean performance of genotypes for ascorbic acid over maturity stages, mg/100 g fresh weight

Genotype	Rainy				Summer			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
CC 23	95.23	101.18	95.23	97.21	107.12	113.12	112.92	111.05
CC 13	95.23	100.18	106.31	100.57	101.18	107.12	101.18	103.16
CC 7	130.12	136.45	136.59	134.38	136.70	142.86	142.61	140.73
CC 2	101.18	101.18	95.23	99.20	95.23	101.18	95.23	97.21
CC 15	101.18	106.92	105.77	104.62	113.19	119.56	113.25	115.34
CC 30	95.23	101.18	95.23	97.21	95.23	101.18	101.18	99.20
CC 28	101.18	107.12	107.12	105.14	112.55	113.64	119.08	115.09
CC 31	113.97	118.68	113.33	115.33	119.54	124.17	113.24	118.98
CC 3	118.01	124.40	124.74	122.38	124.86	130.43	124.79	126.69
CC 11	89.40	95.23	89.26	91.30	95.23	101.18	101.18	99.20
Mean	104.07	109.25	106.88	106.74	110.08	115.44	112.47	112.66

	CD (0.05) values	SE values
Season (S)	0.62	0.22
Variety (V)	1.39	0.50
SV	1.97	0.70
Maturity (M)	0.76	0.27
SM	1.08	0.38
VM	2.41	0.86
SVM	3.41	1.22

Table 22 Reaction of genotypes towards bacterial wilt, per cent

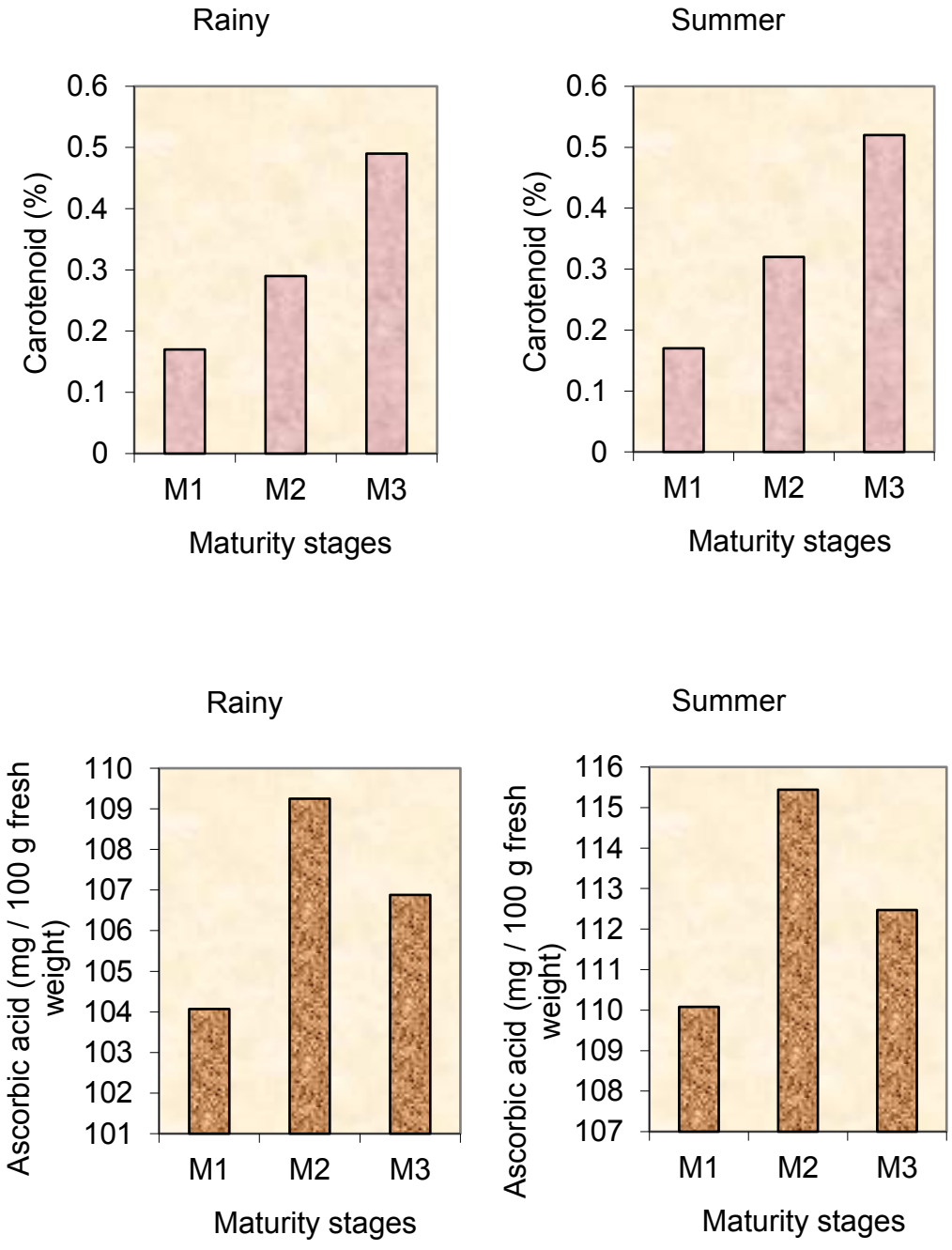


Fig. 6 Influence of harvest maturity on carotenoids and ascorbic acid of *C. chinense*

Minimum ascorbic acid (89.26) was recorded from CC 11 in rainy and from CC 2 (95.23) in summer season.

Interaction between season and maturity was significant. In both seasons, ascorbic acid increased from turning stage to red ripe stage and then declined in the withering stage. The interaction of season x maturity x genotype was also significant. Considering the genotypes in relation to season and maturity stages, maximum ascorbic acid was from CC 7 in summer season.

4.4 INCIDENCE OF DISEASES

4.4.1 Bacterial wilt

Incidence of bacterial wilt was maximum for CC 11 during rainy and summer season (35.36 and 29.09 per cent respectively). Minimum incidence was recorded by CC 31. Plants were seriously affected during rainy than summer. In general, CC11 was most susceptible whereas CC 31 was the most resistant genotype.

4.4.2 Leaf curl disease

The 'vulnerability index' for leaf curl incidence was maximum for CC 11 (78.63) and minimum for CC 7 (21.09). The genotype CC 3 was on par with CC 7 (23.37). Genotype CC 7, CC 3, CC 13 and CC 23 were resistant, CC 31 was moderately resistant and CC 28, CC 15, CC 2, CC 30 and CC 11 were susceptible.

Genotype	Rainy	Summer	Mean
CC 23	29.09 (5.49)	22.82 (4.88)	25.96 (5.19)
CC 13	14.45 (3.93)	20.74 (4.66)	17.60 (4.29)
CC 7	8.12 (3.02)	3.53 (2.13)	5.83 (2.58)
CC 2	14.45 (3.93)	20.73 (4.66)	17.62 (4.30)
CC 15	20.74 (4.66)	14.45 (3.93)	17.54 (4.30)
CC 30	16.53 (4.19)	3.53 (2.13)	10.03 (3.16)
CC 28	14.45 (3.93)	8.12 (3.02)	11.29 (3.48)
CC 31	0 (1.00)	1.45 (1.56)	0.73 (1.28)
CC 3	3.53 (2.13)	10.20 (3.34)	6.87 (2.74)
CC 11	35.36 (6.03)	29.09 (5.49)	32.23 (5.76)
Mean	15.67 (3.83)	13.47 (3.58)	14.57 (3.71)
SE ± M	0.29	0.35	-
CD (0.05) (0.05)	0.85	1.05	-

Table 23 Reaction of genotypes towards leaf curl disease

Genotype	Leaf curl incidence (V.I.)
CC 23	38.49
CC 13	29.24
CC 7	21.09
CC 2	69.37
CC 15	65.59
CC 30	71.95
CC 28	60.14
CC 31	51.98
CC 3	23.37
CC 11	78.63
Mean	50.98
SE ± M	1.71
CD (0.05)	5.09

Discussion

5. DISCUSSION

Hot chilli (*Capsicum chinense*) is an economically important crop valued for its perennial nature and highly pungent fruits with characteristic flavour. It has high capsaicin content and is an ideal source for the extraction of high pungency oleoresin. Oleoresin is fastly gaining momentum in the export market, replacing the dry chilli powder. The natural colour from chilli can very well be used for colouring food products. Green chillies are considered to be an important and rich source of ascorbic acid.

Productivity of chilli depends on external factors like weather conditions as well as internal physiological characters. In Kerala, the main seasons, *viz*., rainy and summer may have great influence on plant growth, flowering, fruit and quality characters of chilli. The stage of maturity is also an important factor affecting the chemical constituents of chilli fruits.

The present investigation was envisaged with the objectives of assessing the magnitude of genetic variability in *C. chinense* and for identifying superior genotypes for yield and quality based on season and stage of maturity.

5.1 VARIABILITY IN *C. CHINENSE* GENOTYPES

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 genotype 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 significant difference among the ten genotypes for all the characters studied namely, plant height, primary branches per plant, days to first flowering, days to harvest, fruits per plant, fruit length, fruit girth, fruit weight, pedicel length, pedicel-fruit ratio, yield per plant, driage, capsaicin, oleoresin, carotenoid and ascorbic acid. Such variation indicates the scope for improving the population for these characters as reported earlier by Hiremath and Mathapati (1977) and Kumar *et al*. (1993) in *C. annuum*.

High phenotypic and genotypic variances were observed for fruits per plant and yield per plant. Wide variation was observed in phenotypic and genotypic variances among the characters. For all the characters, genotypic variance formed the major portion of phenotypic variance with very little effect of environment.

High phenotypic and genotypic coefficients of variation (PCV and GCV) were observed for fruits per plant and yield per plant. Similar results were also reported by Cherian (2000) and Manju (2001). The high PCV and GCV observed for these characters in the present study are evident from their high variability which in turn offers good scope for selection. The lowest PCV and GCV were exhibited by days to harvest. 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.

The total variability existing in a population is a sum of heritable and non-heritable components and it is necessary to portion 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 per cent) was registered for fruits per plant, fruit length, fruit weight, yield per plant, fruit girth,

driage, capsaicin, oleoresin, carotenoid and ascorbic acid. Similar findings were also reported by Rajput *et al*. (1983) for fruits per plant and fruit yield, Singh *et al*. (1994) for fruit characters and Manju (2001) for quality characters like capsaicin, oleoresin and ascorbic acid content. High heritability estimates indicate the presence of large number of fixable additive factors and hence these fruits 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 characters including fruits per plant, oleoresin, yield per plant, carotenoid and primary branches per plant.

High heritability coupled with low genetic advance attributable to non- additive gene action was noticed for plant height and days to harvest.

On the basis of the present study it can be concluded that simultaneous selection based on multiple characters having high estimates of heritability and genetic advance may be of appreciable use in this crop.

Correlation provides information on the nature and extent of relationship between all pairs of characters. A study of correlation among yield and its components will be of great value in planning and evaluating breeding programme. In this study, both at phenotypic and genotypic levels, fruits per plant showed strong positive association with yield per plant. Days to first flowering was negatively correlated with yield. The very high positive association of fruits per plant with yield indicated that fruits per plant was the primary yield attribute in chilli. Similar reports were suggested by Sundaram and Irulappan (1998), Cherian (2000) and Manju (2001).

Plant height and primary branches per plant was positively correlated with fruits per plant. Production of increased vegetative growth like plant height and primary branches per plant lead to larger canopy of the plant resulting in increased fruits per plant.

High negative correlation of days to first flowering and days to harvest with fruits per plant and yield per plant were observed. Hence any selection aimed for earliness will be useful for improving yield and yield associated characters.

Fruits per plant showed high negative correlation with fruit length, fruit girth and fruit weight, confirming the findings of Kumar *et al*. (2003). This indicates that the increase in fruit size was associated with reduction in fruit number. Fruit girth showed high positive correlation with fruit weight.

Capsaicin content is positively correlated with fruit length, fruits per plant and negatively correlated with fruit girth, fruit weight and bacterial wilt. Hence selection based on these characters may be done to improve capsaicin content. A negative correlation of capsaicin with fruit girth and fruit weight was also reported by Kumar *et al.* (2003). Aiming at capsaicin improvement, selection of small fruited genotypes will reduce the fruit yield leading to decreased capsaicin output per unit area. Hence, the best alternate will be selection of genotypes with medium fruit weight and fairly good capsaicin content.

Oleoresin content showed positive correlation with days to harvest indicating that late varieties are rich in oleoresin content because they get more time for the accumulation of chemical constituents by metabolic inter conversion than the early varieties. Oleoresin had negative association with pedicel length and as oleoresin is absent in pedicel, more the pedicel length, the less will be the percentage of oleoresin.

Carotenoid content was positively correlated with oleoresin content because the carotenoids are the major component of oleoresin. Ascorbic acid content showed high negative correlation with plant height.

Yield is a complex qualitative 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 contributions 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 effect on fruit yield. Similar results were also reported by Cherian (2000) and Manju (2001) in *C. chinense*. Driage exhibited direct positive effect on fruit yield. Pedicel- fruit ratio and carotenoid had negative effect on fruit yield.

5.2 INFLUENCE OF SEASON

Ten *C. chinense* genotypes were evaluated in two seasons, *viz*., rainy and summer season. The correlation between fruit yield and its components, intercorrelation among different characters and the direct and indirect contributions of these characters on fruit yield were also worked out.

The results revealed significant difference for all the characters studied. Variability was attributed due to genetic as well as environmental factors. Season x genotype interaction was significant for almost all the characters analysed.

The genotype CC 3 was found as the tallest followed by CC 7 when the two seasons were considered together. All genotypes were taller in rainy season than summer season. The genotype CC 3 recorded maximum number of primary branches per plant in both the seasons. Here also the genotypes produced more number of primary branches during rainy season

than in summer season. High irradiance during summer may result in high rates of transpiration. Thus the internal deficiencies of water and its consequent retardation of cell division and cell enlargement may reduced height and number of primary branches during summer season (Meyer *et. al*., 1973).

Flowering is an indication of the transition of vegetative phase to the reproductive phase in plants. Early flowering is a favourable character. Genotype CC 13 was earliest in flowering and CC 30 was earliest for harvesting. In the present study genotypes were earlier in rainy season compared to summer season. This may be due to the increased growth and development observed in *C. chinense* during rainy season. However Mini (1997) reported that flowering was earlier in summer compared to rainy and winter season in *Capsicum* spp.

The season at which a plant grows control the productivity to a great extent. As far as the fruits per plant was concerned, significant variation observed in the present study among genotypes in both the seasons. CC 3 was the tallest genotype and had highest number of primary branches per plant. As the plant height and branching increases, more number of flowers will be produced and thus the fruits per plant increases. Obviously, genotypes had more fruits per plant during rainy season and CC 3 had more fruits. The reduction in number of fruits in summer may be due to the occurrance of disease.

Maximum fruit length was observed for the genotype CC 11 whereas maximum fruit girth and fruit weight was recorded by CC 15. Both fruit length and fruit girth contributed more to fruit weight in CC 15. Among the seasons, a slight increase was noticed in fruit length, girth and weight in summer season.

Pedicel in chilli is non edible and fruits with short pedicel is desirable. CC 13 had the lowest pedicel length in rainy and summer

seasons. Fruits with lowest pedicel-fruit ratio is best for drying purpose and thus for oleoresin and capsaicin extraction. CC 11 registered lowest pedicel-fruit ratio followed by CC 13. No significant difference on pedicel fruit ratio was observed due to season.

Yield is a complex character, which is the outcome of a number of genetic factors and environmental conditions. CC 30 was the highest yielder followed by CC 13 and CC 3 in both the seasons. Even though CC 3 had maximum fruits per plant, it had lower yield due to the small sized fruits. High yield per plant in CC 30 may be attributed to fruit size and more number of fruits per plant. Fruit yield was more in rainy season than summer season. The days are comparatively longer and warmer during summer months. The carbohydrate accumulation will be generally more during longer days of the summer and less amount will be utilised in respiration during short nights. Consequently, more amount of carbohydrate will available for growth and development under the warm humid conditions favouring the flowering and fruit set of tropical crops (Balbaa *et al.,* 1968). Eventhough the situation is like that, in the present study the plant height, primary branches per plant, fruits per plant, yield per plant etc. were less and genotypes were late in summer season. This may be due to the incidence of leaf curl virus in the summer season which drastically reduced the yield and yield attributing factors.

Genotype CC 15 had maximum driage per cent during rainy season. When the seasons were compared, there were not much variation in driage per cent which showed that driage per cent is not influenced by environment in *C.chinense*.

Pungency is considered as the most important quality trait in chillies. Capsaicin, the pungent principle of chilli is a condensation product of 3-hydroxy, 4-methoxy benzylamine and decylenic acid. Capsaicin has significant physiological action and is used in many pharmaceutical and

cosmetic preparations. Maximum capsaicin was recovered from the genotype CC 3. In the present study, the capsaicin content was more during summer season than rainy season. Moisture stress may increased the pungency of the fruits. Similar results were reported by Ohta (1962), Balbaa *et al*. (1968) and Mahendran and Bandara (2000).

Oleoresin represents the total flavour extracts of ground chilli. The results of the present study indicated significant variation between genotypes and season for oleoresin content. Highest oleoresin was obtained in CC 28 in summer season. Oleoresin content showed an increase in summer season than rainy season. This result is in agreement with Mini (1997). Waller and Nowacki (1978) pointed out that the highest alkaloid level in opium poppy was found under climatic condition of water stress.

Colour is a prized quality character of capsicums aesthetically rewarding with commercial importance. The principal colouring matter of chilli fruit is the carotenoid pigment. Capsaicin and capsorubin are the main pigments contributing red colour to chillies. In the present study, the high colour was in CC 7. In general, genotypes showed a slight increase in colour during summer season. Moisture stress and high temperature during summer season may impart more colour to the genotypes. Similar results were reported by Mahendran and Bandara (2000) in chilli.

Chillies are rich source of ascorbic acid or vitamin C. Maximum ascorbic acid was obtained from CC 7 in both the seasons. In the present study the genotypes showed an increase in ascorbic acid during summer season. However this is not in agreement with Mahendran and Bandara (2000), who reported that long term moisture deficits during the late vegetative, flowering, fruit setting and fruit ripening stage delayed ascorbic acid synthesis and its recovery.

Though the genotypes in the present study performed better in case of plant growth and yield during rainy season than summer, good quality fruits were obtained during summer season indicating that the low yield can be compensated by better quality in summer.

5.3 INFLUENCE OF MATURITY STAGES ON QUALITY

Fruits of ten *C. chinense* genotypes were evaluated for quality characters in three maturity stages *i.e.*, colour turning, red ripe and withering stage during rainy and summer seasons. Pooled analysis of variance showed that genotypes x maturity interaction was significant for all the quality characters.

The genotype CC 3 had maximum capsaicin in withering stage during summer. The present finding that chilli fruits were less pungent at turning stage, moderate at full ripe and highest at withering stage, was in agreement with Balbaa *et al*. (1968). Ahmed *et al*. (1987) reported that the capsaicinoid content increased with fruit maturation in relation to increase in dry matter content. Capsaicin is synthesized and accumulated in capsaicinoid secreting organs in placenta. The site of capsaicin synthesis and total capsaicin content are under genetic control. As the fruit matures, placenta also become mature and capsaicin content increases. At withering stage, moisture content of fruit may be reduced as compared to turning stage and thus the percentage of capsaicin increased.

Oleoresin content was highest in CC 28 in withering stage during summer season. Oleoresin increased as the age of fruit increased. This is in agreement with Sheela *et al*. (2001) who reported that oleoresin content was more in red ripe fruits of *C. frutescens* than in mature green fruits. Mini and Vahab (2002) reported that oleoresin recovery was high in fruits of *Capsicum* spp at withering stage than red ripe and turning stage. The oleoresin comprises of capsaicin, pigments, fixed oil, sugars and resin.

An increase in these constituents would lead to increase in oleoresin content as fruit matures.

Among the genotypes evaluated for carotenoid, CC 11 had the highest carotenoid at withering stage during rainy and summer seasons. In general the genotypes exhibited highest colour at withering stage, moderate at full ripe and lowest at turning stage. The results of Lease and Lease (1956), Benedek (1972) and Mini (1997) support the present results. The deepening of chilli colour at withering stage was ascribed to drying which is accomplished by the subsequent formation of colouring matter. The pigment content increases in relation to the increase in dry matter as reported by Benedek (1972).

The fruits of genotype CC 7 had maximum ascorbic acid content during red ripe stage of summer season. There was a continuous increase in ascorbic acid content of chilli fruits upto red ripe stage and then it declined towards withering stage. This result is in agreement with Lalithakumari *et al.* (1999) and Gnayfeed *et al.* (2001) who reported that with the advance in ripening, ascorbic acid reached their maximum level at the red ripe stage and then declined in *C. annuum*. The ripened fruits contained higher ascorbic acid content than mature green fruits. When the drying of ripened fruits begins, ascorbic acid content declines due to biochemical changes occurred during drying.

In general, the fruits left in plant for withering had high colour, pungency and oleoresin, but low in ascorbic acid. Thus the quality attributes like capsaicin, oleoresin and colour are better during withering stage, indicating the importance of delayed harvest in *C. chinense* when the crop is raised exclusively for oleoresin and capsaicin production. The nutritive value depends on ascorbic acid content which is maximum in red ripe stage projecting that the red fruits can be utilized at vegetable purpose for getting more vitamin.

5.4 INCIDENCE OF DISEASES

Bacterial wilt in chilli is a serious problem in South India. The incidence was more in CC 11. Genotype CC 31 was the highly resistant one. During rainy season, the disease was more serious in the crop. Application of *Pseudomonas fluorescens* managed the disease spread during rainy season. The soil drenching, seedling dip and periodical application of this organism in the field controlled the disease during summer season. The disease was favoured by high soil moisture which helped in dispersal of bacteria. A warm and wet soil was conducive for invasion and development of the disease (Singh, 1975).

Leaf curl is another serious disease affecting chilli and is a major constraint in chilli cultivation in Kerala. In the present study significant differences observed among the genotypes for leaf curl incidence indicated clearly the importance of resistance breeding in *C. chinense*. CC 7 and CC 3 were resistant and CC11 and CC 30 were susceptible. The disease occurred more in summer probably the high temperature resulted in increase in the vector population.

Summary

6. SUMMARY

The present investigation on "Quality characterization of hot chilli (*Capsicum chinense* Jacq.) genotypes in rainy and summer seasons" was conducted at the research plot of the Department of Olericulture, College of Agriculture, Vellayani during the period 2002 to 2003.

The study envisaged with the objectives of assessing the magnitude of genetic variability in *C.chinense* and for identifying superior genotypes for yield and quality based on season and stage of maturity.

The experimental material consisted of ten genotypes initially tested for its feasibility. The experiment was laid out in a randomised block design with three replications during rainy and summer seasons. Evaluation was done for plant growth, flowering, yield and quality characters. The fruits were harvested at three maturity stages and evaluated for quality characters like capsaicin, oleoresin, carotenoid and ascorbic acid content.

Significant differences were observed among the genotypes in two seasons for all the characters studied *viz*., plant height, primary branches per plant, days to first flowering, days to harvest, fruits per plant, fruit length, fruit girth, fruit weight, pedicel length, pedicel-fruit ratio, yield per plant, driage, capsaicin, oleoresin, carotenoid, ascorbic acid and incidence of bacterial wilt and leaf curl.

The experimental data of rainy season were used for the assessment of variability, correlation and path coefficient analysis.

High coefficients of variation [phenotypic (PCV) and genotypic (GCV)] were recorded for fruits per plant, oleoresin content and yield per plant. The lowest PCV and GCV were exhibited by days to harvest.

High heritability coupled with high genetic advance was observed for fruits per plant, oleoresin content and yield per plant indicating scope for improvement of these characters through selection.

Correlation studies revealed that at both phenotypic and genotypic levels, characters like fruits per plant was positively correlated with yield per plant. Days to first flowering had negative correlation with yield.

Path coefficient analysis indicated that fruits per plant exerted the maximum positive direct effect (1.0453) followed by driage (0.5801) and plant height (0.1470). Pedicel fruit ratio had maximum negative effect (-1.2968) on yield. The indirect effects through fruits per plant was consistently high signifying the importance of that characters.

Significant variation among two seasons was observed for primary branches per plant, days to first flowering, days to harvest, fruit length and yield per plant. Quality characters showed significant difference among genotypes, seasons, maturity stages and their interactions.

Characters like plant height, primary branches per plant, fruits per plant and yield per plant were maximum in rainy season. The genotypes were found late in summer for flowering and harvesting. Fruit length, fruit girth, fruit weight, pedicel length, pedicel-fruit ratio and driage showed slight variation with season. Quality characters like capsaicin, oleoresin, carotenoids and ascorbic acid increased in summer than rainy season.

Maximum plant height was for CC 3 in rainy season and CC 7 in summer season. Primary branches per plant was maximum for CC 3 in

rainy and summer seasons. Genotype CC 13 was the earliest to flower and CC 30 was the earliest to harvest in both the seasons.

In both the seasons, maximum fruits were produced by CC 3 and maximum yield by CC 30. Genotype CC 15 had maximum fruit weight.

Significant difference for fruit girth, pedicel length, pedicel-fruit ratio was observed among the genotypes under the two seasons. However no significant difference was observed for these characters under two seasons indicating that the characters were controlled by genetic factors and not by environment.

CC 3 had maximum capsaicin in both the seasons. CC 28 had maximum oleoresin content in both the seasons. Maximum carotenoid content was recorded by CC 7 in two seasons. Ascorbic acid was more in CC 7 in rainy season than summer.

Quality characters like capsaicin, oleoresin and carotenoid content increased as age of fruit increased. They showed a pattern of turning stage < red ripe < withering stage. Whereas ascorbic acid content increased upto red ripe stage and then it declined towards withering stage.

Genotype CC 3 had highest pungency at withering stage in summer season. Maximum oleoresin was for CC 28 at withering stage of summer season. CC 11 recorded maximum carotenoid content at withering stage in both the seasons. Ascorbic acid was maximum for CC 7 in summer at red ripe stage.

Bacterial wilt disease was serious in rainy season and it was managed in summer season. CC 11 was most susceptible whereas CC 31 was the most resistant genotype. Leaf curl disease occurred only in summer and CC 11 was most susceptible and CC 7 was resistant.

The present investigation has enlarged the vision and lead to the understanding of the performance of hot chilli genotypes under two seasons. Chilli genotypes had good quality under summer season and capsaicin, oleoresin and carotenoid was more at withering stage whereas ascorbic acid was more at red ripe stage. Yield was more in rainy season than summer season. It is hoped that the information generated will be useful in selecting high yielding varieties, best season of cultivation and stage of harvest.

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*Original not seen

QUALITY CHARACTERIZATION OF HOT CHILLI (*Capsicum chinense* Jacq.) GENOTYPES IN RAINY AND SUMMER SEASONS

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Abstract of the
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ABSTRACT

The research project "Quality chracterization of hot chilli (*Capsicum chinense* Jacq.) genotypes in rainy and summer seasons" was carried out in the Department of Olericulture, College of Agriculture, Vellayani during 2001 to 2003. The objectives of the study were assessing the magnitude of genetic variability in *C. chinense* and for identifying superior genotypes for yield and quality based on season and stage of maturity.

Ten selected superior genotypes obtained from the preliminary germplasm evaluation trial were used for the study in the two seasons.

Analysis of variance revealed significant difference among the genotypes for all the characters studied in both seasons. In rainy season high PCV and GCV were recorded for fruits per plant followed by oleoresin. High heritability coupled with high genetic advance was observed for fruits per plant, oleoresin content and yield per plant. Correlation studies and path coefficient analysis revealed that fruits per plant is the primary yield component as evidenced from its high positive correlation as well as high direct and indirect effects on yield.

Significant variation among two seasons was observed for primary branches per plant, days to first flowering, days to harvest, fruit length and yield per plant. The genotypes were generally late in summer for flowering and harvesting. Genotype CC 13 was the earliest in flowering and CC 30 in harvesting in both the seasons. Fruits per plant and yield per plant was maximum in rainy season. In both the seasons, maximum fruits were produced by CC 3 and maximum yield by CC 30. Genotype CC 3 had maximum capsaicin, CC 28 had maximum oleoresin and CC 7 had maximum carotenoid and ascorbic acid content.

Quality characters showed significant difference among genotypes, season, maturity and their interactions. Genotypes had good quality in summer. Capsaicin, oleoresin and carotenoid increased as age of fruit increased and reached the maximum at withering stage, whereas ascorbic acid was increased upto red ripe stage and then declined.

Bacterial wilt was serious during summer and leaf curl disease during rainy season.