EVALUATION OF HYBRIDS FOR YIELD AND QUALITY IN CHILLI (*Capsicum annuum* L.)

by

AISWARYA C. S

(2014 - 12 - 112)

THESIS

Submitted in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF OLERICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM – 695 522
KERALA, INDIA

2016

DECLARATION

I, hereby declare that this thesis entitled "Evaluation of hybrids for yield and quality in chilli (*Capsicum annuum* L.)" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society

Aiswarya C. S
22/9/2016

Vellayani,
Date 22/9/2016

Aiswarya. C. S
(2014 -12-112)

CERTIFICATE

Certified that this thesis entitled **"Evaluation of hybrids for yield and quality in chilli (*Capsicum annuum* L.)"** is a record of research work done independently by Miss Aiswarya C S under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her

Sreelatha
22/9/16

Vellayani,
Date 22-9-16

Dr. I. Sreelathakumary
(Major Advisor, Advisory Committee)
Professor (Department of Olericulture)
College of Agriculture
Vellayani

CERTIFICATE

We, the undersigned members of the advisory committee of Miss Aiswarya C S, a candidate for the degree of **Master of Science in Horticulture** with major in Olericulture, agree that the thesis entitled **"Evaluation of hybrids for yield and quality in chilli (*Capsicum annuum* L.)"** may be submitted by Miss Aiswarya C S, in partial fulfilment of the requirement for the degree

23/9/16

Dr. I. Sreelathakumary
(Chairman, Advisory Committee)
Professor (Olericulture)
Department of Olericulture
College of Agriculture, Vellayani
Thiruvananthapuram- 695522

23/9/16

Dr.V. A. Celine
(Member, Advisory Committee)
Professor and Head
Department of Olericulture
College of Agriculture, Vellayani
Thiruvananthapuram- 695522

Dr. P. Manju
(Member, Advisory Committee)
Professor and Head
Department of Plant Breeding & Genetics
College of Agriculture, Vellayam
Thiruvananthapuram- 695522

22/9/2016

Dr. C.R. Sudharmai Devi
(Member, Advisory Committee)
Professor
Department of Soil Science &Agricultural Chemistry
College of Agriculture, Vellayani
Thiruvananthapuram- 695522

22/9/16

EXTERNAL EXAMINAR
Dr Pitchaimuthu M
Principal Scientist
Division of Vegetable Crops
ICAR-IIHR
Hessarghetta Lake post
Bengaluru

ACKNOWLEDGEMENT

This Thesis will be incomplete without expressing my deep sense of gratitude and indebtedness to God Almighty for all the blessings showered on me all throughout

I am very happy and grateful to express my thanks to my chairman Dr I Sreelathakumary Professor Department of Olericulture, for her valuable guidance, critical supervision, encouragement, unfailing patience, understanding nature and timely support during the course of this investigation and preparation of thesis I consider myself fortunate for getting this opportunity to work with such a great teacher

I express my profound gratitude to Dr V A Celine Professor and Head, Department of Olericulture, for her explicit instruction, affectionate advices, constant encouragement, valuable suggestions rendered during the course of my study

I cordinally offer my sincere and heartfelt gratitude to Dr P Manju Professor and Head, Department of Plant Breeding and Genetics for giving me suggestions and guidance during thesis work

I wish to express my gratefulness to Dr C R Sudharmai Devi Professor, Department of Soil Science and Agriculturl Chemistry for her support and valuable advices throughout the course of research programme

I am extremely thankful to Dr S Sarada Assistant Professor Department of Olericulture for her kind treatment, affection and constant care

I would like to place my special thanks to Dr Abdul Vahaab, for constant encouragement and his expert advice during the project work

I express my sincere thanks to non-teaching staff members of Department of Olericulture, Saji chettan, Ajitha chechi and all the laborers for their sincere work during the field experiment

I express my sincere thanks to the authorities of Kerala Agricultural University for granting me KAU Research Fellowship and other facilities for the conduct of research work

Words are inadequate to express my sincere thanks to Nisha chechi and Pritam chechi for their selfless help moral support and constant encouragement throughout the period of my study

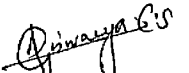
My grateful thanks to my seniors Litty Varghese, M Nagaraju and Vijeth S for their immense help and suggestions rendered at critical stages

My special thanks to Feba Varghese for her sincere help during my field experiment

I wish to express my sincere thanks to my friends Jaffin, Shweta, Lakshmi, Saranya, Shalini, for their undying love constant encouragement and support

I am deeply indepted to my Mother for being a source of inspiration and for her constant encouragement, sustained interest, patience and blessings without which I would not have completed this endeavor

Finally, I wish my humble thanks to one and all who have directly or indirectly contributed to the conduct of the study



Aiswarya C S

CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF ABBREVIATIONS

%	-	per cent
µg	-	Micro gram
ANOVA	-	Analysis of variance
ASTA	-	American Spice Trade Association
a m	-	Anti meridian
BP	-	Better parent
CD (0 05)	-	Critical difference at 5 % level
cm	-	centimeter
DAT		Days after trasplanting
d f	-	Degrees of freedom
et al	-	And co-workers/co-authors
F_1	-	First filial generation
g	-	gram
HB	-	Heterobeltiosis
kg	-	kilogram
KAU		Kerala Agricultural University
mm	-	Milli meters
MP	-	Mid parent

NBPGR	-	National Bureau of Plant Genetic Resources
RH	-	Relative heterosis
SE	-	Standard error
S E D	-	Standard error difference
S E M	-	Standard error mean
SH	-	Standard heterosis
t	-	tonne
viz	-	namely

LIST OF ILLUSTRATIONS

Introduction

1. INTRODUCTION

Chilli (*Capsicum annuum* L) is an important vegetable cum condiment crop having immense commercial as well as therapeutic value It is orginated from Tropical America The crop was introduced to India by the Portuguese in the 16th century AD and by the 19th century its cultivation spread throughout the country *Capsicum annuum* is the most common cultivated species All the green chillies in the market and most dry chillies belongs to this group It belongs to the family Solanaceae having chromosome number (2n =24)

Chilli has now emerged as a commercial crop at the global level Chilli is valued in the world for the pungency, colour and aroma Chilli forms an indispensable vegetable in the diet of the people of India India is the leading country in production and consumption of chilli In India Andhra Pradesh accounts for the major share of chilli production followed by Karnataka, Orissa, Maharashtra, West Bengal, Rajasthan and Tamil Nadu The genus Capsicum consists of 22 wild and 5 cultivated species The cultivated species are *Capsicum annuum, Capsicum frutescens, Capsicum chinense, Capsicum baccatum* and *Capsicum pubescens* Among the five cultivated species *Capsicum annuum, Capsicum frutescens* and *Capsicum chinense* are widely cultivated in Kerala

Even though India ranks first in area and production of chilli the productivity is low Hybridization is the most potent technique for breaking yield barriers in any crop Heterosis breeding provides an opportunity to increase productivity in chilli The primary objective of heterosis is to achieve high yield potential and good quality aspects of the crop plants Commercial hybrids are becoming popular than the open pollinated cultivars because of superiority in yield and quality traits Hybrids are becoming popular in many crops as they give an opportunity to utilize the synergistic effect of a genetic combination

For a systematic breeding program it is essential to identify the parents as well as crosses to bring the genetic improvement in economic character The magnitude of heterosis depends on the genetic diversity existing between the parents In a crop like chilli, where there are evidences for polygenic action

determining the yield, and the yield components the choice of parents must be based on refined biometrical techniques The value of genotypes depends on the ability to produce superior hybrids in combination with other genotypes

In chilli variability is due to the ability to cross pollinate which provides possibility to improve the yield and other quality attributes through the breeding program To exploit the available variability through the breeding program the genetic study regarding the yield and quality trait is very essential

The yield in chilli is due to the interaction between many of the correlated characters Selection of these characters is very important when based on the component characters which will be highly heritable and also positively correlated The correlation coefficient method of analysis helps to identify the mutual relationship between several characters and it also helps to identify the component traits on which selection can be relied Correlation studies provides information on all characters which are associated with yield

A hybrid possessing higher yield, better quality will be an important contribution to farmers An ideal chilli hybrid should be vigorous, have good branching habit, early flowering, prolonged production of flowers, high fruit weight, good plant height and high yield potential It may be difficult to develop a hybrid having all these characters but it is reasonable to develop one which can have maximum number of desirable characters keeping yield as a primary motto

Hence, the present study was undertaken with the following objectives

1 Evaluation of hybrids for yield attributes
2 Evaluation of hybrids for quality characters
3 To estimate the heterosis for yield and quality attributes
4 To estimate the correlation between the yield and yield contributing traits

Review of Literature

2. REVIEW OF LITERATURE

Chilli (*Capsicum annuum* L) is an important vegetable crop which is widely cultivated in India as well as in many countries across the world But the average productivity is relatively low therefore for enhancing its productivity development of hybrids through sound breeding program is much necessary F_1 hybrids are becoming very popular due to their vigour, uniformity, disease resistance, stress tolerance and good traits which includes earliness, long shelf life, and stable and high yield (Sood and Kumar, 2010) Diallel is the mating design which is most commonly used for the estimation of genetic parameters

Relevant literature for the present study in chilli are described under the following headings

2 1 HETEROSIS FOR YIELD

The term heterosis refers to the increase in size and yield of the cross breds as compared to the corresponding inbred lines (Shull, 1948) Maximum heterosis is recorded in F_1 generation but the dominance of the progeny over their respective parents is lost in subsequent generation which can be obtained through successive selfing (Meyer *et al* , 2004) Based on the criteria used to compare the performance of the hybrids heterosis can be of three types (Gupta, 2000) they are relative heterosis, heterobeltiosis, and standard heterosis

In chilli, hybrid seed production is economical since the fruits contain more number of seeds and in chilli the natural cross pollination extents upto 7 to 68 % (Sekar and Arumugam, 1985) Heterosis in chilli was first reported by (Deshpande, 1933) for the traits such as earliness, plant height, fruit girth, fruit plant ^{1} and yield plant ^{1}

Bhagyalakshmi *et al* (1991) observed negative standard heterosis in fourteen hybrids among fifteen hybrids for days to first flowering and relative heterosis for number of fruits They also reported that crosses between LCA 208

× LCA 960, LCA 206 × LCA 1079, LCA 960 × X 235 and X 235 × G_4 recorded maximum heterosis value for fruit yield in chilli

Ahmed *et al* (1999) crossed six pepper cultivars viz , Elephant Trunk, Pusa Jwala, Shalimar Long, SPE-1, Punjab Lal and G-4 in all possible combinations without reciprocals and found that high heterosis over better parent for yield and earliness in the crosses Shalimar Long × Punjab Lal, Elephant Trunk × Shalimar Long and Shalimar Long × SPE-1

Lohithaswa *et al* (2000) observed significant desirable heterosis in twenty hybrids for the trait flesh to seed ratio, fruit weight, fruits plant ^{1} CA-342 recorded maximum standard heterosis for the trait flesh to seed ratio

Malathi (2001) observed highly significant positive heterosis over the mid, better and best parents for number of fruits plant ^{1} and plant height and revealed a significant heterosis over mid, better and best parents in the cross CA86-1 × CA84 for dry fruit weight and CA 86-2 × CA 84 for number of branches plant^{-1}

Patel *et al* (2001) estimated the heterosis based on the mean performance of the chilli hybrids The hybrid S-49 x DPS-120 recorded significant standard heterosis 15 36 per cent for the trait green fruit yield plant^{-1} The maximum relative heterosis and heterobeltiosis were shown by the hybrid G-4 x Anand Chilli

Performance and heterosis of two hybrids of chilli for qualitative traits in three different seasons were studied by Malathi and Veeraraghavathatham (2004) The performance of all quality traits were higher than their parents Among hybrids CA-867 x CA-84 showed highly significant and positive over better and best parents in all seasons for all traits

Jagadeesha and Wali (2004) studied genetics of dry fruit yield and its components in 45 hybrids and 18 divergent lines and reported six parents, Byadagi Kaddi, VN-2, Arka Lohith, KDC-1, LCA-312, Pusa Jwala were good combiners for dry fruit yield and important yield contributing characters

Lankesh kumar (2005) estimated heterosis for different characters in chilli Among the seventy two hybrids thirty hybrids showed desirable heterosis for the trait fruit yield The superior hybrids identified for fruit characters and yield were Co-1 x Byadagi dabbi, Co-1 x Lokur local, G-3 x Lokur local and G-4 x Byadagi dabbi

Geleta and Labuschangne (2006) observed highly significant desirable heterosis over the better parent for flesh thickness, fruit weight and yield attributes among the twenty one hybrids evaluated

Shankarnag *et al* (2006) studied heterosis for growth, earliness, and early green fruit yield in chilli and reported that the crosses L3 × T15 was found superior for plant height, L1 × T16 for number of secondary branches, L1 × T14 for days to first harvest and L5 × T14 for early green fruit yield Superior crosses also showed maximum heterosis over the two check hybrids Maximum heterosis was shown by the cross L5 × T14 for green fruit yield plant ^{1}

Shekhawat *et al* (2007) reported heterosis for fourteen different characters in chilli hybrids Among the eighteen hybrids twelve hybrids showed desirable heterobeltiosis for yield and yield related traits

Yield and yield related characters were studied in fourteen parents and their crosses by (Ganesh Reddy *et al* , 2008) and reported that for the trait dry fruit yield plant ^{1} the heterobeltiosis ranged from -56 87 to 88 27 per cent and standard heterosis ranged from -62 18 to 60 51 per cent

With the six diverse genotypes Arka Lohit, MDU Y, S 1, Arka Abir, Bydagi Kaddi and Co 4 different hybrids were made which were evaluated for yield and quality characters For the character dry fruit yield hectare ^{1} the heterobeltiosis ranged from 40 35 to 126 32 per cent The hybrid Byadaggi Kaddi x Arka Abir and MDU Y x Co 4 were identified as superior for quality traits (Prasath and Ponnuswami, 2008)

Twelve genotypes of hot pepper were crossed in half diallel manner The standard heterosis for the trait dry fruit yield plant ^{1} ranged from -52 67 to 92 05 per cent and the heterosis over the better parent ranged from -52 67 to 161 79 per cent (Fekadu *et al* , 2009)

Kamble *et al* (2009) estimated the magnitude of heterosis in forty five hybrids in chilli Four hybrids showed significant heterosis over the commercial check variety for yield attributes The standard heterosis for the trait green fruit yield plant ^{1} ranged from -61 59 to 69 59 per cent

Patel *et al* (2010) studied heterosis for green fruit yield and other related characters in chilli in a line x tester fashion involving five GMS lines and 10 testers Six hybrids exhibited higher magnitude of heterobeltiosis and standard heterosis for yield related traits For the trait green fruit yield plant ^{1} heterobeltiosis ranged from -36 33 to 197 55 per cent and standard heterosis ranged from 21 47 to 448 55 per cent

Patil *et al* (2012) reported the heterosis studies in chilli for yield and quality traits Eight diverse parents were crossed in half diallel manner for obtaining twenty eight hybrids For trait green fruit yield plant ^{1} seven hybrids recorded heterosis over the better parent which ranged from -35 37 to 90 57 per cent and four hybrids recorded positive standard heterosis which ranged from -63 23 to 41 49 per cent

Pandey *et al* (2012) studied the magnitude of heterosis for yield and yield attributing traits in chilli Sixty six hybrids were produced from twelve parents crossed in diallel mating design Among the hybrids twenty hybrids exhibited significant positive heterosis for yield plot ^{1}

Twenty cytoplasmic genetic male sterility (CGMS) based F_1 hybrids, three promising genotypes and a check were evaluated in three different environments for stability analysis of chilli by Tembhurne and Rao (2012) Considering all the stability parameters, JCH-47, BCH-24 and BVC-37 exhibited wider stability for dry fruit yield plant ^{1}, JCH 01 had stability for favourable environment and JCH-05, JCH-14, JCH-23, JCH-24, JCH-54 and RCH-23 showed below average stability Highest performing F_1 hybrid JCH-54 was identified as stable performer under unfavourable environment for dry fruit yield

Thirty five genotypes consisting of 10 parents and 25 F_1 hybrids were evaluated for yield and quality traits by Chaudhary *et al* (2013) Among the hybrid CA-867 x CA-84 showed highly significant and positive heterosis over better and best parents in all seasons for all traits

Genetic expression of CMS based hybrids for yield and its attributing traits in chilli was studied by Krishna *et al* (2013) Eight chilli genotypes including four lines consisting of three CMS line and one fertile line were selected Based on evaluation three chilli hybrids were found to be superior hybrids for yield and its attributing traits

Estimation of heterosis for days to first flower, days to harvest and fruit yield was done by Sharma *et al* (2013) in chilli A wide range of heterosis was reported over better parent and standard check in F_1 generation for days to first flower, days to harvest and fruit yield characters

Afroza *et al* (2014) studied heterosis for fruits plant^{-1}, flesh to seed ratio and other characters in chilli Ten lines of chilli were crossed in diallel fashion for producing forty five hybrids Among the hybrids thirty two hybrids showed higher magnitude of relative heterosis, heterobeltiosis and standard heterosis for traits fruits plant^{-1} and flesh to seed ratio

Darshan (2014) observed the heterotic behaviour of hybrids for various traits For the trait yield plot^{-1} all the thirty hybrids recorded significant positive heterosis over mid parent which ranged from 16 85 to 1005 14 % Standard heterosis ranged from -56 39 to 728 90 %

Kumar *et al* (2014) conducted heterosis studies in chilli using seventy two hybrids produced by hybridization for yield attributes Heterosis over the better parent ranged from -24 67 to 70 27 per cent and standard heterosis ranged from -26 36 to 49 09 per cent

Navhale (2014) reported the heterosis and combining ability studies in chilli for different traits In this study forty two hybrids were produced from seven parents crossed in diallel mating design Twenty one hybrids exhibited desirable heterosis

over the standard check for the traits plant height, days to first flower, fruits plant ^{1} yield plot ^{1}

Heterosis studies in chilli was done by Patel *et al* (2014) for green fruit yield and its components Among the twenty eight hybrids evaluated three hybrids found to be most superior for yield related traits hence can be further evaluated to exploit the heterosis

Singh *et al* (2014) studied heterosis for both quantitative and qualitative characters Among the sixty six hybrids evaluated the heterobeltiosis ranged from -71 82 to 331 11 per cent

Heterosis over the better parent for the trait green fruit yield plant ^{1} ranged from -2 08 to 50 49 and the heterosis over the standard check ranged from -0 60 to 38 74 per cent The study also recorded the maximum extent of significant heterobeltiosis for the trait ascorbic acid Ahmed *et al* (2015)

Bhutia *et al* (2015) developed chilli hybrids which are rich in capsaicin, antioxidants and vitamins Here five parents were crossed in half diallel manner to study the extent of heterosis for different characters The hybrids showed maximum heterobeltiosis for different quality characters

Nagaraju (2015) reported that among the fifteen hybrids all the hybrids showed significant desirable heterosis over mid parent, fourteen hybrids recorded significant positive heterosis over the better parent while ten hybrids showed significant positive heterosis over the standard check for the trait green fruit yield plant ^{1}

2 2 QUALITY CHARACTERS

Quality characters in chilli includes the capsaicin, ascorbic acid, oleoresin and colour value

2.2 1 Capsaicin

The pungency in chilli is due to the capsaicin content The pericarp contains almost all of the pungency, whereas the chilli seeds contain only traces of pungency with a capsaicin content of 0 005 per cent In *Capsicum annuum* species the total capsaicinoid content ranges from 0 1 to 1 per cent Capsaicinoids are synthesised and accumulated in the epidermal tissues of the chilli placenta Capsaicinoid

accumulation is controlled by several factors *viz*, age of the plant, temperature, light and nutritional status

Doshi and Shukla (2000) evaluated forty three hybrids for capsaicin content Negative heterobeltiosis was noticed among all the hybrids and only one hybrid showed significant positive standard heterosis

Jha *et al* (2001) studied that all the cultivars in chilli followed a uniform pattern of capsaicin accumulation in the stage of fruit development

Patel *et al* (2004) reported that the hybrids ACMS-4 × GVC-101' and 'ACMS-2 × GVC-101' showed greatest significant positive relative heterosis and heterobeltiosis for the capsaicin content

Prasath and Ponnuswami (2008) estimated the heterosis for yield and quality characters in chilli hybrids The hybrids developed by the six diverse genotypes were evaluated The standard heterosis for the trait capsaicin ranged 53 57 to 202 38 per cent

The capsaicin content of the ripe fruit in chilli was estimated and it ranged from 0 13 to 0 15 per cent Chattopadhayay *et al* (2011)

Ghosh and Pugalendhi (2012) studied the improvement of chilli cultivar Co-4 for quality characters through hybridization Among hybrids Punjab Lal x Co-4 exhibited high capsaicin content higher than that of Co 4

Extent of heterosis for quantative and qualitative trait was studied by Bhutia *et al* (2015) and reported that for the trait capsaicin content relative heterosis ranged from -4 00 to 46 67 per cent and standard heterosis ranged from -31 43 to 46 67 per cent

2.2.2 Oleoresin

Fruits of chilli contain fixed oil which is non pungent in nature and which yields twenty to twenty five percent alcoholic extract it is referred as oleoresin It has great demand in pharmaceutical and food industries

Prasath and Ponnuswami (2008) estimated the heterosis for yield and quality characters in chilli hybrids The standard heterosis for the trait oleoresin ranged from -9 43 to 21 83 per cent

Ghosh and Pugalendhi (2012) studied the improvement of chilli cultivar Co-4 for quality characters through hybridization Among hybrids Co-4 x Byadagi Kaddi exhibited highest oleoresin content higher than that of Co-4

Darshan (2014) reported that the oleoresin content among the chilli hybrids ranged from 10 to 19 per cent

2.2.3 Ascorbic acid

Chilli fruits contain high amount of Vitamin C content Choudhary and Samadia (2004) estimated the ascorbic acid content in chilli hybrids and it varies from 70 83 to 237 30 mg per 100 g fresh fruit weight

Dandunayak (2008) reported that ascorbic acid content among the chilli hybrids varies from 132 5 to 177 5 mg per 100g fresh fruit

Patel *et al* (2010) estimated the heterosis for the quality traits and observed that heterosis for ascorbic acid over the better parent ranged from 45 11 to 21 1 per cent and heterosis over the check ranged from -22 82 to 59 07 per cent

Darshan (2014) studied that among the hybrids in chilli the ascorbic acid content varies from 100 to 207 49 mg per 100g fresh fruit

2.2.4 Colour value

Colour value is the most desirable quality attribute in chilli which is preferred by the consumers More than 20 different pigments from chilli fruits have been identified (Deli *et al*, 2001) green chlorophylls, yellowish orange lutein, zeaxanthin, violaxanthin, antheraxanthin, β-cryptoxanthin and β-carotene Red capsanthin, capsorubin and cryptoxanthin are characteristic exclusively for the genus *Capsicum* and are the main pigments that determine the colour of red pepper Colour is measured spectrophotometrically in ASTA (American Spice Trade Association) units or SICU (Standard International Colour Units)

The estimates of heterosis for quality characters were studied by Dhall and Hundall (2005) and they reported that the colour value among the chilli cultivars varies from 85 40 to 178 20 ASTA units The colour value among different genotypes in chilli ranged from 84 20 to 178 20 ASTA units Savita (2005)

Srilakshmi (2006) observed the correlation of colour value with the yield attributes and also the colour value among the chilli genotypes ranged from 34 02 to 241 00 ASTA units Prasath *et al* (2007) reported that colour value ranged from 32 820 to 208 56 ASTA units in chilli

Ghosh and Pugalendhi (2012) studied the improvement of chilli cultivar Co-4 for quality characters through hybridization Among hybrids Co-4 x Byadagi Kaddi exhibited highest capsanthin content higher than that of Co-4

Nawalagatti *et al* (1999) studied the differences in yield and quality parameters of four chilli cultivars, six lines and two hybrids Among them, the cultivars showed the highest capsaicin and total colouring matter followed by hybrids

2 3 CORRELATION ANALYSIS

Correlation between yield and yield related traits is very important in breeding programmes Correlation coefficient ranges from +1 to -1 Correlation analysis measures the mutual relationship between the various traits

Aliyu *et al* (2000) in a study of thirteen diverse genotypes reported that yield plant^{-1} was negatively correlated with plant height Positive association of yield with fruit weight and fruit number in chilli was reported by Munshi and Behera (2000)

Chatterjee *et al* (2001) reported that fruit weight, pericarp thickness, number of seeds fruit^{-1} had positive association with the fruit yield Acharya *et al* (2002) reported that positive significant correlation of total green fruit yield plant^{-1} with the total dry fruit yield per plant

Sreelathakumary and Rajamony (2002) conducted correlation studies in chilli genotypes and reported positive correlation of yield plant^{-1} with fruits plant^{-1}, fruit length and fruit weight

Green fruit yield plant^{-1} had significant positive correlation with the traits such as fruits plant^{-1}, fruit length fruit diameter, plant height, capsaicin content and the colour value but the green fruit yield plant^{-1} is having negative correlation with the days to first flowering Khuranna *et al* (2003)

Sreelathakumary and Rajamony (2003) studied twenty accession of bird pepper (*Capsicum frutescens*) Green fruit yield plant^{-1} has highly significant positive correlation with fruit characters such as number of fruits plant^{-1}, fruit length and fruit weight

Evaluation of thirty six genotypes in chilli was done by Ajjapplavara *et al* (2005) and they reported that positive correlation of fruit weight with all the fruit related traits such as fruit length, fruit girth

Significant positive correlation was reported in chilli Ahmed *et al* (2006) for number of days to fifty per cent flowering with plant height, fruit number, flesh to seed ratio and average seed weight

Mathew (2006) observed positive correlation of green fruit yield plant^{-1} with number of fruits plant^{-1}, number of secondary branches, fruit weight, fruit length, among the forty nine bird chilli accessions Fruit yield per plant showed significant positive association with number of fruits plant^{-1} Reddy *et al* (2006)

Gupta *et al* (2009) estimated the correlation coefficient in chilli at phenotypic levels and found that green fruit yield plant^{-1} is having positive correlation with number of fruits plant^{-1} and fruit length

Study conducted by Chattopadhyay *et al* (2011) among the thirty four chilli genotypes revealed that number of fruits plant^{-1} and ascorbic acid content was positively correlated with the green fruit yield plant^{-1}

Yield plant^{-1} had significant positive correlation with plant height, fruits plant^{-1}, fruit girth and the capsanthin content was reported by Kumari *et al* (2011)

Singh and Singh (2011) in a study of thirty diverse chilli genotypes reported that significant positive correlation was observed among the traits such as fruits plant^{-1}, yield, fruit weight

Krishnamurthy *et al* (2013) reported that number of fruits plant^{-1} has significant positive association with green fruit yield plant^{-1} in chilli (*Capsicum annuum* L)

Studies on twenty three different genotypes in chilli revealed that green fruit yield plant^{-1} has significant positive correlation with fruits plant^{-1}, fruit length

Green fruit yield plant^{1} had highly significant positive correlation with number of fruits plant^{1} plant height and seed yield (Kadwey *et al*, (2015)

Correlation between the green fruit yield plant^{1} and it's components were estimated by Patel *et al* (2015) in forty diverse chilli genotypes revealed that green fruit yield plant^{1} had maximum significant association with number of fruits plant^{1}, fruit weight, moisture and chlorophyll content

Rohini and Lakshmanan (2015) studied the correlation analysis in chilli for yield and yield attributing traits In the study green fruit yield plant^{-1} was positively correlated to the number of fruits plant^{1}, fruit length, fruit girth and the plant height

2 4 INCIDENCE OF PESTS

Pest are major threat to chilli cultivation which will ultimately affect the yield

2.4.1 Thrips

Thrips are the serious pest affecting the chilli cultivation Chilli thrips, *Scirtothrips dorsalis* causes huge economic loss by causing upward curling of the leaf They suck the sap from the tender leaves and shoots and causes the typical leaf curl symptom Apart from the typical leaf curl symptom it also causes leaf and bud dropping, drying of the growing points, and reduction in plant height

Ayyar *et al* (1935) observed that *Scirtothrips dorsalis* causes upward curling of leaf in chilli Leaf curl syndrome called the murda is a typical malady with which chilli losses it's vigour This is either due to thrips or mite

Reddy *et al* (2000) did screening of thirty three genotypes of chilli against leaf curl symptom caused by thrips and mites and repoted that Sel-7-11-13-1 showed maximum tolerance to the leaf curl while the lowest was reported by the Sel-4-1

Evaluation of sixty two genotypes in chilli against the thrips and mites was reported by Mallapur (2000) The study revealed that thirteen varieties showed lower percentage of leaf curl symptom caused by thrips and mites as compared with the checks

Screening of twenty four genotypes in chilli against the thrips was done to identifying the source of resistance The cultivar Pant- C1, LCA- 304, LCA-312 were found to be having resistance (Tatagar *et al* , 2001)

Kalaiyarasan *et al* (2002) observed that the accessions PS-64 has lower thrip population in the field as well as in pot culture Lower thrips infestation was in the accession PS-69, PS-166, PS-171

Singh and Chowdhary (2005) evaluated that ten chilli hybrids and reported lower thrip incidence The hybids were developed from five diverse parents

2.4.2 Mites

The yellow mite species attacking the chilli is *Polyphagotarsonemus latus* The nymphs and adults feed exclusively on the lower surface of the leaves Leaves become brittle and downward curling can be observed Seveare infestation results in defoliation, bud shedding and drying of the growing points

Desai *et al* (2006) evaluated twenty one genotypes against the mites ACG77 was found superior with low pest population and leaf curl symptom

Reddy *et al* (2008) screened 50 genotypes to identify resistance source against chilli thrips and mites

Materials and Methods

3. MATERIALS AND METHODS

The experiment entitled "Evaluation of hybrids for yield and quality in chilli (*Capsicum annuum* L.)" was conducted in the Department of Olericulture, College of Agriculture, Vellayani, during the period 2015-16

The experiment comprised of two parts

Part 1 Production of F_1 hybrids

Part 2 Evaluation of F_1 hybrids

3.1 Part 1 PRODUCTION OF F_1 HYBRIDS

3.1.1 Materials

The materials for the study comprised of five parents, 10 hybrids and two standard check Arka Harita (IIHR) and Vellayani Athulya (KAU) Ten superior F_1 hybrids selected based on specific combining ability and *per se* performance from the previous research programme were used for the study The seeds of the selected hybrids were produced in a crossing block The five parents were selfed to produce the selfed seeds and they were crossed in a half diallel manner to produce 10 hybrids during 2015-16 The detailed description of parental lines and crosses are given in Tables 1 and 2 (Plate 1, 2 and 3)

Table 1. Details of parents used for hybridization.

Sl. No.	Name of parents	Accession number	Source
1	P_1	EC 391083 (CA 3)	NBPGR, Hyderabad
2	P_2	EC-596920(CA 5)	NBPGR, Hyderabad
3	P_3	EC-596940 (CA 6)	NBPGR, Hyderabad
4	P_4	EC 599969 (CA 8)	NBPGR, Hyderabad

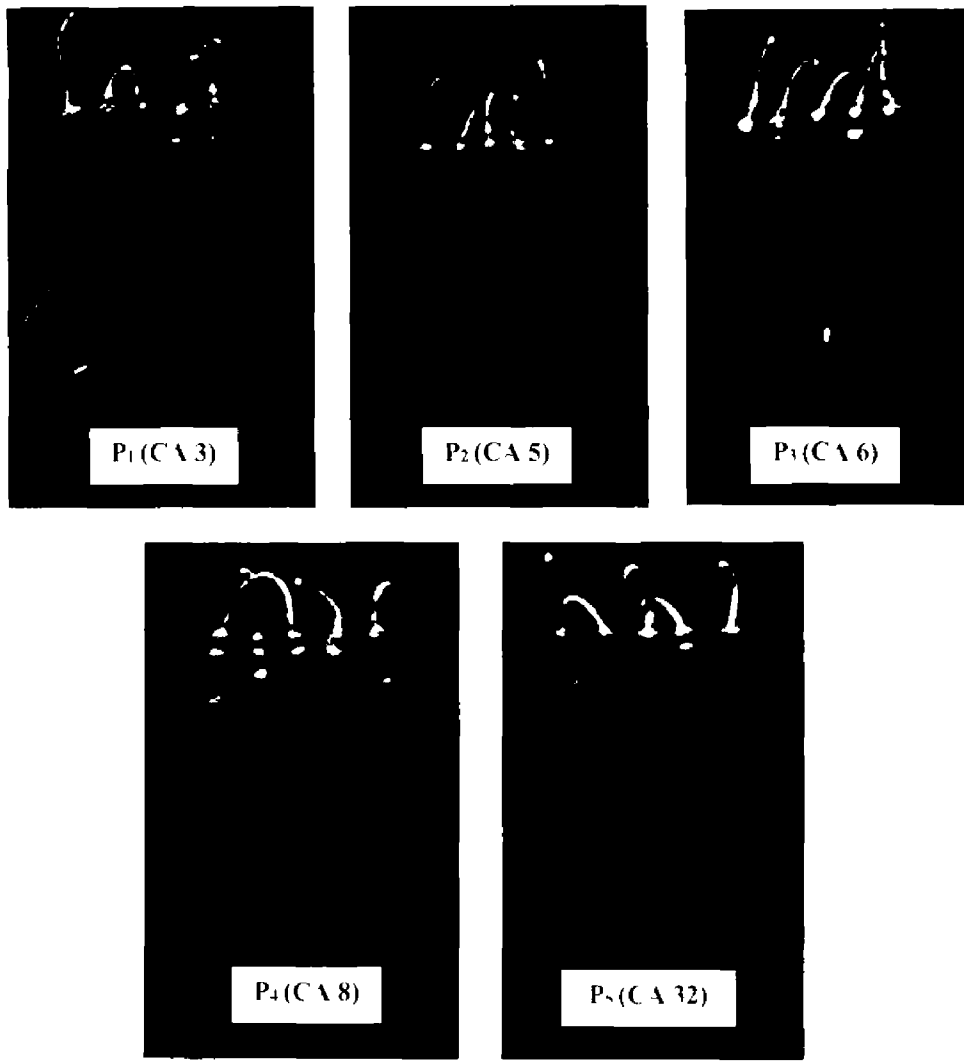


Plate 1 Fruits of parents used in the hybridisation

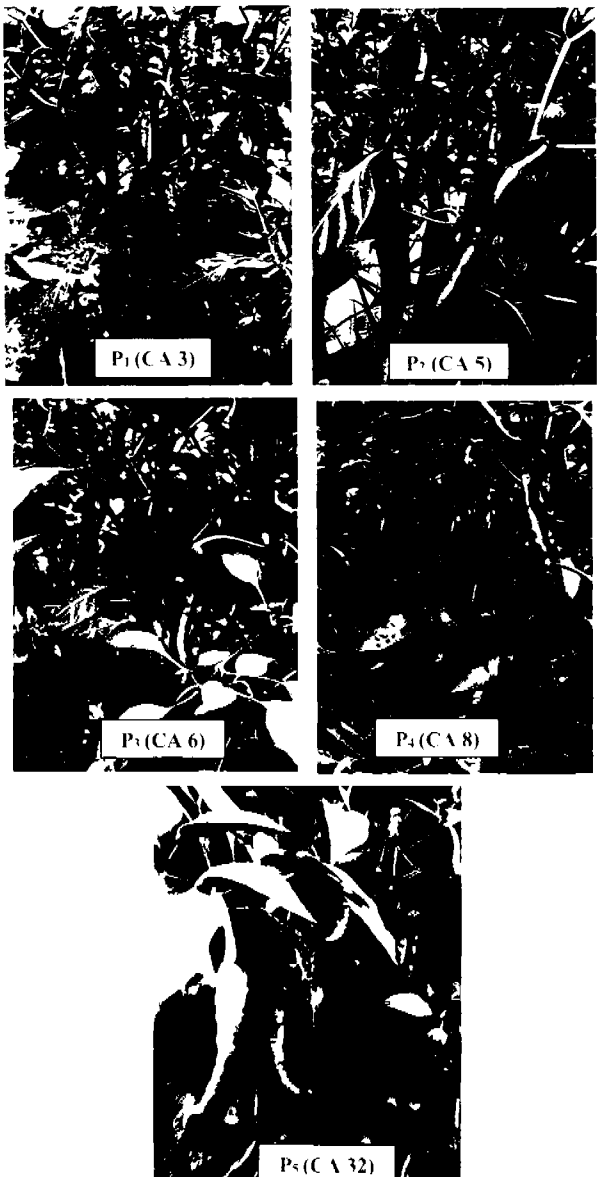


Plate 2 Parents used as experimental material

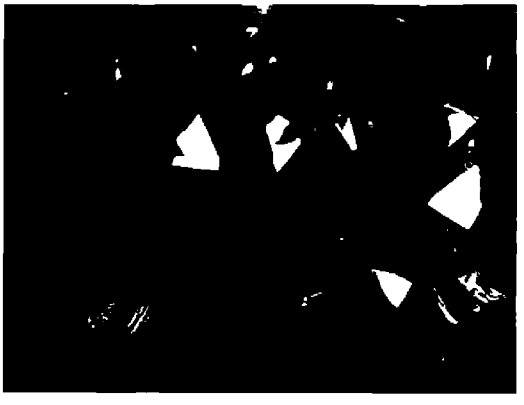


Plate 3 Development of F1 hybrids

5	P_5	Dharwad local-2 (CA 32)	Dharwad, Bangalore

Table 2. Details of hybrid combinations

SI. No.	Parents	Cross combinations
1	$P_1 \times P_2$	CA 3 x CA 5
2	$P_1 \times P_3$	CA 3 x CA 6
3	$P_1 \times P_4$	CA 3 x CA 8
4	$P_1 \times P_5$	CA 3 x CA 32
5	$P_2 \times P_3$	CA 5 x CA 6
6	$P_2 \times P_4$	CA 5 x CA 8
7	$P_2 \times P_5$	CA 5 x CA 32
8	$P_3 \times P_4$	CA 6 x CA 8
9	$P_3 \times P_5$	CA 6 x CA 32
10	$P_4 \times P_5$	CA 8 x CA 32
11	Check	Arka Harita
12	Check	Vellayani Athulya

3.1.2 Selfing and crossing technique

In chilli, anthesis occurs between 8 00 to 11 00 a m Hence, well developed flower-buds likely to open next morning were emasculated during evening hours and bagged On the next day morning (between 8 to 10 a m) emasculated buds were pollinated by the male parents The pollinated buds were again bagged with paper bags and labeled The mature crossed fruits were harvested and the seeds were collected separately from each cross For maintenance of parental lines, flower buds of different parents were selfed by bagging the individual buds and properly tagged and later the seeds were collected from the mature fruits accordingly

3 2 Part 2 EVALUATION OF F_1 HYBRIDS

3.2.1 Materials

Five parents, 10 hybrids and standard checks Arka Harita (hybrid) and Vellayani Athulya (variety) were used for field experiment for the study of heterosis and correlation

3.2.2 Methods

3 2.2.1 Design and Layout

The experiment was laid out in Randomized Block Design consisting of 17 treatments and three replications for two seasons *viz* , May 2015 to September 2015 (first season) and October 2015 to February 2016 (second season) Thirty days old seedlings having 8-10 cm height were transplanted into the main field at a spacing of 45 x 45 cm The crop has received timely management practices as per package of practices recommendations of Kerala Agricultural University (KAU, 2011)

3.2.2 2 Biometric Observations

Five randomly selected plants were tagged in each treatment to record the observations and the average from these five plants was worked out for statistical analysis To record dry fruit weight red ripe fruits were harvested and dried from randomly selected five plants from each treatment Following are the observations recorded in this experiment

3.2.2.3 Vegetative Characters

3 2 2.3.1 Plant Height (cm)

Plant height was recorded from the ground level to the top-most bud leaf of the plants at the time of peak harvest and presented in centimeters

3.2.2.3.2 Primary Branches Plant^{-1}

Number of branches arising from the main stem was recorded at the peak harvest stage and average was worked out

3.2.2.4 Flowering Characters

3.2 2.4.1 Days to First Flower

Number of days from the date of transplanting to the first flowering of observational plants was recorded and the average obtained

3.2.2.4.2 Days to First Harvest

Number of days from the date of transplanting to the first fruit harvest of observational plants was recorded and the average obtained

3 2.2.5 Fruit and Yield Characters

3.2.2.5.1 Fruits Plant^{-1}

Total number of fruits produced plant ^{1} was counted

3.2 2.5 2 Fruit Length (cm)

Five fruits were selected at random from the observational plants Fruit length was measured as the distance from pedicel attachment of the fruit to the apex *using* twine and scale Average was taken and expressed in centimeters

3.2 2 5.3 Fruit Girth (cm)

Fruit girth was taken at broadest part from the fruits used for recording the fruit length Average was taken and expressed in centimeters

3 2 2 5 4 Fruit Weight (g)

Weight of fruits used for recording fruit length was measured and average was found out and expressed in grams

3.2.2.5.5 Flesh Thickness (mm)

The thickness of fruit pericarp was measured and expressed in milli meters

3.2.2.5.6 Flesh to Seed Ratio

The ratio between flesh weight and seed weight of fruit was recorded

3 2.2.5.7 Seeds Fruit^{-1}

Seeds fruit ^{1} were counted in five fruits and average was taken

3.2.2.5.8 Green Fruit Yield Plant^{-1} (g)

Weight of green fruits harvested from selected plants was recorded, average worked out and expressed in grams per plant

3.2.2.5.9 Dry Fruit Yield Plant^{-1} (g)

Weight of dry fruits harvested from selected plants was recorded, average worked out and expressed in grams per plant

3 2 2 5 10 Yield Plot^{-1} (kg)

The weight of fruits harvested from each plot was recorded

3.2.2.5.11 Driage (%)

The driage of fruits was expressed in percentage as per the formula

$$\text{Driage} = \frac{\text{Weight of dried fruit} \times 100}{\text{Weight of red ripe fruit}}$$

3 2.2.5.12 Seed Yield Fruit^{-1} (g)

The weight of the seeds fruit ^{1} was recorded

3 2.2.6 Quality Characters

3.2 2.6.1 Capsaicin (%)

Capsaicin content of different accessions was 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 phosphomoloybdic 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°C and powdered finely in a mixer grinder 500 mg each of the sample was weighed into test tubes Added 10 ml of acetone to it and kept overnight Aliquot of 1ml was pipetted into 100 ml conical flask, 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 upto 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 (Prepare a standard curve using 0 5, 1 0, 1 5, 2 0 and 2 5ml of standard capsaicin solution containing 50, 100, 150, 200 and 250 µg capsaicin respectively) were prepared and their optical density measured at 725 nm Standard graph was prepared and calculated capsaicin content in the samples

3 2 2 6 2 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°C and powdered finely in a mixer grinder Weighed two grams of chilli powder and

packed in filter paper and placed in Soxhlet's apparatus 200 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 the solvent (around 60°C) After complete extraction (4 - 5hours) the solvent was evaporated to dryness

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

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

3.2.2 6.3 Ascorbic acid (mg per 100 g fresh fruit weight)

Ascorbic acid content of fruit was estimated by 2,6-dichlorophenol indophenol dye method (Sadasivam and Manickam, 1992)

Reagents

1 Oxalic acid (4 %)

2 Ascorbic acid standard

Stock solution was prepared by dissolving 100 mg of ascorbic acid in 100 ml of four per cent oxalic acid 10 ml of this stock solution was diluted to 100 ml with four per cent oxalic acid to get working standard solution

3 2, 6-dichlorophenol indophenol dye

Forty two mg sodium bicarbonate was dissolved in a small volume of distilled water 52 mg of 2,6-dichlorophenol indophenol was added into this and made up to 200 ml with distilled water

4. Working standard

Diluted 10 ml of stock solution to 100 ml with 4% oxalic acid The concentration of working standard is 100 mg per ml

Procedure

Pippeted out 5 ml of the working standard solution into a 100 ml conical flask and added 10 ml of 4% oxalic acid Titrated it against the dye (V_1 ml) End point is the appearance of pink colour which persisted for at least 5 seconds

Five g of fresh fruit was extracted in four per cent oxalic acid medium, filtered the extract and volume was made upto 100 ml using oxalic acid From this

five ml of aliquat was taken, added 10 ml of four per cent oxalic acid and titrated as above against the dye and determined the endpoint (V_2 ml)

Ascorbic acid content of the sample was calculated using the formula

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

3.2.2.6 4 Colour

Red ripe chillies were dried and the stalk and seeds were removed before powdering 0 1 g of ground chilli powder was transferred into a 250 ml Erlenmeyer flask with 100 ml isopropanol and kept overnight at room temperature The contents were filtered through a Whatman No 42 filter paper The first 10 ml was discarded and 25 ml of the filtrate was pipetted into a volumetric flask and diluted to the mark with isopropanol The absorbance was read at 450 nm against isopropanol as blank Standard colour solution was prepared by dissolving 0 5 mg per ml of reagent grade potassium dichromate in 1 8M sulphuric acid

$$\text{Colour value (ASTA units)} = \frac{\text{Absorbance of sample at 450 nm} \times 200}{\text{Absorbance of standard solution at 450 nm}}$$

Extractable colour in ASTA units

3.2.2.7 Incidence of pest and diseases.

No incidence of diseases were observed Among the pests, thrips and mites were found to be major problems during the study Based on visual symptoms scoring was done

3.2 2 7.1 Thrips and mites.

The scoring was based on 0 to 4 scale The plant damage was recorded based on visual score of the characteristic symptom of each observational plant The observation was taken on 30th, 60th and 90th days after planting (DAT) (Varghese and Giraddi 2005)

Leaf curl index (LCI) of thrips and mites were calculated using the formula

$$LCI = \frac{\text{Sum of grades of plant} \times \text{corncerned category score}}{\text{Total number of plants assessed}}$$

Table 3 Scoring procedure for sucking pest thrips and mites

Score	Symptoms
0	No symptom
1	1 to 25% leaves per plant showing curling or damage
2	26 to 50% leaves per plant showing curling – moderately damaged
3	51 to 75% leaves per plant showing curling, heavily damaged, malformation of growing points, and reduction in plant height
4	>75% leaves per plant showing curling, severe and complete destruction of growing points, drastic reduction in plant height, defoliation and severe malformation

3.2.3 Statistical analysis

3.2.3.1 Analysis of Variance

Analysis of variance (ANOVA) for individual character was carried out on the basis of mean value per entry per replication as suggested by Panse and Sukhatme (1967) for Randomized Block Design (RBD) The model of analysis of variance is as given below

ANOVA for each character

Source	d.f.	Mean squares	Expectation of mean squares
Replications	(r-1)	M_r	$\sigma^2e + g\,\sigma^2r$
Genotypes	(g-1)	M_g	$\sigma^2e + r\,\sigma^2g$
Parents	(p-1)	M_p	
Hybrids	(h-1)	M_h	
Parents Vs. hybrids	1	M_pVs M_h	
Error	(r-1) (g-1)	M_e	σ^2e

Where,

r = number of replications

g = number of genotypes

p = number of parents

h = number of hybrids

Significance of the treatments was tested at 5 and 1 per cent level of probability

3.2 3.2 Pooled analysis

Pooled analysis was done using the data of evaluation of 17 treatments for two seasons.

ANOVA for pooled analysis

Source	d.f.	Mean squares	Expectation of mean squares
Replications	(r-1)	M_r	σ2ea + g σ2r
Genotypes	(g-1)	M_g	σ2ea + r σ2g
Parents	(p-1)	M_p	
Hybrids	(h-1)	M_h	
Parents Vs. hybrids	1	M_pVs M_h	
Error	(r-1) (g-1)	M_e	σ2e

Where,

r = number of replications

g = number of genotypes

s = number of seasons

Significance of the treatments was tested at 5 and 1 per cent level of probability

3.2.3 3 Test of Significance

Test of significance for various components was carried out by 'F' test The 'F' values were calculated as under

$$\text{Genotypes} = \frac{M_g}{M_e}$$

$$\text{Parents} = \frac{M_p}{M_e}$$

$$\text{Hybrids} = \frac{M_h}{M_e}$$

$$\text{Parents vs hybrids} = \frac{M_p \text{ vs } M_h}{M_e}$$

M_g= mean squares of genotypes

M_p= mean squares of parents

M_h=mean squares of hybrids

M_e = mean squares of error

3.2.3.4 Critical Difference of the Estimates

To test the significance of differences of the estimates, critical difference is calculated as

$$S\ E\ D = \sqrt{\frac{2M_e}{r}} \quad \text{and } S\ E\ M = \sqrt{\frac{M_e}{r}}$$

$$C\ D = S\ E\ D \times t$$

Where,

t = Table 't' value for error degree of freedom at 0 01 and 0 05 levels of probability

3.2.3.5 Co-efficient of Variation

The co-efficient of variation for each character was calculated as under,

$$C V\% = \frac{\sqrt{M_e}}{\bar{X}} x100$$

Where,

M_e = error mean square

$\bar{X}$ = general mean for the character

3.2.4 Heterosis

The magnitude of heterosis was estimated in relation to mid parent (MP), better parent (BP), and standard checks (Arka Harita) and (Vellayani Athulya) as percentage increase or decrease of F_1s over the respective check

Estimation of heterosis was carried out following the methods suggested by Turner (1953) and Hayes *et al* (1955)

$$\text{Mid parent value (MP)} = \frac{P_1 + P_2}{2}$$

a) Heterosis over mid parent (MP) $= \frac{F_1 - \overline{MP}}{\overline{MP}} \times 100$ **(Relative heterosis)**

Where,

$\overline{MP}$ = Mean performance of parent P_1 and P_2

$\overline{F_1}$ = Mean performance of hybrid

b) Heterosis over better parent (BP) $= \frac{F_1 - \overline{BP}}{\overline{BP}} \times 100$ **(Heterobeltiosis)**

Where,

$\overline{BP}$ = Mean performance of better parent

$\overline{F_1}$ = Mean performance of F_1 hybrid

c) Heterosis over standard check (SC) $= \frac{F_1 - \overline{SC}}{\overline{SC}} \times 100$ **(Standard heterosis)**

Standard heterosis was worked over hybrid Arka Haritha and over variety Vellayani Athulya

Where,

$\overline{SC}$ = Mean performance of standard check

F_1 = Mean performance of F_1 hybrid

3.2.4.1 Test of Significance

Test of significance was done by comparing the mean deviation with values of critical difference (CD) obtained separately for MP, $\overline{BP}$ and SC $\overline{by}$ using the following formula

Mean deviation for heterosis over MP $= \sqrt{\frac{3 \times mse}{2r}}$ x 't' value

Mean deviation for heterosis over BP & SC $= \sqrt{\frac{2 \times mse}{r}}$ x't' value

Where,

r = Number of replications

t = Table value of 't' at error degree of freedom at 0 01 and 0 05 levels of probability

m s e = Error mean sum of squares

3.2 5 Correlation

From replicated data simple correlation can be calculated with the help of the following formula

r_{xy} - MSPt/ [MStx MSty] ½

where, MSPt = Mean sum of products of genotypes

MStx = Mean square of treatments for the variable x

MSty = Mean square of treatments for the variable y

Results

4. RESULTS

The research study entitled "Evaluation of hybrids for yield and quality in chilli (*Capsicum annuum* L)" was conducted in the Department of Olericulture, College of Agriculture, Vellayani, during the year 2015-2016 Ten hybrids obtained from half diallel mating of five parents were evaluated along with their parents and two checks Arka Harita (hybrid) and Vellayani Athulya (standard variety) for two seasons *viz*, May 2015 to September 2015 (first season) and October 2015 to February 2016 (second season) Results of the study are presented here under the following headings Field view of the experiment is given in Plate 4

1 Analysis of variance for experimental design
2 Mean performance of parents and hybrids
3 Estimation of heterosis
    a) Relative heterosis (RH)
    b) Heterobeltiosis (BH)
    c) Standard heterosis (SH)
4 Correlation analysis
5 Scoring for pests and diseases

4 1 ANALYSIS OF VARIANCE FOR EXPERIMENTAL DESIGN

Analysis of variance revealed significant difference among the treatments for all the characters studied for two seasons *viz*, May 2015 to September 2015 and October 2015 to February 2016 and are presented in Table 4-6 Variance among the parents was significant for all characters

4 2 MEAN PERFORMANCE OF PARENTS AND HYBRIDS

The mean values of parents and hybrids for different characters for two seasons along with the pooled data are presented in Table 7 - 13 and the fruits of different hybrid combinations are given in Plate 5 The hybrid performance was compared with two checks for all the characters

Plate 4 Evaluation of F1 hybrids and parents along with checks (Field view)

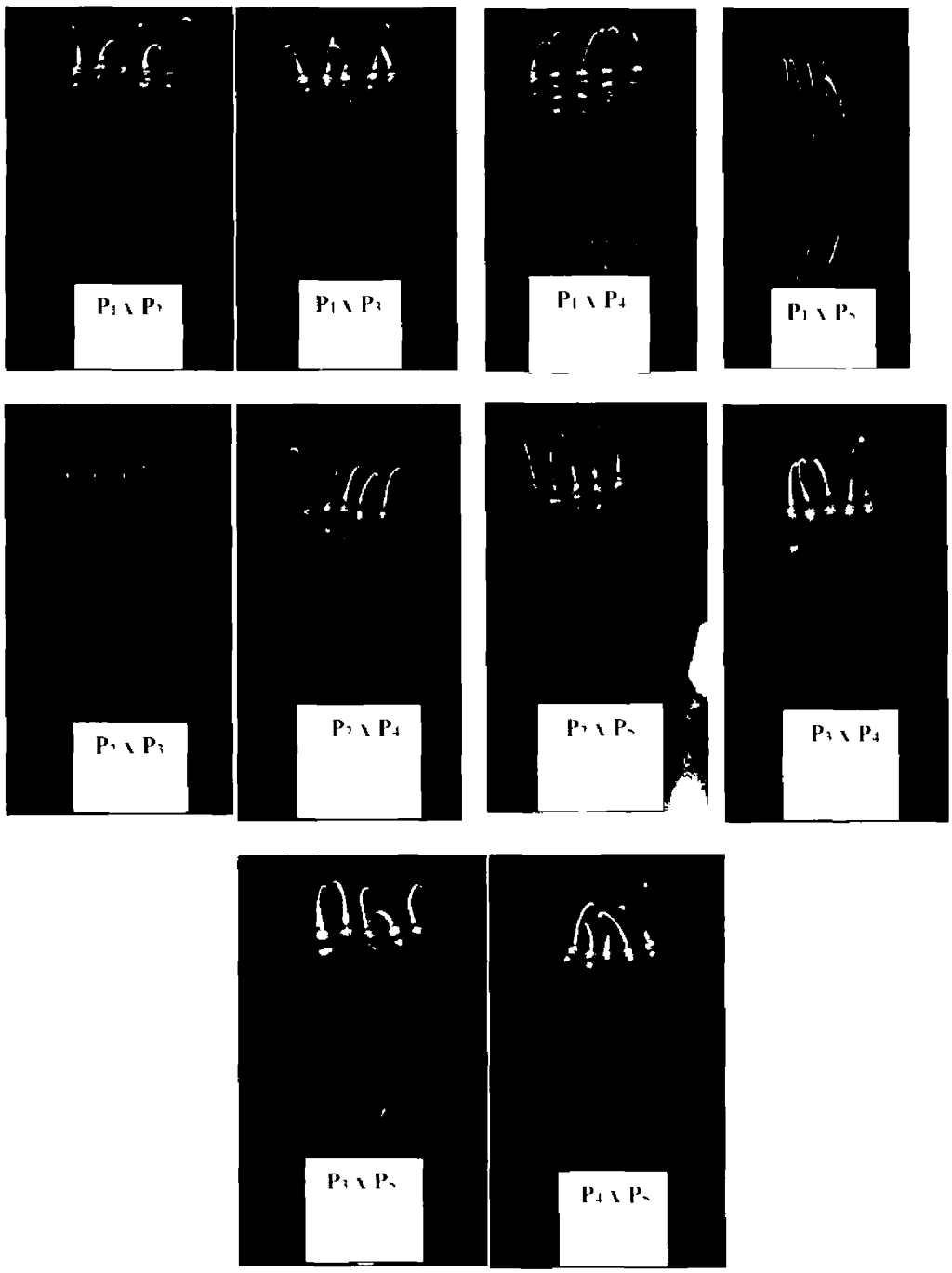


Plate 5 Fruits of different hybrid combinations

Table 4. ANOVA table for biometric characters in chilli for first season

Source of variation	d f	Plant height (cm)	Primary branches plant^{-1}	Days to first flower	Days to first harvest	Fruits plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Flesh thickness (mm)
Replicates	2 00	6 63	0 03	0 02	0 00	172 96	0 00	0 01	0 76	0 00
Treatments	16 00	210 35**	2 21**	11 98**	10 43**	2144 73**	6 37**	1 61**	28 44**	0 66**
Parents	4 00	535 45**	2 79**	1 14**	1 22**	743 72**	4 20**	0 38**	3 09**	0 56**
Hybrids	9 00	62 67**	1 76**	4 79**	4 51**	299 35**	2 01**	0 55**	7 25**	0 08**
Parents Vs Hybrids	1 00	169 20 **	6 78**	46 94**	43 82**	19436 34**	31 03**	0 12**	31 49**	0 20**
Error	32 00	14 63	0 01	0 03	0 05	89 71	0 00	0 01	0 39	0 00

Source of variation	d f	Flesh to seed ratio	Seeds fruit^{-1}	Green fruit yield plant^{-1} (g)	Dry fruit yield plant^{-1} (g)	Yield plot^{-1} (kg)	Drage (%)	Seed yield fruit^{-1} (g)	Capsaicin (%)	Oleoresin (%)	Ascorbic acid (mg/100g)	Colour (ASTA units)
Replicates	2 00	0 00	2 04	9953 62	76 40	8 17	0 00	0 00	0 00	0 07	0 79	0 76
Treatments	16 00	15 95**	1817 76**	150102 72**	3190 41**	124 47**	21 00**	0 12**	0 07**	21 01**	361 22**	1158 34**
Parents	4 00	14 19**	593 70**	29333 01**	1210 22**	24 27**	6 27**	0 08**	0 00**	5 10**	4 69**	1252 72**
Hybrids	9 00	9 29**	564 76**	66366 98**	1108 88**	54 98**	18 58**	0 09**	0 00**	25 89**	281 02**	910 62**
Parents Vs Hybrids	1 00	2 68**	12194 06**	1439737 00**	30265 40**	1194 65**	0 62	0 00**	0 88**	69 87**	2641 71**	1485 39**
Error	32 00	0 00	4 82	6358 15	35 57	5 26	0 16	0 00	0 00	0 37	0 49	0 36

*Significant at 5 per cent level

*Significant at 1 per cent level

Table 5. ANOVA table for biometric characters of chilli for second season.

Source of variation	d f	Plant height (cm)	Primary branches plant ^{1}	Days to first flower	Days to first harvest	Fruits plant ^{1}	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Flesh thickness (mm)
Replicates	2 00	31 33	0 04	0 05	0 01	49 85	0 04	0 00	0 19	0 00
Treatments	16 00	218 16**	1 52**	13 08**	12 80**	4565 15**	6 96**	1 88**	30 77**	0 66**
Parents	4 00	575 20**	1 86**	0 81**	0 56**	378 71**	3 92**	0 76**	2 51**	0 34**
Hybrids	9 00	59 96**	1 69**	4 29**	4 29**	4191 18**	2 28**	0 50**	10 47**	0 25**
Parents Vs Hybrids	1 00	153 66**	0 36**	73 91**	71 49**	24308 19**	26 94**	0 11*	28 97**	0 07**
Error	32 00	14 18	0 02	0 02	0 02	32 25	0 41	0 02	0 15	0 00

Source of variation	d f	Flesh to seed ratio	Seeds fruit ^{1}	Green fruit yield plant ^{1} (g)	Dry fruit yield Plant ^{1} (g)	Yield plot ^{1} (kg)	Drage (%)	Seed yield fruit ^{1} (g)	Capsaicin (%)	Oleoresin (%)	Ascorbic acid (mg/100g)	Colour (ASTA units)
Replicates	2 00	0 00	1 19	594 46	14 82	0 49	0 07	0 00	0 00	0 00	0 14	0 00
Treatments	16 00	14 37**	1932 53**	132993 00**	3568 29**	110 28**	25 87**	0 11**	0 06**	21 11**	332 59**	1154 62**
Parents	4 00	11 50**	610 69**	15711 40**	418 91**	13 03**	6 07**	0 08**	0 00**	5 49**	8 40**	1245 60**
Hybrids	9 00	10 00**	589 25**	90901 51**	2442 97**	75 37**	27 23**	0 09**	0 00**	26 45**	232 22**	913 54**
Parents Vs Hybrids	1 00	1 07**	13138 21**	1085263 25**	29087 32**	900 22**	0 53	0 00**	0 88**	63 13**	2270 04**	1537 60**
Error	32 00	0 00	10 49	901 30	24 20	0 75	0 19	0 00	0 00	0 07	0 66	0 44

*Significant at 5 per cent level

**Significant at 1 per cent level

Table 6. ANOVA table for biometric characters of chilli in pooled analysis for two season

Source of variation	d f	Plant height (cm)	Primary branches plant ^{1}	Days to first flower	Days to first harvest	Fruits plant ^{1}	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Flesh thickness (mm)
Replicates	2 00	5 15	0 03	0 03	0 00	174 68	0 02	0 01	0 18	0 00
Treatments	16 00	427 61**	3 57**	24 67**	22 80**	5848 89**	13 27**	3 47**	58 58**	1 29**
Season	1 00	118 84**	3 12**	0 81**	0 74**	3358 47**	3 22**	0 59**	4 84**	0 36**
Treatments Vs season	16 00	0 90	0 16**	0 39**	0 43**	860 99**	0 06	0 03*	0 63*	0 03**
Error	66 00	14 96	0 02	0 02	0 03	60 59	0 20	0 01	0 28	0 00

32

Source of variation	d f	Flesh to seed ratio	Seeds fruit ^{1}	Green fruit yield plant ^{1}(g)	Dry fruit yield plant ^{1} (g)	Yield plot ^{1} (kg)	Drying (%)	Seed yield fruit ^{1} (g)	Capsaicin (%)	Oleoresin (%)	Ascorbic acid (mg/100g)	Colour (ASTA units)
Replicates	2 00	0 00	1 16	4015 89	43 26	3 27	0 03	0 00	0 00	0 04	0 36	0 44
Treatments	16 00	30 16**	3747 19**	270086 89**	6354 49**	224 01**	46 24**	0 23**	0 13**	42 10**	688 55**	2312 70**
Season	1 00	1 06**	632 51**	839548 31**	18987 15**	695 15**	3 80**	0 00**	0 00*	9 47**	6 03**	11 56**
Treatments Vs season	16 00	0 15**	3 10	13008 88**	404 21**	10 74**	0 63**	0 00	0 00**	0 02	5 25**	0 26
Error	66 00	0 00	7 49	3717 68	30 43	3 08	0 17	0 00	0 00	0 21	0 58	0 40

*Significant at 5 per cent level

**Significant at 1 per cent level

4.2.1 Plant Height (cm)

The plant height showed significant difference among the treatments for both the seasons During the first season the parent P_3 was tallest (87 40 cm) which was on par with P_4 (83 46 cm) and the parent P_1 was shortest (56 63 cm) Among the hybrids P_1 x P_4 was tallest (83 26 cm) and P_3 x P_5 (69 40 cm) shortest

During second season also the parent P_3 was tallest (85 86 cm) and P_1 shortest (53 46 cm) Among the hybrids P_1 x P_2 (81 60 cm) was tallest and P_3 x P_5 (68 26 cm) shortest Pooled data from both the seasons revealed that plant height for parents ranged from 55 05 cm to 86 63 cm The minimum plant height was recorded in P_1 x P_5 (71 93 cm) The tallest hybrid was P_1 x P_2 and P_1 x P_4 (81 86 cm)

4.2.2 Primary Branches Plant ^{1}

Among the parents P_5 (4 36) had maximum primary branches plant ^{1} and P_1 and P_3 had minimum (2 43) Among hybrids P_3 x P_5 recorded more primary branches plant ^{1} (4 93) and P_1 x P_5 recorded lowest (2 93) for the first season

During the second season also P_5 recorded more (4 93) and P_1 recorded less (3 21) primary branches plant ^{1} Among the hybrids more primary branches plant^{-1} was observed in P_3 x P_5 (5 16) and less in P_1 x P_5 (3 06)

The pooled data from both seasons showed that the primary branches plant ^{1} for parents ranged from 2 82 (P_3) to 4 65 (P_5) Among hybrids the range was 3 00 (P_1 x P_5) to 5 05 (P_3 x P_5)

4.2.3 Days to First Flower

Among the parents P_1 was early to flower (27 00) and P_3 late to flower (28 66) The hybrid P_2 x P_5 was earliest to flower (24 20) which was on par with P_1 x P_4 (24 40) P_1 x P_3 was latest to flower (27 66) during first season

During second season also the parent P_1 was early to flower (27 86) and P_3 late (29 16) Among the hybrids earliest flowering was observed in P_1 x P_4 (23 93) and delayed flowering in P_1 x P_3 (27 13)

Table 7 Mean values of 5 parents, 10 hybrids and 2 checks for plant height, primary branches plant^{-1} and days to first flower

Treatments	Plant height (cm)			Primary branches plant ^{1}			Days to first flower		
	Season I	Season II	Pooled	Season I	Season II	Pooled	Season I	Season II	Pooled
P_1	56 63	53 46	55 05	2 43	3 46	2 95	27 00	27 86	27 43
P_2	63 60	61 80	62 70	2 83	3 83	3 33	27 80	28 46	28 13
P_3	87 40	85 86	86 63	2 43	3 21	2 82	28 66	29 16	28 91
P_4	83 46	81 46	82 46	4 23	4 83	4 53	27 40	27 93	27 66
P_5	79 93	78 13	79 03	4 36	4 93	4 65	27 73	28 33	28 03
$P_1 \times P_2$	82 13	81 60	81 86	4 33	4 72	4 53	24 73	24 86	24 80
$P_1 \times P_3$	78 26	75 93	77 10	3 53	3 76	3 65	27 66	27 13	27 40
$P_1 \times P_4$	83 26	80 46	81 86	3 33	3 54	3 44	24 93	25 66	25 30
$P_1 \times P_5$	73 06	70 80	71 93	2 93	3 06	3 00	26 20	26 86	26 53
$P_2 \times P_3$	81 33	79 06	80 20	4 53	4 60	4 56	27 60	27 06	27 33
$P_2 \times P_4$	77 93	74 33	76 13	4 50	4 43	4 46	24 80	24 66	24 73
$P_2 \times P_5$	82 80	80 60	81 70	4 73	4 80	4 76	24 20	24 26	24 23
$P_3 \times P_4$	79 86	76 46	78 16	3 13	3 33	3 23	24 40	23 93	24 16
$P_3 \times P_5$	69 40	68 26	68 83	4 93	5 16	5 05	26 00	26 46	26 23
$P_4 \times P_5$	75 13	73 13	74 13	4 86	5 00	4 93	25 00	25 40	25 20
Arka Harita	73 33	71 46	72 40	3 53	3 70	3 61	31 60	31 26	31 43
Vellayani Athulya	89 40	87 40	88 40	4 46	4 66	4 56	24 13	23 53	23 83
Gen Mean	77 46	75 31	76 38	3 83	4 18	4 00	26 46	26 64	26 55
CD(0 05)	6 362	6 263	4 459	0 185	0 223	0 146	0 293	0 217	0 180

As per the pooled data for both the seasons among the parents, P_1 (27 43) was the earliest for flowering and P_3 (28 91) was the latest Among the hybrids P_3 x P_4 (24 16) was earliest for flowering and late flowering was observed in P_1 x P_3 (27 40) The check variety Vellayani Athulya showed early flowering among all the treatments in both the seasons and in pooled data

4.2.4 Days to First Harvest

Early days to harvest was observed in parent P_1 (46 00) and late in P_3 (47 66) and among the hybrids early days to harvest was observed in P_2 x P_5 (43 20) and late in P_1 x P_3 (46 66) for the first season

During second season also P_1 recorded earliest days to harvest (46 86) and P_3 (47 93) the latest Early days to harvest was observed in the hybrid P_2 x P_5 (43 26) and late in P_1 x P_3 (46 13)

Pooled data for both the seasons revealed that among the parents, P_1 (46 43) was the earliest for first harvest and P_3 (47 80) was latest for harvest

Among the hybrids P_2 x P_5 (43 23) was earliest for harvest and late harvest was observed in P_1 x P_3 (46 40) The check variety Vellayani Athulya showed early days to harvest among all the treatments in both the seasons as well as in pooled data

4.2 5 Fruits Plant^{-1}

Among the parents, P_3 (93 00) recorded maximum and P_4 (53 73) recorded minimum fruits plant^{-1}, while the hybrid P_4 x P_5 (134 73) had maximum and P_1 x P_3 (103 73) had minimum fruits plant^{-1} during the first season

During second season P_5 recorded maximum (69 26) and P_4 recorded minimum (40 26) fruits plant^{-1} among the parents and P_3 x P_4 recorded maximum (171 53) and P_1 x P_4 recorded minimum (73 60) fruits plant^{-1} among the hybrids

According to the pooled data among the parents the fruits plant^{-1} ranged from P_4 (47 00) to P_3 (78 13) Among the hybrids maximum fruits plant^{-1} was

observed in P_3 x P_4 (148 76) followed by P_4 x P_5 (143 26) and P_3 x P_5 (137 36) Minimum was observed in P_1 x P_3 (91 03)

4.2.6 Fruit Length (cm)

Among the parents P_1 had the longest fruits (11 32 cm) and P_3 shortest (8 44 cm) The hybrid P_1 x P_5 recorded maximum length (12 73 cm) and P_2 x P_3 minimum length (10 65 cm) during first season

For the second season also P_1 had the longest fruits (11 03 cm) and P_3 had shortest fruits (8 24 cm) Fruits of P_1 x P_5 was longest (12 49 cm) among the hybrids which was on par with P_1 x P_4 (12 36 cm) and P_3 x P_5 (10 22 cm) the shortest

Pooled data revealed that fruit length was maximum for parent P_1 (11 17cm) and minimum for P_3 (8 34 cm) The fruit length of hybrids ranged from 10 49 cm (P_2 x P_3) to 12 61 cm (P_1 x P_5)

4.2.7 Fruit Girth (cm)

Fruit girth ranged from 3 28 cm (P_3) to 4 08 cm (P_4) among the parents and among the hybrids it ranged from 3 07 cm (P_2 x P_4) to 4 32 cm (P_3 x P_5) during the first season

Among the parents fruit girth showed a variation from 3 26 cm (P_3) to 4 53 cm (P_4) and for the hybrids it recorded a variation of 3 23 cm (P_2 x P_4) to 4 54 cm (P_3 x P_5) in second season

Pooled data revealed that parent P_4 (4 30 cm) had maximum and P_3 (3 27 cm) minimum fruit girth Fruit girth among the hybrids ranged from 3 15 cm (P_2 x P_4) to 4 43 cm (P_3 x P_5)

4.2.8 Fruit Weight (g)

Fruit weight among the parents ranged from 4 74 g (P_2) to 6 91 g (P_5) Maximum fruit weight was recorded in hybrid P_4 x P_5 (9 80 g) and minimum in P_2 x P_3 (5 40 g) in first season

Table 8. Mean values of 5 parents, 10 hybrids and 2 checks for days to first harvest, fruits plant[1] and fruit length.

Treatments	Days to first harvest			Fruits plant[1]			Fruit length (cm)		
	Season I	Season II	Pooled	Season I	Season II	Pooled	Season I	Season II	Pooled
P_1	46 00	46 86	46 43	85 06	56 40	70 73	11 32	11 03	11 17
P_2	46 80	47 46	47 13	65 06	50 66	57 86	8 80	8 52	8 66
P_3	47 66	47 93	47 80	93 00	63 26	78 13	8 44	8 24	8 34
P_4	46 26	46 93	46 60	53 73	40 26	47 00	9 56	9 36	9 46
P_5	46 73	47 33	47 03	78 93	69 26	74 10	10 46	10 07	10 27
$P_1 \times P_2$	43 73	43 86	43 80	105 60	78 66	92 13	10 87	10 42	10 64
$P_1 \times P_3$	46 66	46 13	46 40	103 73	78 33	91 03	11 47	11 28	11 38
$P_1 \times P_4$	44 06	44 66	44 36	114 20	73 60	93 90	12 58	12 36	12 47
$P_1 \times P_5$	45 20	45 86	45 53	121 93	78 50	100 21	12 73	12 49	12 61
$P_2 \times P_3$	46 60	46 06	46 33	120 33	91 46	105 90	10 65	10 33	10 49
$P_2 \times P_4$	43 80	43 66	43 73	112 73	77 73	95 23	10 88	10 64	10 76
$P_2 \times P_5$	43 20	43 26	43 23	127 40	102 20	114 80	12 54	11 90	12 22
$P_3 \times P_4$	43 73	42 93	43 33	126 00	171 53	148 76	10 94	10 37	10 66
$P_3 \times P_5$	45 00	45 46	45 23	125 80	148 93	137 36	10 86	10 22	10 54
$P_4 \times P_5$	44 00	44 40	44 20	134 73	151 80	143 26	11 26	10 83	11 05
Arka Harita	50 03	50 26	50 15	150 46	142 66	146 56	7 88	7 13	7 51
Vellayani Athulya	43 33	42 60	42 96	73 33	70 33	71 83	12 64	12 68	12 66
Gen. Mean	45 46	45 63	45 54	105 41	90 92	98 16	10 82	10 46	10 64
CD(0 05)	0 370	0 248	0 215	15 753	9 445	8 973	0 117	1 061	0 516

During the second season fruit weight recorded a range of 4 35 g (P_3) to 6 55 g (P_5) among the parents and 4 26 g (P_3 x P_4) to 9 53 g (P_4 x P_5) among the hybrids

Pooled data revealed that fruit weight among the parents ranged from 4 82 g (P_3) to 6 73 g (P_5) Among the hybrids the fruit weight ranged from 5 36 g (P_2 x P_3) to 9 66 g (P_4 x P_5)

4.2.9 Flesh Thickness (mm)

Flesh thickness ranged from 1 42 mm (P_4) to 2 52 mm (P_5) among the parents and 2 04 mm (P_2 x P_4) to 2 55 mm (P_4 x P_5) among the hybrids during first season

Maximum flesh thickness was shown by the parent P_5 (2 71 mm) and minimum by P_4 (1 82 mm) Among the hybrids maximum flesh thickness was observed in P_4 x P_5 (3 08 mm) and minimum in P_2 x P_4 (2 08 mm)

Pooled data revealed that the parent P_5 (2 61mm) had maximum flesh thickness and P_4 (1 62mm) had minimum Among the hybrids flesh thickness was maximum for (P_4 x P_5) 2 81 mm and minimum for (P_2 x P_4) 2 06 mm

4.2.10 Flesh to Seed Ratio

Among the parents the flesh to seed ratio ranged from 3 76 (P_2) to 8 81 (P_5) and among hybrids it ranged from 4 25 (P_2 xP_3) to 10 27 (P_1 x P_5) in first season

In second season the flesh to seed ratio ranged from 4 03 (P_2) to 8 87 (P_5) among the parents and among the hybrids it ranged from 4 44 (P_3 x P_5) to 10 67 (P_1 x P_5)

Pooled data showed that among the parents flesh to seed ratio ranged from 3 90 (P_2) to 8 84 (P_5) and among the hybrids it ranged from 4 36 (P_2 x P_3) to 10 47 (P_1 x P_5)

Table 9. Mean values of 5 parents, 10 hybrids and 2 checks for fruit girth, fruit weight and flesh thickness

Treatments	Fruit girth (cm)			Fruit weight (g)			Flesh thickness (mm)		
	Season I	Season II	Pooled	Season I	Season II	Pooled	Season I	Season II	Pooled
P_1	3 32	3 44	3 38	6 80	5 99	6 39	2 41	2 51	2 46
P_2	3 57	3 63	3 60	4 74	5 12	4 93	2 12	2 21	2 16
P_3	3 28	3 26	3 27	5 30	4 35	4 82	2 23	2 31	2 27
P_4	4 08	4 53	4 30	6 80	6 33	6 56	1 42	1 82	1 62
P_5	3 93	3 99	3 96	6 91	6 55	6 73	2 52	2 71	2 61
$P_1 \times P_2$	4 21	4 23	4 22	8 40	7 38	7 89	2 15	2 24	2 19
$P_1 \times P_3$	3 46	3 70	3 58	6 66	6 47	6 57	2 26	2 38	2 32
$P_1 \times P_4$	3 52	3 85	3 68	8 30	8 16	8 23	2 23	2 33	2 28
$P_1 \times P_5$	4 15	4 10	4 13	8 66	8 38	8 52	2 38	2 41	2 39
$P_2 \times P_3$	3 31	3 41	3 36	5 40	5 33	5 36	2 18	2 28	2 23
$P_2 \times P_4$	3 07	3 23	3 15	6 03	5 61	5 82	2 04	2 08	2 06
$P_2 \times P_5$	4 12	4 27	4 20	9 10	9 17	9 13	2 53	2 71	2 62
$P_3 \times P_4$	3 57	3 63	3 60	6 80	4 26	5 53	2 27	2 26	2 26
$P_3 \times P_5$	4 32	4 54	4 43	9 70	9 40	9 55	2 23	2 23	2 23
$P_4 \times P_5$	3 69	3 78	3 74	9 80	9 53	9 66	2 55	3 08	2 81
Arka Harita	2 75	2 96	2 85	3 36	3 36	3 36	1 13	1 15	1 14
Vellayani Athulya	6 07	6 46	6 27	17 40	17 33	17 36	3 35	3 28	3 31
Gen. Mean	3 79	3 94	3 87	7 65	7 22	7 44	2 23	2 35	2 29
CD(0.05)	0 171	0 220	0 135	1 043	0 635	0 615	0 035	0 032	0 024

4.2.11 Seeds Fruit ^{1}

Seeds fruit ^{1} showed a range from 76 40 (P_4) to 111 20 (P_1) and 101 00 (P_2 x P_3) to 147 13 (P_2 x P_5) among the parents and hybrids respectively during first season

During second season highest number of seeds fruit^{-1} was observed in parent P_1 (116 93) and lowest in P_4 (82 60) Among the hybrids more number of seeds fruit ^{1} was observed in P_2 x P_5 (152 46) and less number in P_2 x P_3 (106 20)

Pooled data revealed that among the parents P_1 (114 06) had maximum number of seeds fruit ^{1} and P_4 (79 50) had minimum number of seeds fruit ^{1} Among the hybrids it ranged from 103 60 (P_2 x P_3) to 149 80 (P_2 x P_5)

4.2.12 Green Fruit Yield Plant^{-1} (g)

Among the parents, P_5 (524 33 g) recorded maximum green fruit yield plant ^{1} and P_2 (294 26 g) recorded minimum and among the hybrids maximum green fruit yield was observed in P_4 x P_5 (1065 13 g) and minimum in P_2 x P_4 (614 46 g) in first season

Green fruit yield plant ^{1} was highest for parent P_5 (373 06 g) and lowest in P_2 (200 73 g) and among the hybrids highest was observed in P_4 x P_5 (860 73 g) and lowest in P_2 x P_4 (352 73 g) in second season

As per pooled data parent P_5 (448 70 g) recorded maximum green fruit yield plant ^{1} and P_2 (247 50 g) recorded minimum The hybrid P_4 x P_5 (962 93 g) recorded maximum green fruit yield plant ^{1} followed by P_3 x P_5 (886 53 g) and P_2 x P_5 (798 70 g) Minimum yield was recorded in the hybrid P_2 x P_4 (483 60 g)

4.2.13 Dry Fruit Yield Plant^{-1} (g)

Data from first season revealed that among the parents P_5 had maximum dry fruit yield plant ^{1} (98 80 g) and P_3 (47 96 g) minimum The hybrid P_4 x P_5 (147 00 g) showed highest dry fruit yield plant ^{1} and lowest was noticed in P_2 x P_4 (98 00 g)

Table 10 Mean values of 5 parents, 10 hybrids and 2 checks for flesh to seed ratio, seeds fruit^{-1} and green fruit yield plant^{-1}

Treatments	Flesh to seed ratio			Seeds fruit ^{1}			Green fruit yield plant^{-1} (g)		
	Season I	Season II	Pooled	Season I	Season II	Pooled	Season I	Season II	Pooled
P_1	5 38	5 65	5 51	111 20	116 93	114 06	495 00	276 00	385 50
P_2	3 76	4 03	3 90	96 00	98 20	97 10	294 26	200 73	247 50
P_3	4 15	5 26	4 71	82 60	84 66	83 63	471 50	217 73	344 61
P_4	7 50	7 74	7 62	76 40	82 60	79 50	353 40	207 73	280 56
P_5	8 81	8 87	8 84	81 80	86 66	84 23	524 33	373 06	448 70
$P_1 \times P_2$	6 60	6 85	6 72	132 13	139 00	135 56	754 26	486 33	620 30
$P_1 \times P_3$	6 36	6 61	6 48	135 13	139 46	137 30	625 73	431 66	528 70
$P_1 \times P_4$	6 74	6 97	6 85	131 60	138 40	135 00	857 66	518 20	687 93
$P_1 \times P_5$	10 27	10 67	10 47	121 73	127 86	124 80	868 12	590 66	729 39
$P_2 \times P_3$	4 25	4 46	4 36	101 00	106 20	103 60	638 86	422 13	530 50
$P_2 \times P_4$	4 86	4 98	4 92	121 53	127 26	124 40	614 46	352 73	483 60
$P_2 \times P_5$	6 35	6 54	6 44	147 13	152 46	149 80	873 06	724 33	798 70
$P_3 \times P_4$	7 35	7 52	7 43	121 80	126 26	124 03	823 73	635 33	729 53
$P_3 \times P_5$	4 36	4 44	4 40	127 93	134 00	130 96	950 33	822 73	886 53
$P_4 \times P_5$	7 25	7 35	7 30	105 20	109 66	107 43	1065 13	860 73	962 93
Arka Harita	2 31	2 44	2 38	63 46	66 53	65 00	384 20	372 33	378 26
Vellayani Athulya	10 93	10 30	10 62	139 93	145 06	142 50	667 66	684 66	676 16
Gen Mean	6 31	6 51	6 41	111 56	116 54	114 05	662 45	481 00	571 73
CD(0.05)	0 100	0 041	0 053	3 653	5 388	3 154	132 617	49 930	70 285

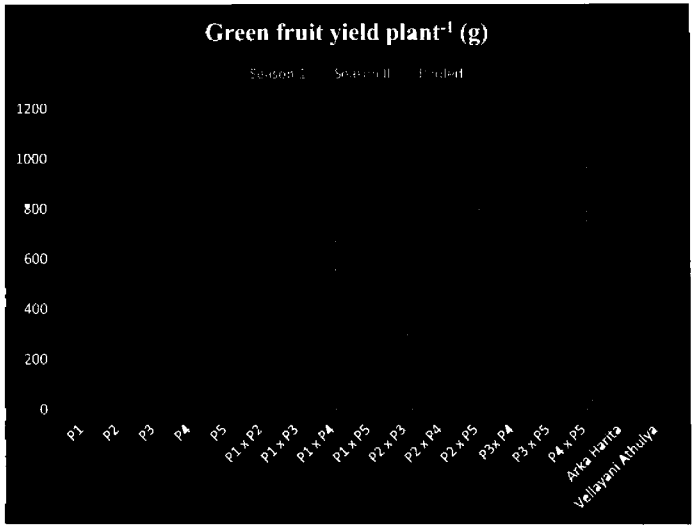


Figure 1. Mean performance of 5 parents 10 hybrids and 2 checks for green fruit yield plant [1]

During second season also maximum dry fruit yield plant^{-1} was observed in parent P_3 (61 15 g) and minimum was observed in P_2 (32 89 g) The hybrid P_4 x P_3 (141 10 g) showed maximum dry fruit yield plant^{-1} and P_2 x P_4 (57 82 g) minimum

Pooled data revealed that parent P_5 (79 98 g) had maximum and P_2 (40 42 g) had minimum dry fruit yield plant^{-1} The hybrid P_4 x P_5 (144 05 g) showed maximum dry fruit yield plant^{-1} which was on par with P_3 x P_5 (139 93 g) It was minimum in the hybrid P_2 x P_4 (77 91 g)

4.2.14 Yield Plot^{-1} (kg)

During first season parent P_5 (15 09 kg) recorded highest yield plot^{-1} and lowest was in P_2 (8 47 kg) Among hybrids maximum yield plot^{-1} was recorded in P_4 x P_5 (30 67 kg) and minimum in P_2 x P_4 (17 69 kg)

Yield plot^{-1} was maximum in the parent P_5 (10 74 kg) and minimum in P_2 (5 77 kg) The hybrid P_4 x P_5 (24 78 kg) recorded the maximum yield plot^{-1} and minimum was recorded in P_2 x P_4 (10 15 kg) in second season

Among the parents P_5 (12 91 kg) recorded maximum yield plot^{-1} and minimum was recorded in P_2 (7 12 kg) Maximum yield plot^{-1} was recorded in the hybrid P_4 x P_5 (27 72 kg) followed by P_3 x P_5 (25 52 kg) and P_2 xP_5 (22 99 kg) It was minimum in P_2 x P_4 (13 92 kg) as per pooled data

4.2.15 Driage (%)

Driage percentage ranged from 21 96 % to 25 55 % among the parents in first season and 21 16 % to 24 66 % in second season respectively Among the hybrids driage percentage varied from 20 00 % to 26 60 % in first season and 19 33 % to 27 23 % in second season respectively

Pooled data revealed that driage percentage among the parents ranged from 21 56 % (P_1) to 25 11 % (P_5) and among hybrids it ranged from 19 66 % (P_2 x P_4) to 26 91 % (P_4 x P_5)

Table 11. Mean values of 5 parents, 10 hybrids and 2 checks for dry fruit yield plant ^{1}, yield plot^{-1} and driage

Treatments	Dry fruit yield plant ^{1} (g)			Yield plot^{-1} (kg)			Driage (%)		
	Season I	Season II	Pooled	Season I	Season II	Pooled	Season I	Season II	Pooled
P_1	79 98	45 22	62 60	14 25	7 94	11 09	24 90	24 16	24 53
P_2	47 96	32 89	40 42	8 47	5 77	7 12	22 96	22 23	22 60
P_3	77 22	36 07	56 64	13 54	6 26	9 90	21 96	21 16	21 56
P_4	56 95	34 05	45 50	10 17	5 98	8 07	24 03	23 23	23 63
P_5	98 80	61 15	79 98	15 09	10 74	12 91	25 55	24 66	25 11
$P_1 \times P_2$	122 33	79 70	101 01	21 72	14 00	17 86	22 54	21 50	22 02
$P_1 \times P_3$	102 06	70 76	86 41	18 01	12 43	15 22	20 40	19 83	20 11
$P_1 \times P_4$	138 84	84 94	111 89	24 65	14 92	19 78	25 03	24 83	24 93
$P_1 \times P_5$	138 70	96 82	117 76	24 99	17 00	21 00	25 70	25 06	25 38
$P_2 \times P_3$	103 06	69 19	86 13	18 39	12 15	15 27	22 03	21 16	21 60
$P_2 \times P_4$	98 00	57 82	77 91	17 69	10 15	13 92	20 00	19 33	19 66
$P_2 \times P_5$	140 00	118 73	129 36	25 14	20 85	22 99	25 76	26 16	25 96
$P_3 \times P_4$	136 97	104 14	120 55	23 71	18 29	21 00	22 10	21 23	21 66
$P_3 \times P_5$	145 00	134 86	139 93	27 35	23 69	25 52	26 16	26 86	26 51
$P_4 \times P_5$	147 00	141 10	144 05	30 67	24 78	27 72	26 60	27 23	26 91
Arka Harita	62 91	61 03	61 97	11 06	10 71	10 88	23 66	24 66	24 16
Vellayani Athulya	108 83	112 23	110 53	19 22	19 70	19 46	30 83	30 33	30 58
Gen Mean	106 15	78 86	92 51	19 07	13 84	16 45	24 13	23 74	23 94
CD(0.05)	9 919	8 181	6 359	3 816	1 438	2 022	0 659	0 729	0 476

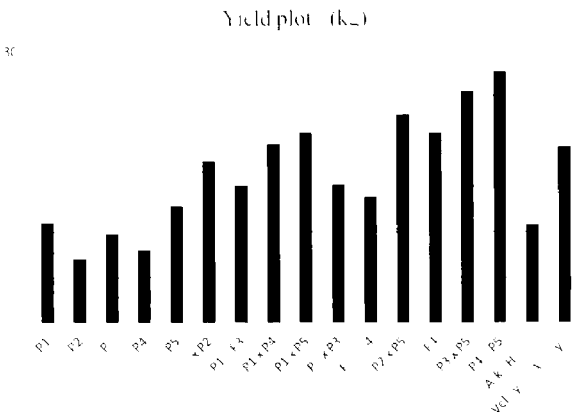


Figure 2 Mean performance of 5 parents 10 hybrids and 2 checks for yield plot [1] (pooled data)

4 2 16 Seed Yield Fruit^{-1} (g)

During the first season the seed yield fruit^{-1} among the parents ranged from 0 41 g (P_5) to 0 83 g (P_3) and among the hybrids ranged from 0 20 g (P_1 x P) to 0 79 g (P_3 x P P x P_5)

Among the parents seed yield fruit^{-1} ranged from 0 42 g (P) to 0 84 g (P) and among the hybrids it ranged from 0 21 g (P_1 x P_5) to 0 80 g (P x P) in second season

Among the parents the maximum seed yield fruit^{-1} was observed in P_3 (0 83) and minimum was recorded in P (0 41) Seed yield fruit^{-1} of hybrids ranged from 0 20 (P_1 x P_5) to 0 80 (P_2 x P_3) as per pooled data

4 2 17 Capsaicin (%)

The parent P (0 45 %) had highest capsaicin content among the parents and lowest in P (0 40 %) Fruits of hybrid P x P (0 78 %) had more capsaicin content and less in P_1 x P_5 P x P_4 and P x P (0 70 %) in first season

During second season highest capsaicin content among the parents was observed in P (0 44 %) and lowest in P (0 40 %) and capsaicin content among the hybrids ranged from 0 68 % (P x P) to 0 77% (P x P)

Capsaicin among the parents ranged from 0 40 % (P) to 0 45 % (P) Among the hybrids it varied from 0 69 % (P x P_4 and P x P_5) to 0 78 % (P x P) as per pooled data

4 2 18 Oleoresin (%)

The highest oleoresin content was observed in the parent P (14 66 %) and lowest in P and P_4 (11 66 %) Among the hybrids maximum oleoresin was recorded in P x P (15 66 %) and minimum in P_1 x P and P x P (10 66 %) during the first season

Table 12 Mean values of 5 parents, 10 hybrids and 2 checks for seed yield fruit[1] capsaicin and oleoresin

Treatments	Seed yield fruit[1] (g)			Capsaicin (%)			Oleoresin (%)		
	Season I	Season II	Pooled	Season I	Season II	Pooled	Season I	Season II	Pooled
P_1	0.73	0.74	0.74	0.44	0.43	0.44	13.66	14.33	14.00
P_2	0.83	0.84	0.83	0.42	0.41	0.42	11.66	12.40	12.00
P_3	0.76	0.76	0.76	0.40	0.40	0.40	12.66	13.20	12.93
P_4	0.62	0.63	0.63	0.43	0.42	0.43	11.66	12.33	12.00
P_5	0.41	0.42	0.41	0.45	0.44	0.45	14.66	15.53	15.10
$P_1 \times P_2$	0.68	0.69	0.68	0.71	0.70	0.71	10.66	11.13	10.90
$P_1 \times P_3$	0.69	0.70	0.69	0.77	0.76	0.77	16.66	17.26	16.96
$P_1 \times P_4$	0.67	0.68	0.67	0.73	0.72	0.73	15.66	16.33	16.00
$P_1 \times P_5$	0.20	0.21	0.20	0.70	0.70	0.70	17.66	18.36	18.01
$P_2 \times P_3$	0.79	0.80	0.80	0.78	0.77	0.78	11.66	11.13	10.90
$P_2 \times P_4$	0.77	0.78	0.78	0.70	0.69	0.69	13.66	14.40	14.03
$P_2 \times P_5$	0.70	0.71	0.70	0.74	0.73	0.74	18.66	19.43	19.00
$P_3 \times P_4$	0.64	0.65	0.64	0.72	0.71	0.72	17.66	18.33	18.00
$P_3 \times P_5$	0.79	0.79	0.79	0.70	0.68	0.69	15.66	16.13	15.90
$P_4 \times P_5$	0.68	0.69	0.68	0.71	0.70	0.71	18.10	18.63	18.36
Arka Harita	1.00	1.00	1.00	0.44	0.43	0.43	13.66	14.26	13.96
Vellayani Athulya	0.30	0.31	0.30	0.40	0.42	0.41	12.66	13.13	12.90
Gen Mean	0.66	0.67	0.66	0.60	0.60	0.60	14.43	15.06	14.76
CD(0.05)	0.011	0.010	0.007	0.010	0.010	0.007	1.007	0.445	0.533

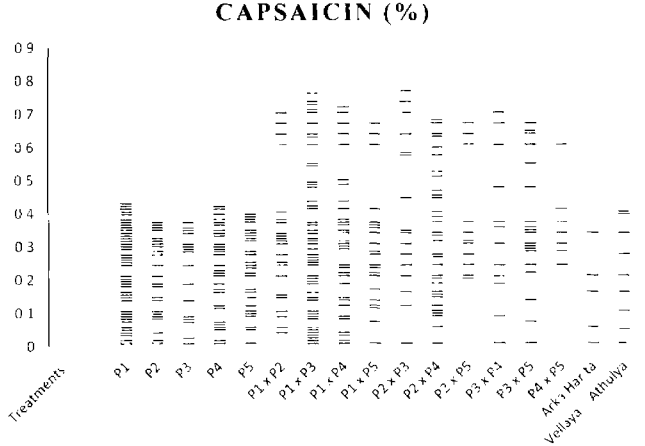


Figure 3. Mean performance of 5 parents 10 hybrids and 2 checks for capsaicin (pooled data)

During second season oleoresin content among the parents ranged from 12 33 % (P_4) to 15 53 % (P_5) and among the hybrids it ranged from 11 13 % (P_1 x P_2 and P_2 x P_3) to 19 13 % (P_2 xP_5)

Pooled data from both the seasons revealed that the parent (P_5) 15 10 % had maximum oleoresin and (P_4) 12 00 % minimum Among the hybrids maximum oleoresin was recorded in (P_2 x P_5) 18 90 % and minimum 10 90 % by (P_1 x P_2) and (P_2 x P_3)

4.2.19 Ascorbic Acid (mg/100 g)

P_4 had the maximum ascorbic acid content (98 10 mg/100g) and minimum in P3 (95 16 mg/100g) and the hybrid P_2 x P_5 had more ascorbic acid (122 66 mg/100g) and less in P_1 x P_4 (102 66 mg/100g) as per first season evaluation

Among the parents ascorbic acid content ranged from 94 66 mg/100g (P_1) to 98 66mg/100g (P_2 and P_4) and among the hybrids it ranged from 96 33mg/100g (P_1 x P_3) to 122 66mg/100g (P_2 x P_5) during second season

According to the pooled data among the parents the maximum ascorbic acid was recorded in (P_4) 98 38 mg/100 g and minimum in (P_1) 94 95 mg/100 g The hybrid with maximum ascorbic acid content was for P_2 x P_5 (122 66 mg/100 g) and minimum was for P_1 x P_5 (94 50 mg/100 g)

4 2.20 Colour (ASTA units)

Colour value ranged from 121 00 ASTA units (P_1) to 169 16 ASTA units (P_5) among the parents in first season and 121 66 ASTA units (P_1) to 169 66 ASTA units (P_5) in second season respectively Among the hybrids it ranged from 140 72 ASTA units (P_3 x P_4) to 195 13 ASTA units (P_2 x P_5) during first season and 141 66 ASTA units (P_3 x P_4) to 195 66 ASTA units (P_2 x P_5) in second season respectively

Pooled data revealed that among the parents the colour value ranged from (P_1) 121 33 ASTA units to (P_5) 169 41 ASTA units and among the hybrids colour value ranged from (P_3 x P_4) 141 19 ASTA units to (P_2 x P_5) 195 39 ASTA units

Table 13 Mean values of 5 parents, 10 hybrids and 2 checks for ascorbic acid and colour value

Treatments	Ascorbic acid (mg/100g)			Colour value (ASTA units)		
	Season I	Season II	Pooled	Season I	Season II	Pooled
P_1	95 23	94 66	94 95	121 00	121 66	121 33
P_2	97 06	98 66	97 86	145 49	145 66	145 58
P_3	95 16	96 66	95 91	164 50	164 66	164 58
P_4	98 10	98 66	98 38	167 04	167 66	167 35
P_5	96 16	97 66	96 91	169 16	169 66	169 41
$P_1 \times P_2$	122 00	121 33	121 66	148 17	148 66	148 42
$P_1 \times P_3$	117 66	116 66	117 16	169 30	170 00	169 65
$P_1 \times P_4$	102 66	101 33	102 00	176 31	176 66	176 49
$P_1 \times P_5$	92 66	96 33	94 50	180 66	181 33	181 00
$P_2 \times P_3$	113 66	113 33	113 50	152 64	152 66	152 65
$P_2 \times P_4$	111 66	110 66	111 16	148 07	148 66	148 37
$P_2 \times P_5$	122 66	122 66	122 66	195 13	195 66	195 39
$P_3 \times P_4$	105 66	105 66	105 66	140 72	141 66	141 19
$P_3 \times P_5$	116 66	115 66	116 16	170 58	171 66	171 12
$P_4 \times P_5$	120 66	119 66	120 16	174 66	175 66	175 16
Arka Harita	115 66	121 33	118 50	180 39	181 66	181 02
Vellayani Athulya	96 00	96 66	96 33	131 00	132 66	131 83
Gen Mean	107 02	107 51	107 26	160 87	161 54	161 21
CD(0 05)	1 170	1 349	0 875	0 998	1 106	0 728

4 2 ESTIMATION OF HETEROSIS

First season data was taken and the magnitude of heterosis was estimated as per cent increase or decrease of F_1 value over mid- parent (RH), better parent (HB) and standard check (SH) for various characters are presented in Tables 14-23 The character wise results are summarised in the following paragraphas

4.3.1 Plant Height (cm)

Relative heterosis for plant height ranged from (P_3 x P_5) -17 05 % to (P_1 x P_2) 36 62 % (Table 14) Among the ten hybrids, five hybrids showed significant positive heterosis and three hybrids showed significant negative heterosis over the mid parent Heterobeltiosis for plant height ranged from -20 59 % (P_3 x P_5) to 29 14 % (P_1 x P_2) Five hybrids showed significant positive heterosis over the standard check hybrid and nine hybrids showed significant negative heterosis over the standard check variety

4.3.2 Primary Branches Plant^{-1}

Relative heterosis for primary branches plant ^{1} ranged from -13 73 % (P_1 x P_5) to 64 56 % (P_1 x P_2) (Table 14) Among the ten hybrids, seven hybrids showed significant positive heterosis and two hybrids showed significant negative heterosis over the mid parent Heterobeltiosis for primary branches plant ^{1} ranged from -32 82 % (P_1 x P_5) to 60 00 % (P_2 x P_3) Among the ten hybrids, seven hybrids showed significant positive heterosis and three hybrids showed negative heterosis over the better parent Six hybrids showed positive heterosis over the standard check hybrid Arka Harita and three hybrids showed positive heterosis over the standard check variety Vellayani Athulya

4.3.3 Days to First Flower

Among the ten hybrids, nine showed significant negative relative heterosis (Table 15) The hybrid P_3 x P_4 (-12 96 %) showed early flowering over the mid parent Ten hybrids showed significant negative heterobeltiosis Early flowering was shown by the hybrid P_3 x P_4 (-14 88 %) over the better parent followed by hybrid P_2 x P_5 (-12 95 %) Ten hybrids showed negative heterosis over the

standard check hybrid Early flowering was shown by P_2 x P_5 (-23 42 %) followed by P_3 x P_4 (-22 78 %) over the standard check hybrid Arka Harita Eight hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya

4.3 4 Days to First Harvest

Nine hybrids showed significant negative relative heterosis (Table 15) The hybrid P_2 x P_5 (-7 63 %) showed early days to first harvest over the mid parent followed by P_3 x P_4 (-6 88 %) Ten hybrids showed significant negative heterobeltiosis Early days to first harvest was shown by the hybrid P_3 x P_4 (-8 25 %) over the better parent followed by the hybrids P_2 x P_5 (-7 69 %), P_1 x P_2 (-6 55 %) Ten hybrids showed significant negative heterosis over the standard check hybridArka Harita and nine hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya

4.3.5 Fruits Plant^{-1}

Heterosis over the mid parent ranged from P_1 x P_3 (16 51 %) to P_4 x P_5 (103 12 %) and ten hybrids showed significant positive relative heterosis (Table 16) Nine hybrids showed significant positive heterosis over the better parent Heterobeltiosis ranged from 24 14 % (P_1 x P_2) to 73 26 % (P_2 x P_4) Nine hybrids showed significant negative heterosis over the standard check hybrid Arka Harita Ten hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya

4.3.6 Fruit Length (cm)

Among the ten hybrids, all the hybrids showed significant positive relative heterosis (Table 16) The heterosis over the mid parent ranged from P_1 x P_2 (8 05 %) to P_2 x P_3 (30 20 %) Nine hybrids showed significant positive heterobeltiosis Heterobeltiosis for fruit length ranged from P_1 x P_2 (-3 95 %) to P_2 x P_3 (21 01 %) All the ten hybrids showed significant positive heterosis over the standard check hybrid Arka Harita Seven hybrids showed significant negative heterosis over the standard check variety Vellayani Athulya

4.3.7 Fruit Girth (cm)

The heterosis over the mid parent ranged from -19 56 % (P_2 x P_4) to 22 24 % (P_1 x P_2) Among the hybrids five showed significant positive relative heterosis (Table 17) Four hybrids showed significant positive heterobeltiosis The heterosis over better parent ranged from -24 59 % (P_2 xP_4) to 18 02 % (P_1 x P_2) All the ten hybrids showed significant positive heterosis over the standard check hybrid Arka Harita All the ten hybrids showed significant negative heterosis over the standard check variety Vellayani Athulya

4.3.8 Fruit Weight (g)

Among the hybrids six showed significant positive relative heterosis (Table 17) The heterosis over the mid parent ranged from 22 00 % (P_1 x P_4) to 58 89 % (P_3 x P_5) The heterosis over the better parent ranged from 22 00 % (P_1 x P_4) to 41 82 % (P_4 x P_5) Six hybrids showed significant positive heterobeltiosis All the ten hybrids showed significant positive heterosis over the standard check hybrid Arka Harita and significant negative heterosis over the standard check variety Vellayani Athulya

4.3.9 Flesh Thickness (mm)

The magnitude of heterosis for flesh thickness ranged from -6 11 % (P_3 x P_5) to 29 42 % (P_4 x P_5) over the mid parent (Table 18) Five hybrids showed significant positive heterosis over mid parent None of the hybrids showed positive significant heterobeltiosis All the ten hybrids showed significant positive heterosis over the standard check hybrid which ranged from 80 53 % (P_2 x P_4) to P_4 x P_5 (125 66 %) All the hybrids showed significant negative heterosis over the standard check variety Vellayani Athulya

4.3.10 Flesh to Seed Ratio

Among the hybrids six showed significant positive relative heterosis over the mid parent (Table 18) The heterosis over the mid parent ranged from -32 73 % (P_3 x P_5) to 44 77 % (P_1 x P_5) Four of the hybrids showed significant positive heterobeltiosis Heterobeltiosis ranged from -50 51 % (P_3 x P_5) to 22 80 % (P_1 x

Table 16 Heterosis (%) for fruits plant[1] and fruit length

	Fruits plant[1]				Fruit length (cm)			
Hybrids	RH	HB	SH (H)	SH (V)	RH	HB	SH (H)	SH (V)
$P_1 \times P_2$	40 67**	24 14*	-29 82**	44 00**	8 05**	3 95**	37 87**	-13 98**
$P_1 \times P_3$	16 51*	11 54	-31 06**	41 45**	16 09**	1 35*	45 48**	-9 23**
$P_1 \times P_4$	64 55**	34 25**	-24 10**	55 73**	20 46**	11 13**	59 51**	0 47
$P_1 \times P_5$	48 70**	43 34**	-18 96**	66 27**	16 89**	12 49**	61 45**	0 74
$P_2 \times P_3$	52 26**	29 39**	-20 03**	64 09**	23 53**	21 01**	35 12**	15 69**
$P_2 \times P_4$	89 79**	73 26**	-25 08**	53 73**	18 51**	13 80**	38 04**	-13 87**
$P_2 \times P_5$	76 94**	61 40**	-15 33**	73 73**	30 20**	19 87**	59 09**	-0 74
$P_3 \times P_4$	71 74**	35 48**	-16 26**	71 82**	21 54**	14 43**	38 80**	-13 40**
$P_3 \times P_5$	46 34**	35 27**	-16 39**	71 55**	14 91**	3 82**	37 79**	-14 03**
$P_4 \times P_5$	103 12**	70 69**	10 46	83 73**	12 48**	7 64**	42 86**	-10 86**

Table 17 Heterosis (%) for fruit girth and fruit weight

	Fruit girth (cm)				Fruit weight (g)			
Hybrids	RH	HB	SH (H)	SH (V)	RH	HB	SH (H)	SH (V)
$P_1 \times P_2$	22 24**	18 02**	53 03**	30 63**	45 50**	23 47**	149 50**	-51 72**
$P_1 \times P_3$	5 00*	4 31	25 91**	-42 92**	10 16	-2 01	98 02**	-61 69**
$P_1 \times P_4$	-4 91*	-13 73**	27 85**	-42 04**	22 00**	22 00**	146 53**	52 30**
$P_1 \times P_5$	14 52**	5 68*	50 85**	31 61**	26 40**	25 42**	157 43**	-50 19**
$P_2 \times P_3$	-3 16	-7 10**	20 46**	-45 39**	7 53	1 89	60 40**	-68 97**
$P_2 \times P_4$	-19 56**	-24 59**	11 74**	-49 34**	4 50	-11 32	79 21**	65 33**
$P_2 \times P_5$	10 04**	5 00*	49 88**	32 05**	56 18**	31 69**	170 30**	-47 70**
$P_3 \times P_4$	2 81	-12 34**	29 90**	-41 11**	12 37	-0 05	101 98**	60 92**
$P_3 \times P_5$	20 02**	10 09**	57 14**	28 76**	58 89**	40 38**	188 12**	-44 25**
$P_4 \times P_5$	7 70**	9 40**	34 26**	-39 13**	42 93**	41 82**	191 09**	-43 68**

RH-Relative heterosis HB-Heterobeltiosis SH-Standard heterosis

SH (H) - Standard heterosis over hybrid Arka Harita SH (V) - Standard heterosis over variety Vellayani Athulya

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

P_2) All the ten hybrids showed significant positive heterosis over the standard check hybrid Arka Harita and significant negative heterosis over the standard check variety Vellayani Athulya

4.3.11 Seeds Fruit^{-1}

Estimation of relative heterosis showed that all the ten hybrids showed significant positive heterosis (Table 19) The relative heterosis ranged from 13 10 % (P_2 x P_3) to 65 50 % (P_2 x P_5) Estimation of heterobeltiosis revealed that all the ten hybrids showed significant positive heterosis Heterosis over the better parent ranged from 5 21 % (P_2 x P_3) to 54 88 % (P_3 x P_5) All the ten hybrids showed significant positive heterosis over the standard check hybrid Arka Harita and nine hybrids showed significant negative heterosis over the standard check variety Vellayani Athulya

4.3.12 Green Fruit Yield Plant^{-1} (g)

Ten hybrids showed significant positive heterosis over the mid parent (Table 19) The magnitude of heterosis ranged from 29 48 % (P_1 x P_3) to 142 70 % (P_4 x P_5) Nine hybrids showed significant positive heterosis over the better parent Heterobeltiosis ranged from 35 50 % (P_2 x P_3) to 103 14 % (P_4 x P_5) All the ten hybrids showed significant positive heterosis over the standard hybrid check Arka Harita which ranged from 59 93 % (P_2 x P_4) to 177 23 % (P_4 x P_5) Six hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya

4.3.13 Dry Fruit Yield Plant^{-1} (g)

The magnitude of heterosis for dry fruit yield plant^{-1} ranged from 29 86 % (P_1 x P_3) to 104 17 % (P_3 x P_4) (Table 20) Ten hybrids showed significant positive heterosis over the mid parent, better parent and standard hybrid check Heterobeltiosis ranged from 27 62 % (P_1 x P_3) to 77 38 % (P_3 x P_4) The heterosis over the standard hybrid check Arka Harita ranged from 55 77 % (P_2 x P_4) to 133 65 % (P_4 x P_5) Seven hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya

Table 18. Heterosis (%) for flesh thickness and flesh to seed ratio

	Flesh thickness (mm)				Flesh to seed ratio			
Hybrids	RH	HB	SH (H)	SH (V)	RH	HB	SH (H)	SH (V)
$P_1 \times P_2$	-5 22**	-11 03**	90 27**	-35 82**	44 46**	22 80**	185 18**	-39 57**
$P_1 \times P_3$	-2 44**	-6 21**	100 59**	32 34**	33 44**	18 22**	174 53**	-41 83**
$P_1 \times P_4$	16 23**	-7 72**	97 35**	33 43**	4 60**	-10 21**	190 94**	-38 35**
$P_1 \times P_5$	-3 58**	5 56**	110 62**	-28 96**	44 77**	16 59**	343 37**	6 05**
$P_2 \times P_3$	0 23	2 24**	92 92**	-34 93**	7 50**	2 50*	83 74**	61 07**
$P_2 \times P_4$	15 23**	-3 77**	80 53**	-39 10**	-13 72**	35 21**	109 93**	-55 52**
$P_2 \times P_5$	9 05**	0 40	123 89**	-24 48**	0 98	-27 92**	174 10**	-41 92**
$P_3 \times P_4$	24 36**	1 79*	100 88**	-32 24**	26 08**	-2 09**	217 27**	-32 77**
$P_3 \times P_5$	-6 11**	-11 51**	97 35**	-33 43**	-32 73**	-50 51**	88 20**	-60 12**
$P_4 \times P_5$	29 42**	1 19	125 66**	-23 88**	-11 09**	-17 67**	213 09**	-33 66**

Table 19. Heterosis (%) for seeds fruit^{-1} and green fruit yield plant^{-1}

	Seeds fruit^{-1}				Green fruit yield plant^{-1} (g)			
Hybrids	RH	HB	SH (H)	SH (V)	RH	HB	SH (H)	SH (V)
$P_1 \times P_2$	27 54**	18 82**	108 19**	-5 57**	91 13**	52 38**	96 32**	12 97
$P_1 \times P_3$	39 46**	21 52**	112 92**	-3 43*	29 48*	26 41	62 87**	-6 28
$P_1 \times P_4$	40 30**	18 35**	107 35**	5 96**	102 18**	73 27**	123 23**	28 46**
$P_1 \times P_5$	26 15**	9 47**	91 81**	-13 01**	70 33**	65 57**	125 96**	30 02**
$P_2 \times P_3$	13 10**	5 21**	59 14**	-27 82**	66 86**	35 50*	66 28**	-4 31
$P_2 \times P_4$	40 99**	26 60**	91 49**	-13 15**	89 75**	73 87**	99 93**	-7 97
$P_2 \times P_5$	65 50**	53 26**	131 83**	5 15**	113 31**	66 51**	127 24**	30 76**
$P_3 \times P_4$	53 21**	47 46**	91 91**	12 96**	99 72**	74 70**	114 40**	23 37*
$P_3 \times P_5$	55 64**	54 88**	101 58**	8 58**	90 86**	81 25**	147 35**	42 34**
$P_4 \times P_5$	33 00**	28 61**	65 76**	-24 82**	142 70**	103 14**	177 23**	59 53**

RH-Relative heterosis HB-Heterobeltiosis SH-Standard heterosis

SH (H) - Standard heterosis over hybrid Arka Harita SH (V) Standard heterosis over variety Vellayani Athulya

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

4.3.14 Yield Plot^{-1} (kg)

The magnitude of heterosis for yield plot ^{1} ranged from 29 65 % (P_1 x P_3) to 142 76 % (P_4 x P_5), 35 84 % (P_2 x P_3) to 103 18 % (P_4 x P_5), 62 90 % (P_1 x P_3) to 177 34 % (P_4 x P_5) over the mid parent, better parent and standard check hybrid respectively (Table 20) Ten hybrids showed significant positive relative heterosis, nine hybrids showed significant positive heterobeltiosis, all the ten hybrids showed significant positive standard heterosis over the check hybrid Arka Harita and six hybrids showed significant positive standard heterosis over the check variety Vellayani Athulya

4.3.15 Driage (%)

Among the hybrids three showed significant positive relative heterosis (Table 21) The magnitude of heterosis for driage per cent ranged from -14 89 % (P_2 x P_4) to 10 13 % (P_3 x P_5) One hybrid showed significant positive heterobeltiosis and five hybrids showed significant positive standard heterosis Heterobeltiosis ranged from -18 07 % (P_1 x P_3) to 4 10 % (P_4 x P_5) Standard heterosis over the hybrid check Arka Harita ranged from -15 49 % (P_2 x P_4) to 12 39 % (P_4 x P_5) All the hybrids showed significant negative heterosis over the standard check variety Vellayani Athulya

4.3.16 Seed Yield Fruit^{-1} (g)

The magnitude of heterosis over the mid parent ranged from -64 64 % (P_1 x P_5) to 34 28 % (P_3 x P_5) (Table 21) Four hybrids showed significant positive relative heterosis Two hybrids showed significant positive heterosis over the better parent Heterosis over the better parent ranged from -72 40 % (P_1 x P_5) to 9 04 % (P_4 x P_5) None of the hybrids showed significant positive heterosis over the standard check hybrid Arka Harita and nine hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya

4.3.17 Capsaicin (%)

Estimation of relative heterosis showed that all the ten hybrids exhibited significant positive heterosis (Table 22) Relative heterosis ranged from 56 46 %

Table 20. Heterosis (%) for dry fruit yield plant [1] and yield plot [1]

	Dry fruit yield plant [1] (g)				Yield plot [1] (kg)			
Hybrids	RH	HB	SH (H)	SH (V)	RH	HB	SH (H)	SH (V)
$P_1 \times P_2$	91 23**	52 95**	94 45**	12 40**	91 20**	52 42**	96 38**	12 99
$P_1 \times P_3$	29 86**	27 62**	62 23**	-6 22	29 65*	26 43	62 90**	-6 28
$P_1 \times P_4$	102 79**	73 59**	120 68**	27 57**	101 91**	73 03**	122 94**	28 26**
$P_1 \times P_5$	55 16**	40 38**	120 47**	27 44**	70 35**	65 58**	126 01**	30 03**
$P_2 \times P_3$	64 66**	33 47**	63 82**	-5 30	67 14**	35 84*	66 34**	-4 30
$P_2 \times P_4$	86 82**	72 08**	55 77**	9 96*	89 81**	73 92**	59 98**	-7 96
$P_2 \times P_5$	90 77**	41 69**	122 53**	28 63**	113 35**	66 53**	127 31**	30 78**
$P_3 \times P_4$	104 17**	77 38**	117 71**	25 85**	100 00**	75 12**	114 44**	23 37*
$P_3 \times P_5$	64 75**	46 75**	130 48**	33 23**	91 04**	81 21**	147 35**	42 31**
$P_4 \times P_5$	88 76**	48 78**	133 65**	35 06**	142 76**	103 18**	177 34**	59 56**

Table 21. Heterosis (%) for driage and seed yield fruit [1]

	Driage (%)				Seed yield fruit [1] (g)			
Hybrids	RH	HB	SH (H)	SH (V)	RH	HB	SH (H)	SH (V)
$P_1 \times P_2$	-5 79**	-9 45**	-4 73**	-26 88**	-13 56**	-18 73**	-32 00**	126 67**
$P_1 \times P_3$	-12 94**	-18 07**	-13 80**	-33 84**	8 00**	9 61**	31 00**	130 00**
$P_1 \times P_4$	2 32	0 54	5 77**	18 81**	1 71*	-9 05**	-33 00**	123 33**
$P_1 \times P_5$	1 88	0 57	8 59**	16 65**	64 64**	72 40**	-79 67**	32 22**
$P_2 \times P_3$	-1 93	-4 06**	6 90**	28 54**	0 42	4 78**	-20 33**	165 56**
$P_2 \times P_4$	14 89**	16 78**	15 49**	35 14**	6 15**	-7 17**	-22 33**	158 89**
$P_2 \times P_5$	6 21**	0 83	8 87**	16 43**	12 53**	-15 94**	-29 67**	134 44**
$P_3 \times P_4$	-3 91**	-8 04**	6 62**	28 32**	7 91**	16 16**	36 00**	113 33**
$P_3 \times P_5$	10 13**	2 40	10 56**	15 14**	34 28**	3 49**	21 00**	163 33**
$P_4 \times P_5$	7 29**	4 10**	12 39**	-13 73**	31 41**	9 04**	-31 67**	127 78**

RH-Relative heterosis HB-Heterobeltiosis SH-Standard heterosis

SH (H) - Standard heterosis over hybrid Arka Harita SH (V) - Standard heterosis over variety Vellayani Athulya

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

(P_1 x P_5) to 88 80 % (P_2 x P_3) Estimation of heterobeltiosis revealed that all the ten hybrids showed significant positive heterosis Heterosis over the better parent ranged from 54 01 % (P_3 x P_5) to 84 38 % (P_2 x P_1) All the ten hybrids showed significant positive heterosis over the standard check hybrid Arka Harita and standard check variety Vellayani Athulya

4.3.18 Oleoresin (%)

The magnitude of heterosis over the mid parent ranged from -15 79 % (P_1 x P_2) to 45 21 % (P_3 x P_4) (Table 22) Eight hybrids showed significant positive heterosis over the mid parent Heterobeltiosis ranged from -21 95 % (P_1 x P_2) to 39 47 % (P_3 x P_4) Seven hybrids showed significant positive heterosis over the better parent, standard check hybrid Arka Harita and standard check variety Vellayani Athulya

4.3.19 Ascorbic Acid (mg/100 g)

Among the ten hybrids, nine showed significant positive relative heterosis and heterobeltiosis (Table 23) Heterosis over the mid parent ranged from -3 17 % (P_1 x P_5) to 26 96 % (P_2 x P_5) Heterosis over the better parent ranged from -3 64 % (P_1 x P_5) to 26 37 % (P_2 x P_5) Four hybrids showed significant positive heterosis over the standard check hybrid Arka Harita and nine hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya

4.3.20 Colour (ASTA units)

Estimation of relative heterosis revealed that seven hybrids had significant positive relative heterosis and heterobeltiosis (Table 23) Relative heterosis ranged from -15 11 % (P_3 x P_4) to 24 53 % (P_1 x P_5) Heterosis over the better parent ranged from -15 76 % (P_3 x P_4) to 15 35 % (P_2 x P_5) One hybrid showed significant positive heterosis over the standard check hybrid Arka Harita and ten hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya

Table 22. Heterosis (%) for capsaicin and oleoresin

	Capsaicin (%)				Oleoresin (%)			
Hybrids	RH	HB	SH (H)	SH (V)	RH	HB	SH (H)	SH (V)
$P_1 \times P_2$	64 12**	60 45**	60 45**	76 23**	15 79**	-21 95**	-21 95**	-15 79**
$P_1 \times P_3$	82 03**	73 88**	73 88**	90 98**	26 58**	21 95**	21 95**	31 58**
$P_1 \times P_4$	66 79**	64 93**	64 93**	81 15**	23 68**	14 63**	14 63**	23 68**
$P_1 \times P_5$	56 46**	54 74**	58 21**	73 77**	24 71**	20 45**	29 27**	39 47**
$P_2 \times P_3$	88 80**	84 38**	76 12**	93 44**	-12 33**	-15 79**	21 95**	15 79**
$P_2 \times P_4$	62 93**	61 07**	57 46**	72 95**	17 14**	17 14**	0 00	7 89
$P_2 \times P_5$	69 06**	63 50**	67 16**	83 61**	41 77**	27 27**	36 59**	47 37**
$P_3 \times P_4$	72 33**	66 41**	62 69**	78 69**	45 21**	39 47**	29 27**	39 47**
$P_3 \times P_5$	62 93**	54 01**	57 46**	72 95**	14 63**	6 82	14 63**	23 68**
$P_4 \times P_5$	60 45**	56 93**	60 45**	76 23**	37 47**	23 41**	32 44**	42 89**

Table 23 Heterosis (%) for ascorbic acid and colour value

	Ascorbic acid (mg/100g)				Colour value (ASTA units)			
Hybrids	RH	HB	SH (H)	SH (V)	RH	HB	SH (H)	SH (V)
$P_1 \times P_2$	26 89**	25 69**	5 48**	27 08**	11 20**	1 84**	17 86**	13 11**
$P_1 \times P_3$	23 60**	23 56**	1 73**	22 57**	18 60**	2 92**	-6 15**	29 24**
$P_1 \times P_4$	6 21**	4 66**	-11 24**	6 94**	22 42**	5 55**	-2 26**	34 59**
$P_1 \times P_5$	-3 17**	-3 64**	19 88**	3 47**	24 53**	6 80**	0 15	37 91**
$P_2 \times P_3$	18 26**	17 10**	-1 73**	18 40**	-1 52**	-7 21**	-15 38**	16 52**
$P_2 \times P_4$	14 43**	13 83**	-3 46**	16 32**	5 24**	11 36**	-17 91**	13 04**
$P_2 \times P_5$	26 96**	26 37**	6 05**	27 78**	24 03**	15 35**	8 17**	48 95**
$P_3 \times P_4$	9 35**	7 71**	-8 65**	10 07**	-15 11**	-15 76**	-21 99**	7 42**
$P_3 \times P_5$	21 95**	21 32**	0 86	21 53**	2 25**	0 84**	-5 43**	30 22**
$P_4 \times P_5$	24 23**	23 00**	4 32**	25 69**	3 90**	3 25**	3 17**	33 33**

RH-Relative heterosis HB-Heterobeltiosis SH-Standard heterosis

SH (H) - Standard heterosis over hybrid Arka Harita SH (V) - Standard heterosis over variety Vellayani Athulya

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

4.4 CORRELATION ANALYSIS

Simple correlation was estimated for the various characters and presented in Table 24 Green fruit yield plant^{-1} had positive correlation with primary branches plant^{-1} (0 3937), fruits plant^{-1} (0 5601), fruit length (0 6721), fruit weight (0 4651), flesh thickness (0 4311), and seeds fruit^{-1} (0 6232) and negative correlation with days to first harvest (-0 6665)

Plant height had positive correlation with primary branches plant^{-1} (0 3283), fruit girth (0 3327) and fruit weight (0 3325) Primary branches plant^{-1} exhibited positive correlation with fruit girth (0 3694), fruit weight (0 4003) and negative correlation with days to first harvest (-4012)

Days to first harvest exhibited negative correlation with fruit length (-0 7742), fruit girth (-0 5212), fruit weight (-0 6502), flesh thickness (-0 6083) and seeds fruit^{-1} (-0 8006) Fruits plant^{-1} had negative association with the fruit girth (-0 3380)

Fruit length recorded significant positive association with fruit girth (0 5114), fruit weight (0 6694), flesh thickness (0 6817) and seeds fruit^{-1} (0 8355)

A positive correlation was observed for fruit girth with fruit weight (0 8991) and flesh thickness (0 6628) Fruit weight had positive correlation between flesh thickness (0 7606), and seeds fruit^{-1} (0 5995) Flesh thickness exhibited positive correlation with seeds fruit^{-1}

4 5 SCREENING FOR INCIDENCE OF PESTS AND DISEASES

The incidence of the pests and diseases were observed during the cropping period No disease incidence was noted Scoring of thrips and mites were given in Table 25 Majority of the treatments showed score 1 which indicates 1 to 25 % leaf curl symptom The incidence of thrips was more in the hybrid $P_3 \times P_4$ (1 96) and less in the hybrid $P_1 \times P_5$ (1 00) The incidence of mites ranged from 0 33 ($P_1 \times P_4$) to 1 83 ($P_1 \times P_3$, $P_2 \times P_4$, $P_3 \times P_5$)

Table 24. Correlation matrix for different characters

Character	Plant height (cm)	Primary branches plant^{-1}	Days to first harvest	Fruits plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Flesh thickness (mm)	Seeds fruit^{-1}	Green fruit yield plant^{-1} (g)
Plant height (cm)	1 0000	0 3283*	0 2385	0 0217	0 1420	0 3327*	0 3325*	0 1642	0 1280	0 1445
Primary branches plant^{-1}		1 0000	0 4012**	0 1911	0 2551	0 3694**	0 4003**	0 1468	0 2336	0 3937**
Days to first harvest			1 0000	-0 0534	-0 7742**	0 5212**	-0 6502**	-0 6083**	-0 8006**	-0 6665**
Fruits plant^{-1}				1 0000	0 1310	-0 3380*	-0 1283	-0 1630	0 1723	0 5601**
Fruit length (cm)					1 0000	0 5114**	0 6694**	0 6817**	0 8355**	0 6721**
Fruit girth (cm)						1 0000	0 8991**	0 6628**	0 4633	0 2607
Fruit weight (g)							1 0000	0 7606**	0 5995**	0 4651**
Flesh thickness								1 0000	0 6188**	0 4311**
Seeds fruit^{-1}									1 0000	0 6232**
Green fruit yield plant^{-1} (g)										1 0000

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

Table 25. Scoring for thrips and mites

Treatments	Thrips			Mites		
	Season I	Season II	Pooled	Season I	Season II	Pooled
P_1	2 20	2 40	2 30	0 00	0 33	0 16
P_2	1 46	1 73	1 59	2 00	1 66	1 83
P_3	1 66	2 00	1 83	1 46	1 13	1 29
P_4	1 20	1 20	1 20	0 00	0 33	0 16
P_5	1 73	1 80	1 76	1 73	1 86	1 79
$P_1 \times P_2$	1 66	2 00	1 83	1 00	0 66	0 83
$P_1 \times P_3$	1 20	1 20	1 20	0 00	0 33	0 16
$P_1 \times P_4$	1 40	1 60	1 50	1 60	1 26	1 43
$P_1 \times P_5$	1 60	1 66	1 63	0 00	0 33	0 16
$P_2 \times P_3$	1 20	1 20	1 20	1 66	2 00	1 83
$P_2 \times P_4$	1 60	1 66	1 63	2 00	1 66	1 83
$P_2 \times P_5$	1 66	1 86	1 76	1 00	1 33	1 16
$P_3 \times P_4$	1 80	2 13	1 96	0 00	0 66	0 33
$P_3 \times P_5$	1 00	1 00	1 00	1 66	2 00	1 83
$P_4 \times P_5$	1 46	1 53	1 49	1 53	1 53	1 53
Arka Harita	1 66	2 00	1 83	2 00	2 00	2 00
Vellayani Athulya	1 33	1 53	1 43	0 66	1 00	0 83

Discussion

5. DISCUSSION

Chilli (*Capsicum annuum* L.) is one of the most important commercially grown spice cum vegetable in the tropics Now hybrids have become very popular in many crops as they give an opportunity to utilize the synergistic effect of a genetic combinations Phenotypic expression of the hybrids varies with different environments In chilli, temperature, relative humidity, total rainfall and total sunshine hours affect the traits differently at the beginning or middle or end of the crop season. Stable hybrids are particularly of great importance in the country like India, where the crops are grown in varied environmental conditions The quality in chilli is determined by pungency level, fruit colour, fruit size, pericarp thickness, external glossiness and ascorbic acid content

The present investigation was conducted at the Department of Olericulture, College of Agriculture, Vellayani, during 2015-2016 to evaluate chilli hybrids for yield and quality parameters for two seasons and to identify superior hybrids with high yield and quality The experiment was carried out in Randomized Block Design with seventeen treatments in three replications The experimental materials for the study consisted of five parents *viz*, CA 3 (P_1), CA 5 (P_2), CA 6 (P_3), CA 8 (P_4) and CA 32 (P_5) and ten F_1 hybrids The hybrid Arka Harita and variety Vellayani Athulya were used as checks for the estimation of standard heterosis In this chapter, an attempt was made to discuss the salient experimental findings in detail

5 1 MEAN PERFORMANCE

Analysis of variance revealed significant difference among the treatments for all the characters studied for two seasons *viz*, plant height, primary branches plant^{-1}, days to first flower, days to first harvest, fruits plant^{-1}, fruit length, fruit girth, fruit weight, flesh thickness, flesh to seed ratio, seeds fruit^{-1}, green fruit yield plant^{-1}, dry fruit yield plant^{-1}, yield plot^{-1}, drirage, seed yield fruit^{-1}, capsaicin,

oleoresin, ascorbic acid, colour value and incidence of thrips and mites Such variations indicated scope for improving the population for these characters

5.1.1 Growth and yield characters

There was significant difference among the treatments for vegetative characters Pooled data from both the seasons revealed that among the hybrids P_1 x P_2 and P_1 x P_4 and among the parents P_3 was the tallest The hybrid P_3 x P_5 and parent P_5 (CA 32) recorded maximum primary branches plant^{-1} in both the seasons Considerable variations in vegetative characters was reported by Bini (2004) and Kumari *et al* (2010) The parent P_1 was early in flowering and harvest The hybrid P_3 x P_4 was earliest to flower among the hybrids (24 16 days) Hybrid P_2 x P_5 was earliest to harvest (43 23 days) In chilli Kumari *et al* (2010), Navhale *et al* (2014) and Kumar *et al* (2014) had reported a similar range

Fruit characters have direct influence on the total yield of a crop Significant differences in fruit characters were noticed among the parents and hybrids in the present study Among the hybrids maximum fruits plant^{-1} was observed in P_3 x P_4 Fruit length among the hybrids ranged from 10 49 to 12 61 cm and fruit girth ranged from 3 15 to 4 43 cm (pooled data) Maximum fruit weight was observed in the hybrid P_4 x P_5 (9 66 g) Similar variations in the fruit characters like fruits plant^{-1}, fruit length, fruit girth and fruit weight in chilli were reported by Jagadeesh and Wali (2005), Ganesh Reddy *et al* (2008), Payakhapaab *et al* (2012), Kumar *et al* (2014) and Singh *et al* (2014) Flesh thickness was maximum for the hybrid P_4 x P_5 Flesh to seed ratio was maximum for hybrid P_1 x P_5 The flesh thickness contributed to the fruit weight These results are in conformation with the results of earlier scientists Lohithaswa *et al* (2000) and Afroza *et al* (2014) Among the hybrids seeds fruit^{-1} exhibited a range from 103 60 to 149 80 Wide variation in the seeds fruit^{-1} was also reported by Ganesh Reddy *et al* (2008), and Navhale *et al* (2014)

In this study among the parents highest green fruit yield (448 70 g), dry fruit yield plant^{-1} (79 98 g), yield plot^{-1} (12 91 kg) was recorded in P_5 The highest green

fruit yield plant ^{1} (962 93 g), dry fruit yield plant ^{1} (144 05 g), yield plot ^{1} (27 72 kg) was recorded in the hybrid P_4 x P_5 followed by P_3 x P_5 and P_2 x P_5 Similar differential response for yield and yield attributes in different accessions and hybrids of chilli were reported by Kumari *et al* (2010), Tembhurne and Rao (2012), Patel *et al* (2014), Darshan (2014) and Nagaraju (2015) In the present study drage among the hybrids ranged from 19 66 to 26 91 % and seed yield fruit ^{1} ranged from 0 20 to 0 80 g Similar findings have also been reported by Bhagyalakshmi *et al* (1991), Singh and Hundal (2001) and Pandey *et al* (2012)

Incidence of thrips and mites has become a major threat for the cultivation of chilli in Kerala Pooled data from both the seasons revealed that leaf curl incidence of thrips ranged from 1 00 to 1 96 and mites ranged from 0 16 to 1 83

5.1.2 Quality characters

Chilli is rich in the quality parameters such as capsaicin, oleoresin, ascorbic acid and the colour value Good quality chilli is preferred by the consumers Capsaicin is the pungent principle in chilli which is an important quality character The parent P_5 had highest capsaicin content (0 45 per cent) Among the hybrids P_2 x P_3 had highest capsaicin content (0 78 per cent) P_2 x P_4 and P_3 x P_5 had the minimum capsaicin content (0 69 per cent) Variation in capsaicin content was reported by Chattopadhyay *et al* (2011) in chilli

Another important quality trait is oleoresin Oleoresin content in chilli will give many advantages like uniform quality, longer shelf life, free from microorganisms and it is also gaining importance in food industries as natural colourant Considering the need of chilli oleoresin from the industries and export markets there is a need to develop chilli hybrids which are having high oleoresin content Highest oleoresin content was in parent P_5 (15 10 per cent) and among hybrids maximum oleoresin content was observed in P_2 x P_5 (18 90 per cent) and minimum in P_1 x P_2 and P_2 x P_3 (10 90 per cent) Similar results were reported by Singh and Hundal (2001), Prasath *et al* (2007) and Chattopadhyay *et al* (2011)

Chilli is a good source of Vitamin C The parent P_4 had highest ascorbic acid content (98 38 mg per 100 g) Among the hybrids P_2 x P_5 had recorded maximum ascorbic acid content (122 66 mg per 100 g) and minimum in P_1 x P_5 (94 50 mg per 100g) Similar studies were reported by Choudhary and Samadia (2004) and Dandunayak (2008)

Colour value is the principal criteria for estimating the quality in chilli The major red colour in chilli is due to capsanthin and capsorubin The parent P_5 had highest colour value (169 41 ASTA units) The hybrid P_2 x P_5 recorded the maximum colour value (195 39 ASTA units) and minimum in P_3 x P_4 (141 19 ASTA units) Similar results were reported by Prasath and Ponnuswami (2008) and Chaudhary *et al* (2013)

Based on the evaluation of parents and hybrids for two seasons it is revealed that the parent P_1 (CA 3) was good for characters like days to first flower, days to first harvest, fruit length and seeds fruit^{-1}, the parent P_2 (CA 5) had more seed yield fruit^{-1}, the parent P_3 (CA 6) showed superiority for traits like plant height and fruits plant^{-1}, the parent P_4 (CA 8) was good for fruit girth and the parent P_5 showed superiority for primary branches plant^{-1}, fruit weight (6 73 g), flesh thickness (2 61 mm), flesh to seed ratio (8 84), green fruit yield plant^{-1} (448 70 g), dry fruit yield plant^{-1} (79 98 g), yield plot^{-1} (912 91 kg), drirage percentage (25 11) and all quality characters like capsaicin (0 45 per cent), oleoresin (15 10 per cent) and colour value

Among the hybrids the hybrid P_4 x P_5 (CA 8 x CA32) showed superiority for fruit weight (9 66 g), flesh thickness (2 81 mm), green fruit yield plant^{-1} (962 93 g), dry fruit yield plant^{-1} (144 05 g), yield plot^{-1} (27 72 kg) and drirage percentage (26 91) The hybrid P_3 x P_5 (CA 6 x CA 32) was good for primary branches plant^{-1} and fruit girth (4 43 cm) The hybrid P_2 x P_5 (CA 5 x CA 32) showed superiority for days to first harvest, seeds fruit^{-1} and quality characters like oleoresin, ascorbic acid and colour value The hybrid P_1 x P_5 was good for fruit length and flesh to seed ratio

Considering overall performance of the parents for both seasons superiority can be attributed to P_5 (CA 32) for yield related traits and quality traits Among hybrids P_4 x P_5 (CA 8 x CA 32), P_3 x P_5 (CA 6x CA 32) and P_2 x P_5 (CA 5 x CA 32) are considered as superior hybrids based on green fruit yield plant ^{1}, dry fruit yield plant ^{1}, yield plot ^{1} and other yield related and quality traits

5 2 HALF DIALLEL ANALYSIS

Half diallel analysis is a method (Griffing, 1956) in which the selected parents are crossed in all possible combinations excluding reciprocals

Diallel mating design is a crossing design which is used for separating the genetic effects from the environment effects The diallel analysis helps to obtain information on the genetic systems governing the inheritance of attributes to be improved Hence, help in predicting the performance in the subsequent generations by assessing the potential of different crosses Plant breeders use diallel analysis as an aid in selection and to investigate genetic properties of parents and their crosses Half diallel analysis was carried out to evaluate the parents and their hybrids on the basis of mean performance and heterosis

5 3 EVALUATION OF HYBRIDS

Heterosis is the superiority of F_1 hybrids over its parents Heterosis breeding has a great advantage for increased chilli production since it helps in effective transfer of desirable genes which controls both qualitative and quantitative characters in the resultant progenies The F_1 hybrids are more popular than the cultivated varieties due to their increased vigour, disease resistance, stress tolerance, high yield and other desirable traits such as earliness and long shelf life According to the criteria used for comparing the performance of hybrids the heterosis can be of 3 types, relative heterosis, heterobeltiosis and standard heterosis Heterosis breeding is an important aid in improving economic traits in chilli (Satish and Lad, 2007)

5.3.1 Plant Height (cm)

Plant height is an important growth parameter On the basis of mean performance, the hybrids P_1 x P_2, P_1 x P_4 P_2 x P_5 were found superior Five hybrids showed significant positive standard heterosis over the hybrid check Arka Harita and none of the hybrids showed significant positive standard heterosis over the check variety Vellayani Athulya Highest standard heterosis was observed in P_1 x P_4 Similar findings have been reported by Kamble *et al* (2009), Patel *et al* (2010), Tembhurne and Rao (2012) and Navhale *et al* (2014)

5.3.2 Primary Branches Plant^{-1}

The number of primary branches plant^{-1} also contributed to the total yield plant^{-1} Mean performance revealed that the hybrids P_3 x P_5, P_4 x P_5 and P_2 x P_5 were superior among the hybrids Six hybrids showed significant positive standard heterosis and three hybrids showed significant negative standard heterosis over the hybrid check Arka Harita Three hybrids exhibited significant positive standard heterosis over the check variety Vellayani Athulya Patil *et al* (2012), Navhale *et al* (2014), Kumar (2014) and Bhutia *et al* (2015) also observed similar results

5 3.3 Days to First Flower

Early flowering is an indication of early yield and it is considered as an important character in any crop improvement programme For days to first flowering negative heterosis is the desirable character With respect to mean performance the hybrids P_3 x P_4, P_2 x P_5 and P_1 x P_2 were found superior None of the hybrids exhibited significant positive heterosis over the standard check hybrid Arka Harita Eight hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya Highest standard heterosis was shown by the hybrid P_2 x P_5 Similar results were also reported by Shekhawat *et al* (2007), Kamble *et al* (2009), Sharma *et al* (2013) and Kumar *et al* (2014)

5.3.4 Days to First Harvest

Early harvest was reported by the hybrids P_2 x P_5, P_3 x P_4 and P_2 x P_4 All the ten hybrids showed significant negative heterosis over the standard check hybrid Arka Harita and nine hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya Highest standard heterosis was exhibited by the hybrid P_2 x P_5 Shekhawat *et al* (2007), Kamble *et al* (2009), Fekadu *et al* (2009), Sharma *et al* (2013), Navhale *et al* (2014) and Ahmed *et al* (2015)

5.3.5 Fruits Plant ^{1}

In chilli fruits plant ^{1} is one of the major component contributing to total yield The mean value for fruits plant ^{1} was high for the hybrids P_3 x P_4, P_4 x P_5 and P_3 x P_5 Highest standard heterosis was noticed in P_4 x P_5 (83 73 %) over check Vellayani Athulya Nine hybrids showed significant negative heterosis over the standard check hybrid Arka Harita All the ten hybrids had significant positive heterosis over the standard check variety Vellayani Athulya Similar findings have also been reported by Lankeshkumar (2005), Shekhawat *et al* (2007),Ganesh Reddy *et al* (2008), Fekadu *et al* (2009), Kamble *et al* (2009), Payakhapaab *et al* (2012), Navhale *et al* (2014) and Afroza *et al* (2014)

5 3.6 Fruit Length (cm)

Fruits length is an important character in deciding consumer preference The hybrids P_1 x P_5, P_1 x P_4, P_2 x P_5 differ from other hybrids in having high mean value Highest standard heterosis was observed in P_1 x P_5 (61 45 %) over check Arka Haritha All the ten hybrids exhibited significant positive heterosis over the standard check hybrid Arka Harita Seven hybrids showed significant negative heterosis over the standard check variety Vellayani Athulya Similar findings have also been reported by earlier workers, Patel *et al* (2001), Shekhawat *et al* (2007), Ganesh Reddy *et al* (2008), Payakhapaab *et al* (2012), Kumar (2014) and Navhale *et al* (2014)

5.3.7 Fruit Girth (cm)

Fruit girth contributes towards total yield and it is a highly desirable trait Maximum mean performance and standard heterosis for fruit girth was exhibited by $P_3 \times P_5$ The hybrids $P_1 \times P_2$ $P_2 \times P_5$ and $P_3 \times P_5$ were superior based on mean value and standard heterosis All the ten hybrids showed significant positive heterosis over the standard check hybrid Arka Harita and all the ten hybrids exhibited significant negative heterosis over the standard check variety Vellayani Athulya These results are in conformity with the results obtained by Patel *et al* (2001), Prasath and Ponnuswami (2008), Tembhurne and Rao (2012), Kumar *et al* (2014) and Ahmed *et al* (2015)

5.3.8 Fruit Weight (g)

Fruit weight is one of the component characters directly affecting the total yield The hybrids $P_4 \times P_5$, $P_2 \times P_5$ and $P_3 \times P_4$ exhibited maximum fruit weight Highest standard heterosis was shown by the hybrid $P_4 \times P_5$ (191 09 %) over check Arka Haritha Ten hybrids showed significant positive heterosis over the standard check hybrid Arka Harita and significant negative heterosis over the standard check variety Vellayani Athulya Similar findings have also been reported by Patel *et al* (2001), Jagadeesha and Wali (2005), Ganesh Reddy *et al* (2008), Pandey *et al* (2012) and Kumar *et al* (2014)

5.3.9 Flesh Thickness (mm)

The hybrid $P_4 \times P_5$ was superior based on the high mean value, and high standard heterosis (125 66 %) for this character Other superior hybrids were $P_2 \times P_5$ and $P_1 \times P_5$ All the ten hybrids showed significant positive standard heterosis over the standard check hybrid Arka Harita and none of the hybrids exhibited significant positive heterosis over the standard check variety vellayani Athulya In earlier studies, Geleta and Labuschagne (2006), Kumar *et al* (2014) and Ahmed *et al* (2015) also found similar results in chilli

5.3.10 Flesh to Seed Ratio

High value for flesh to seed ratio was observed in P_1 x P_5, P_3 x P_4 and P_4 x P_5 All the hybrids showed significant positive heterosis over the standard check hybrid Arka Harita and none of the hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya Maximum standard heterosis was observed in P_1 x P_5 (343 37 %) Similar findings have also been reported by Lohithaswa *et al* (2000) and Afroza *et al* (2014)

5.3.11 Seeds Fruit^{-1}

Less seeds are more preferred by the consumer but more seeds are preferred by the breeder and seed producer The hybrid P_2 x P_5 was found superior for trait seeds fruit ^{1} based on the mean performance and standard heterosis Other promising hybrids P_1 x P_3 and P_1 x P_2 also had high mean performance All the ten hybrids exhibited significant positive standard heterosis over the standard check hybrid Arka Harita Among the hybrids nine showed significant negative heterosis over the standard check variety Vellayani Athulya Similar results were reported by Shekhawat *et al* (2007) Ganesh Reddy *et al* (2008), Kumar *et al* (2014) and Navhale *et al* (2014)

5.3.12 Green Fruit Yield Plant^{-1} (g)

High green fruit yield plant ^{1} is one of the most important breeding objectives in any crop improvement programme Here the hybrids P_4 x P_5, P_3 x P_5 and P_2 x P_5 had highest yield plant^{-1} based on mean value The maximum relative heterosis, heterobeltiosis, and standard heterosis over check hybrid Arka Harita and standard heterosis over Vellayani Athulya were observed in the cross P_4 x P_5 (142 70 %, 103 14 %, 177 23 %, 59 53 % respectively) All the hybrids recorded significant positive standard heterosis over the hybrid check Arka Harita Six hybrids recorded significant positive heterosis over the check variety Vellayani Athulya These results are in conformation with the results of earlier workers

Shekhawat *et al* (2007), Patel *et al* (2010), Tembhurne and Rao (2012), Patil *et al* (2012) and Navhale *et al* (2014)

Among ten F_1 hybrids, nine exhibited more than 50% relative heterosis for total green fruit yield plant^{-1} Eight hybrids exhibited more than 50% heterobeltiosis All the hybrids exhibited more than 50% standard heterosis over the hybrid check Arka Harita and only one hybrid had more than 50% standard heterosis over the check variety Vellayani Athulya The hybrid which showed more than 50% standard heterosis over the check variety Vellayani Athulya was P_4 x P_5 (CA 8 x CA 32)

5.3.13 Dry Fruit Yield Plant^{-1} (g)

Among the hybrids P_4 x P_5 P_3 x P_5 P_2 x P_5 and P_3 x P_4 were having highest dry fruit yield plant^{-1} based on their mean value All the hybrids recorded significant positive heterosis over the standard check hybrid Arka Harita Seven hybrids showed significant positive heterosis over the standard check variety Vellayani Athulya

Among ten F_1hybrids, nine exhibited more than 50% relative heterosis for total dry fruit yield plant^{-1} Four hybrids exhibited more than 50% heterobeltiosis The crosses were P_1 x P_2, P_1 x P_4 P_2 x P_4 and P_3 x P_4 All the hybrids exhibited more than 50% standard heterosis over the standard check hybrid Arka Harita and none of the hybrids exhibited more than 50% standard heterosis over the standard check variety Vellayani Athulya Similar findings have also been reported by earlier workers Bhagyalakshmi *et al* (1991), Lohithaswa *et al* (2000), Shekhawat *et al* (2007), Ganesh Reddy *et al* (2008), Kumar *et al* (2014) and Navhale *et al* (2014)

5.3.14 Yield Plot^{-1} (kg)

The following hybrids P_4 x P_5 P_3 x P_5 P_2 x P_5, P_1 x P_4 and P_1 x P_5 had the highest yield plot^{-1} based on high mean value Highest standard heterosis was

recorded in P_4 x P_5 (177 34 %, 59 56 %) over check Arka Harita and Vellayam Athulya respectively Among the parents P_5 recorded maximum fruit yield Out of ten hybrids, nine recorded significant positive heterobeltiosis All the hybrids showed significant positive relative heterosis Ten hybrids recorded significant positive heterosis over the standard check hybrid Arka Harita and six hybrids recorded significant positive heterosis over the standard check variety Vellayani Athulya Among the hybrids, ten exhibited more than 50% standard heterosis over the hybrid check Arka Harita for total yield plot^{-1} and one recorded more than 50% standard heterosis over the check variety Vellayani Athulya The hybrid was P_4 x P_5 (CA 8 x CA 32) Nine hybrids exhibited more than 50% relative heterosis Similar results are obtained by Payakhapaab *et al* (2012), Pandey *et al* (2012) and Nagaraju (2015)

5.3.15 Driage (%)

On the basis of mean performance P_4 x P_5 P_3 x P_5 P_2 x P_5 P_1 x P_5 and P_3 x P_4 were superior for driage Maximum standard heterosis was recorded in hybrid P_4 x P_5 (12 39 %) over check Arka Haritha Four hybrids recorded significant negative relative heterosis Five recorded significant negative heterobeltiosis Similar findings have also been reported by earlier worker Singh and Hundal (2001)

5.3.16 Seed Yield Fruit^{-1} (g)

The hybrids P_2 x P_3, P_3 x P_5 and P_2 x P_4 were found superior according to the *per se* performance None of the hybrids showed significant positive standard heterosis over hybrid check Arka Harita and one hybrid recorded significant negative heterosis over the standard check variety Vellayani Athulya

5 3.17 Capsaicin (%)

Capsaicin is an important quality parameter in chilli and pungency in chilli is due to capsaicin The hybrids P_2 x P_3 P_1 x P_3 and P_2 x P_5 were different from

other hybrids in having high mean value All the hybrids had positive significant relative heterosis, heterobeltiosis, standard heterosis Similar results were reported by Shekhawat *et al* (2007), Prasath and Ponnuswami (2008), Chaudhary *et al* (2013) and Navhale *et al* (2014)

5.3.18 Oleoresin (%)

Oleoresin is another important quality parameter Based on mean performance the hybrids P_2 x P_5, P_4 x P_5 and P_1 x P_5 were found superior for oleoresin content Highest standard heterosis was recorded in P_2 x P_5 Eight hybrids recorded significant positive relative heterosis Seven hybrids showed significant positive heterobeltiosis Seven hybrids showed significant positive standard heterosis over the hybrid check Arka Harita Similar findings have also been reported by earlier workers Singh and Hundal (2001), Prasath and Ponnuswami (2008), Chaudhary *et al* (2013) and Darshan (2014)

5.3.19 Ascorbic Acid (mg/100 g)

Chilli is a good source of Vitamin C With respect to mean performance and standard heterosis the hybrids P_2 x P_5 P_1 x P_2 and P_4 x P_5 were found superior P_2 x P_5 had highest significant standard heterosis Four hybrids showed significant positive heterosis over the standard hybrid check Arka Harita and nine hybrids recorded significant positive heterosis over the standard check variety Vellayani Athulya Similar findings were reported by Shekhawat *et al* (2007), Sharma *et al* (2013) and Ahmed *et al* (2015)

5 3.20 Colour (ASTA units)

Colour value is an important trait by which we can assess the quality of chilli High colour value is usually preferred by the consumers The hybrids P_3 x P_5, P_1 x P_5 and P_1 x P_4 were found superior based on mean performance Highest standard heterosis was recorded by the hybrid P_2 x P_5 Seven hybrids showed significant positive relative heterosis and heterobeltiosis One hybrid P_2 x P_5

recorded significant positive heterosis over the standard check hybrid Arka Harita All the hybrids observed significant positive heterosis over the standard check variety Vellayani Athulya Similar results were observed by Nandadevi *et al* (2003), Prasath and Ponnuswami (2008), Chaudhary *et al* (2013)

From the study it was found that none of the hybrids were superior for all the characters studied However, the superior hybrids P_4 x P_5, P_3 x P_5 and P_2 x P_5 exhibited desirable standard heterosis for 5 characters viz , fruit weight, green fruit yield per plant, dry fruit yield per plant, yield per plot and driage

5 4 CORRELATION STUDIES

Correlation coefficient is a statistical method of quantifying the association or coherence between two variables Correlation helps to identify the relationships among different characters on which selection can be based for improvement of economic traits A study of correlations between the yield and yield components will be of great value in planning and evaluating any breeding programme

A significant positive correlation of characters like primary branches plant^{-1}, fruits plant^{-1}, fruit length, fruit weight, flesh thickness and seeds fruit^{-1} with green fruit yield plant^{-1} was observed in the present study suggesting that selection for these characters would lead to the improvement in yield This in agreement with the findings of Manju (2001), Gupta *et al* (2009), Singh and Singh (2011), Krishnamurthy *et al* (2013), Kadwey *et al* (2015) and Rohini and Lakshmanan (2015) Significant negative correlation was observed between green fruit yield plant^{-1} and days to harvest

Fruit length had significant positive correlation with the fruit girth, fruit weight, flesh thickness and seeds fruit^{-1} Similar results were reported by Sreelathakumary and Rajamony (2003) Fruit weight had positive correlation with flesh thickness and seeds fruit^{-1} Fruit girth had positive correlation with fruit

weight and flesh thickness Similar reports were made by Munshi and Behera (2000), Chatterjee *et al* (2001) and Ajjapplavara *et al* (2005)

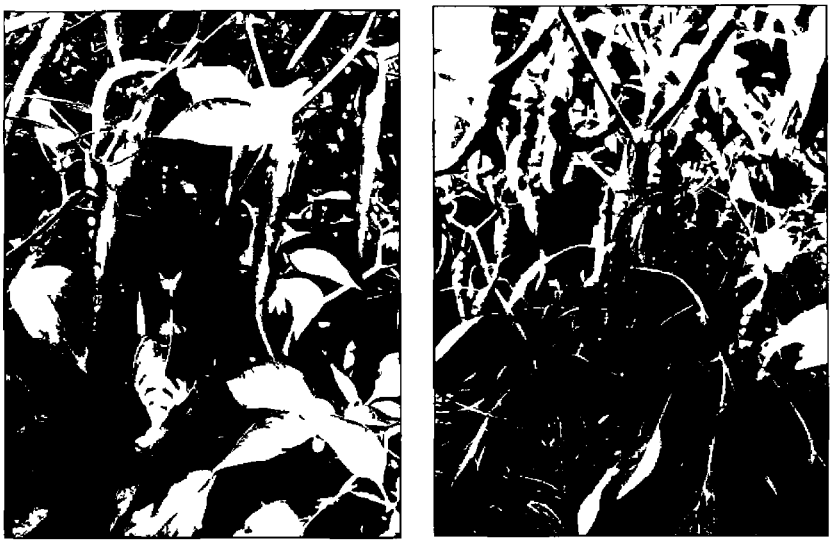
Plant height had significant positive correlation with primary branches plant^{-1}, fruit girth and fruit weight Production of increased vegetative growth like primary branches plant^{-1} leads to larger canopy of the plants and resulted in increased yield This is in line with similar findings of Reddy *et al* (2006) Flesh thickness had significant positive correlation with seeds fruit^{-1} Similar results were reported by Chatterjee *et al* (2001)

Table 26. Superior hybrids based on mean performance and standard heterosis

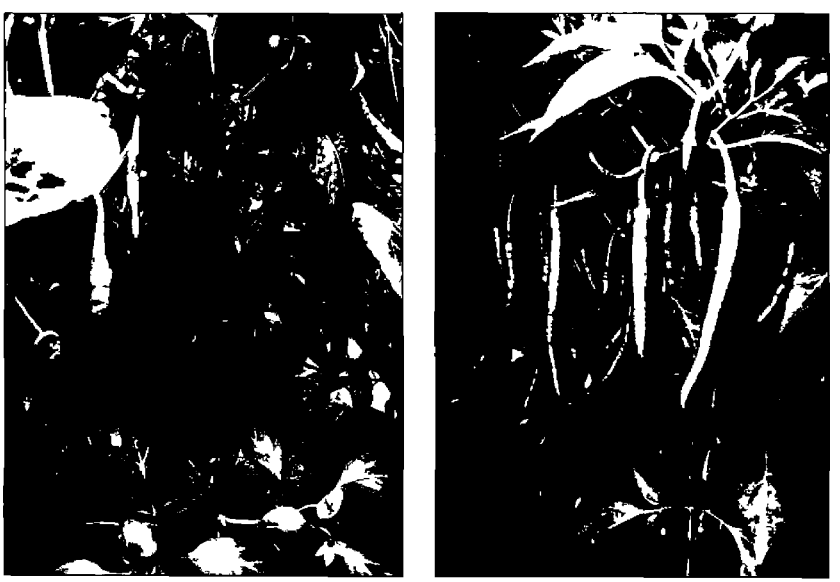
Character	Mean performance	Standard heterosis	Superior hybrids
Plant height (cm)	$P_1 \times P_2$ $P_1 \times P_4$ $P_2 \times P_5$	$P_1 \times P_4$ $P_2 \times P_5$ $P_1 \times P_2$	$P_1 \times P_4$
Primary branches plant^{-1}	$P_3 \times P_5$ $P_4 \times P_5$ $P_2 \times P_5$	$P_3 \times P_5$ $P_4 \times P_5$ $P_2 \times P_5$	$P_3 \times P_5$
Days to first flower	$P_3 \times P_4$ $P_2 \times P_5$ $P_1 \times P_2$	$P_2 \times P_5$ $P_3 \times P_4$ $P_1 \times P_2$	$P_2 \times P_5$
Days to first harvest	$P_2 \times P_5$ $P_3 \times P_4$ $P_2 \times P_4$	$P_2 \times P_5$ $P_1 \times P_2$ $P_3 \times P_4$	$P_2 \times P_5$
Fruits plant^{-1}	$P_3 \times P_4$ $P_4 \times P_5$ $P_3 \times P_5$	$P_4 \times P_5$ $P_2 \times P_5$ $P_3 \times P_4$	$P_4 \times P_5$
Fruit length (cm)	$P_1 \times P_5$ $P_1 \times P_4$ $P_2 \times P_5$	$P_1 \times P_5$ $P_1 \times P_4$ $P_2 \times P_5$	$P_1 \times P_5$
Fruit girth (cm)	$P_1 \times P_5$ $P_1 \times P_2$ $P_2 \times P_5$	$P_3 \times P_5$ $P_1 \times P_2$ $P_1 \times P_5$	$P_3 \times P_5$
Fruit weight (g)	$P_4 \times P_5$ $P_2 \times P_5$ $P_3 \times P_4$	$P_4 \times P_5$ $P_3 \times P_5$ $P_2 \times P_5$	$P_4 \times P_5$
Flesh thickness (mm)	$P_4 \times P_5$ $P_2 \times P_5$ $P_1 \times P_5$	$P_4 \times P_5$ $P_2 \times P_5$ $P_1 \times P_5$	$P_4 \times P_5$
Flesh to seed ratio	$P_1 \times P_5$ $P_3 \times P_4$ $P_4 \times P_5$	$P_1 \times P_5$ $P_3 \times P_4$ $P_4 \times P_5$	$P_1 \times P_5$

Table 26. Continued

Character	Mean performance	Standard heterosis	Superior hybrids
Seeds fruit^{-1}	$P_2 \times P_5$ $P_1 \times P_3$ $P_1 \times P_2$	$P_2 \times P_5$ $P_1 \times P_3$ $P_1 \times P_5$	$P_2 \times P_5$
Green fruit yield plant^{-1} (g)	$P_4 \times P_5$ $P_3 \times P_5$ $P_2 \times P_5$	$P_4 \times P_5$ $P_3 \times P_5$ $P_2 \times P_5$	$P_4 \times P_5$
Dry fruit yield plant^{-1} (g)	$P_4 \times P_5$ $P_3 \times P_5$ $P_2 \times P_5$	$P_4 \times P_5$ $P_3 \times P_5$ $P_2 \times P_5$	$P_4 \times P_5$
Yield plot^{-1} (kg)	$P_4 \times P_5$ $P_3 \times P_5$ $P_2 \times P_5$	$P_4 \times P_5$ $P_3 \times P_5$ $P_2 \times P_5$	$P_4 \times P_5$
Drirage (%)	$P_4 \times P_5$ $P_3 \times P_5$ $P_2 \times P_5$	$P_4 \times P_5$ $P_3 \times P_5$ $P_2 \times P_5$	$P_4 \times P_5$
Seed yield fruit^{-1} (g)	$P_2 \times P_3$ $P_3 \times P_5$ $P_2 \times P_4$	$P_2 \times P_3$ $P_3 \times P_5$ $P_2 \times P_4$	$P_2 \times P_3$
Capsaicin (%)	$P_2 \times P_3$ $P_1 \times P_3$ $P_2 \times P_5$	$P_2 \times P_3$ $P_1 \times P_3$ $P_2 \times P_5$	$P_2 \times P_3$
Oleoresin (%)	$P_2 \times P_5$ $P_4 \times P_5$ $P_1 \times P_5$	$P_2 \times P_5$ $P_4 \times P_5$ $P_1 \times P_5$	$P_2 \times P_5$
Ascorbic acid (mg/100g)	$P_2 \times P_5$ $P_1 \times P_2$ $P_4 \times P_5$	$P_2 \times P_5$ $P_1 \times P_2$ $P_4 \times P_5$	$P_2 \times P_5$
Colour value (ASTA units)	$P_2 \times P_5$ $P_1 \times P_5$ $P_1 \times P_4$	$P_2 \times P_5$ $P_4 \times P_5$ $P_1 \times P_5$	$P_2 \times P_5$



P_4 x P_5



P_3 x P_5 P_2 x P_5

Plate 6 Superior hybrids for yield attributes.

$P_2 \times P_5$

Plate 7 Superior hybrid for quality characters.

P5 (C V 32)

Plate 8. Superior parent for yield attributes

Summary

6. SUMMARY

The research project entitled "Evaluation of hybrids for yield and quality in chilli (*Capsicum annuum* L.)" was conducted at Department of Olericulture, College of Agriculture, Vellayani during 2015-16. The objective of the study was to evaluate chilli hybrids for yield and quality for two seasons and to identify superior hybrids with high yield and good quality.

The experimental material consisted of five parents *viz*., CA 3 (P_1), CA 5 (P_2), CA 6 (P_3), CA 8 (P_4) and CA 32 (P_5) and 10 F_1s produced in half diallel mating design. The hybrid Arka Harita and variety Vellayani Athulya were used as checks for the estimation of standard heterosis. The experiment was laid out in Randomized Block Design (RBD) with 17 treatments and three replications for two seasons *viz*., May 2015 to September 2015 and October 2015 to February 2016. Analysis of variance, estimation of heterosis and correlation analysis was worked out. The hybrids and parents were evaluated for the following traits *viz*., plant height (cm), primary branches plant^{-1}, days to first flower, days to first harvest, fruits plant^{-1}, fruit length (cm), fruit girth (cm), fruit weight (g), flesh thickness (mm), flesh to seed ratio, seeds fruit^{-1}, green fruit yield plant^{-1} (g), dry fruit yield plant^{-1} (g), yield plot^{-1} (kg), drinage (%), seed yield fruit^{-1}, capsaicin (%), oleoresm (%), ascorbic acid (mg/100 g) and colour (ASTA units). In addition pest scoring was also carried out.

The salient findings of the present study are summarized below.

Analysis of variance revealed significant differences among the treatments for all the characters studied for two seasons. Plant height for parents ranged from 55.05 cm (P_1) to 86.63 cm (P_3). The minimum plant height was recorded in the hybrid $P_1 \times P_5$ (71.93 cm). The tallest hybrids were $P_1 \times P_2$ and $P_1 \times P_4$ (81.86 cm). The primary branches plant^{-1} for parents ranged from 2.82 (P_3) to 4.65 (P_5). Among hybrids the range was from 3.00 ($P_1 \times P_5$) to 5.05 ($P_1 \times P_5$).

The results revealed that parent P_1 (27 43) was the earliest for flowering and P_3 (28 91) was the latest for flowering Among the hybrids the range was from (24 16) P_3 x P_4 to (27 40) P_1 x P_5 Days to harvest for parents ranged from (46 43) P_1 to (47 80) P_3 Among the hybrids P_2 x P_5 (43 23) was earliest for harvest and late harvest was observed in P_1 x P_3 (46 40)

Fruits plant^{-1} among the parents ranged from P_4 (47 00) to P_3 (78 13) and among the hybrids maximum fruits plant^{-1} was observed in P_3 x P_4 (148 76) followed by P_4 x P_5 (143 26) and P_3 x P_5 (137 36) Fruit length was maximum for parent P_1 (11 17 cm) and minimum for P_3 (8 34 cm) The fruit length of hybrids ranged from 10 49 cm (P_2 x P_3) to 12 61 cm (P_1 x P_5)

The parent P_4 (4 30 cm) recorded maximum fruit girth Fruit girth among the hybrids ranged from 3 15 cm (P_2 x P_4) to 4 43 cm (P_3 x P_5) The result revealed a great variation for fruit weight Among the parents fruit weight ranged from 4 82 g (P_3) to 6 73 g (P_5) Among the hybrids the fruit weight ranged from 5 36 g (P_2 x P_3) to 9 66 g (P_4 x P_5)

The parent P_5 (2 61mm) had maximum and P_4 (1 62mm) had minimum flesh thickness among the parents respectively Among the hybrids flesh thickness was maximum in (P_4 x P_5) 2 81 mm and minimum in (P_2 x P_4) 2 06 mm Among the parents flesh to seed ratio ranged from 3 90 mm (P_2) to 8 84 mm (P_5) and among the hybrids it ranged from 4 36 mm (P_2 x P_3) to 10 47 mm (P_1 x P_5)

Among the parents P_1 (114 06) had maximum and P_4 (79 50) had minimum seeds fruit^{-1} The magnitude of variation among the hybrids with respect to seeds fruit^{-1} ranged from 103 60 (P_2 x P_3) to 149 80 (P_3 x P_5) Maximum green fruit yield plant^{-1} was recorded by the parent P_5 (448 70 g) and minimum by P_2 (247 50 g) The hybrid P_4 x P_5 (962 93 g) recorded maximum green fruit yield plant^{-1} followed by P_3 x P_5 (886 53 g) and P_2 x P_5 (798 70 g) Minimum yield was recorded in the hybrid P_5 x P_4 (483 60 g)

Among the parents P_5 (79 98 g) had maximum and P_2 (40 42 g) had minimum dry fruit yield plant^{-1} The hybrid P_4 x P_5 (144 05 g) showed maximum dry fruit yield plant^{-1} which was on par with P_3 x P_5 (139 93 g) Yield plot^{-1} for parents ranged from 7 12 kg (P_2) to 12 91 kg (P_5) Among the hybrids maximum yield plot^{-1} was recorded in the hybrid P_4 x P_5 (27 72 kg) followed by P_3 x P_5 (25 52 kg) and P_2 xP_5 (22 99 kg)

Driage percentage among the parents ranged from (P_3) 21 56 % to (P_5) 25 11 % and among the hybrids (P_2 x P_4) 19 66 % to (P_4 x P_5) 26 91 % Among the parents the maximum seed yield fruit^{-1} was observed in P_2 (0 83) and minimum was recorded m P_5 (0 41) Seed yield fruit^{-1} of hybrids ranged from P_1 x P_5 (0 20) to P_2 x P_3 (0 80)

Capsaicin among the parents ranged from 0 40 % (P_3) to 0 45 % (P_5) Among the hybrids it varied from 0 69 % (P_5 x P_4 and P_3 x P_5) to 0 78 % (P_2 x P_3) Parent (P_5) 15 10 % had maximum oleoresin and (P_4) 12 00 % minimum Among the hybrids maximum oleoresin was recorded in (P_2 x P_5) 18 90 % and minimum 10 90 % by (P_1 x P_2) and (P_2 x P_3)

Among the parents (P_4) 98 38 mg/100 g recorded maximum ascorbic acid content The hybrids showed a range of 94 50 mg/100 g (P_1 x P_5) to 122 66 mg/100 g (P_2 x P_5) Colour value among the hybrids ranged from (P_1) 121 33 ASTA units to (P_5) 169 41 ASTA units and among the hybrids colour value ranged from 141 19 ASTA units (P_3 x P_4) to 195 39 ASTA units (P_2 x P_5)

The crop was monitored for incidence of diseases and pests during the cropping period The crop was free from leaf curl, fruit rot, mosaic, bacterial wilt and white fly Thrips and mites were predominant ones exhibiting characteristic damage The leaf curl index of thrips ranged from 1 00 to 1 96 and mites ranged from 0 16 to 1 83

Correlation study revealed that green fruit yield plant^{-1} had positive correlation with primary branches plant^{-1} (0 3937), fruits plant^{-1} (0 5601), fruit

length (0 6721), fruit weight (0 4651), flesh thickness (0 4311), and seeds fruit^{-1} (0 6232) and negative correlation with days to first harvest (-0 6665)

The heterosis was calculated over the standard check hybrid Arka Harita and standard check variety Vellayani Athulya revealed some superior hybrids for different traits The maximum heterosis for plant height was recorded in P_1 x P_4 (13 55%) over the standard check hybrid Arka Harita None of the hybrids showed significant desirable heterosis over the standard check variety Vellayani Athulya The hybrid P_3 x P_5 showed maximum desirable heterosis (39 62% and 10 45%) for primary branches plant^{-1} over the checks Arka Harita and Vellayani Athulya respectively For days to first flower and days to harvest maximum negative heterosis is desirable P_2 x P_5 recorded maximum desirable heterosis over the standard check hybrid Arka Harita for these two traits (-23 42%, -13 66% respectively) and none of the hybrids showed significant desirable heterosis over the standard check variety Vellayani Athulya

The hybrid P_4 x P_5 exhibited maximum desirable standard heterosis (83 73%) for fruits plant^{-1} over the standard check variety Vellayani Athulya and none of the hybrids exhibited desirable heterosis over the standard check hybrid Arka Harita The maximum standard heterosis for fruit length and flesh to seed ratio were observed in P_1 x P_5 (61 45%, 343 37% respectively) The hybrid P_3 x P_5 recorded the highest standard heterosis for fruit girth (57 14%) while the hybrid P_4 x P_5 showed maximum standard heterosis for fruit weight (191 09%), flesh thickness (125 66%), driage (12 39%) over the check hybrid Arka Harita For the fruit characters like fruit length fruit girth, fruit weight, flesh thickness, flesh to seed ratio and driage none of the hybrids showed significant desirable heterosis over the check variety Vellayani Athulya

The maximum standard heterosis was recorded in P_4 x P_5 for the traits green fruit yield plant^{-1} (177 23 %, 59 53 %), dry fruit yield plant^{-1} (133 65 %, 35 06 %) and yield plot^{-1} (177 34 %, 59 56 %) over the check hybrid Arka Harita and check variety Vellayani Athulya respectively followed by the hybrids P_1 x P_5, P_2 x P_5 Maximum standard heterosis for seed yield fruit^{-1} was recorded in P_2 x P_3

(165 56 %) over the check variety Vellayam Athulya None of the hybrids exhibited significant desirable heterosis over the check hybrid Arka Harita

For the quality traits such as oleoresin, ascorbic acid and colour value the hybrid P_2 x P_5 recorded maximum standard heterosis while the hybrid P_2 x P_3 recorded maximum standard heterosis (76 12 %, 93 44 %) for capsaicin over the checks Arka Harita and Vellayani Athulya

Considering the mean performance of the parents for both seasons superiority can be attributed to parent P_5 (CA 32) for yield related traits and quality traits

Based on the mean performance and standard heterosis the hybrids CA 8 x CA 32 (P_4 x P_5), CA 6 x CA 32 (P_3 x P_5) and CA 5 x CA 32 (P_2 x P_5) were found superior for green fruit yield plant^{-1}, dry fruit yield plant^{-1} and yield plot^{-1}and other yield related and quality traits The hybrid CA 5 x CA 32 (P_2 x P_5) was found good for the quality traits

FUTURE LINE OF WORK

The superior hybrids identified *viz* , CA 8 x CA 32 (P_4 x P_5), CA 6 x CA 32 (P_3 x P_5) and CA 5 x CA 32 (P_2 x P_5) can be advanced to farm trials and multilocation trials to assess their stability over different agroclimatic situations and for release as commercial F_1 hybrids in chilli

References

7. REFERENCES

Acharya, P , Joshi, A K and Rajput, C B S 2002 Studies on variability and 77 character associated for different traits in six generations of the cross 'LCA 301 x Punjab Lal' (*Capsicum annuum* L) under two environments with respect to leaf curl complex *Capsicum Eggplant Newsl* 21 60-63

Afroza, B , Khan, S H , Hussain, K , Praveen, K and Mushtaq, F 2014 Combining ability studies for yield and yield attributing traits in sweet pepper (*Capsicum annuum* L) *Vegetos* 27 (3) 34-39

Ahmed, M A M and Ahmed, A S A E 2015 Production and evaluation of high yielding sweet pepper hybrids under poly house conditions *Am Eurasian J Agric Environ Sci* 15 (4) 573-580

Ahmed, N , Bhat, M A , Tanki M I and Singh, A K 2006 Correlation and path analysis in paprika (*Capsicum annuum* L) *Indian J Hortic* 63(1) 92-95

Ahmed, N , Tanki, M I and Nayeema, J 1999 Heterosis and combining ability studies in hot pepper *Appl Biol Res* 1 11-14

Ajjaplavara, P S , Patil, S S , Hosamani, R M , Patil, A A and Gangaprasad, S 2005 Correlation and path coefficient analysis in chilli *Karnataka J Agric Sci* 18(3) 748- 751

Aliyu, L , Ahmed, M K and Magaji, M D 2000 Correlation and multiple regression analysis between morphological characters and components of yield in pepper (*Capsicum annuum* L) *Crops Res* 19 318-323

Ayyar, T V R , Subbiah, M S and Krishnamurthi, P S 1935 The leaf curl disease of chillies caused by thrips in the Guntur and Madras tracts *Madras Agric J* 23 403- 410

Bhagvalakshmi, P V , Shankar, C R , Subrahmanyam, D and Babu, V G 1991 Heterosis and combining ability studies in chillies *Indian J Genet Plant Breed* 51(4) 420-423

Bhutia, N D, Tania, S, Varun, D S, Subrata, D and Chattopadhyay, A 2015 Estimation of heterosis, dominance effect and genetic control of fresh fruit yield, quality and leaf curl disease severity traits of chilli pepper (*Capsicum annuum* L) *Scientia Hortic* 182 47-55

Bini, P 2004 Genetic Improvement and Molecular characterization of Paprika (*Capsicum annuum* L) genotypes Ph D thesis, Kerala Agricultural University, Thrissur, 126p

Chatterjee, R, Kohli, U K and Chatterjee, R. 2001 Correlation and path coefficient analysis in bell pepper (*Capsicum annuum* L) *Hortic J* 14 51—55

Chattopadhyay, A, Sharangi, A B, Dai, N and Dutta, S 2011 Diversity of genetic resources and genetic association analysis of green and dry chillies of Eastern India *Chilean J Agric Res* 71(3) 350-356

Chaudhary, A, Kumar, R, and Solankey, S S 2013 Estimation of heterosis for yield and quality components in chilli (*Capsicum annuum* L) *Afr J Biotechnol* 12(47) 6605-6610

Choudhary, B S and Samadia, D K 2004 Variability and character association in chilli land races and genotypes under arid environment *Indian J Hort* 61 132–136

Dandunayak 2008 Assessment of genetic diversity in local chilli collections (*Capsicum annuum* L) M Sc (Ag) thesis, University of Agricultural Sciences, Dharwad, 105p

Darshan, S 2014 Heterosis and combining ability analysis to leaf curl virus in chilli M Sc (Ag) thesis, Kerala Agricultural University, Thrissur, 175p

Deli, J, Molnar, P, Matus, Z and Toth, G 2001 Carotenoid composition in the fruits of red paprika (*Capsium annuum* Var *Lycopersiciformemibrum*) during ripening biosynthesis of carotenoids in red paprika *J Agric Food Chem* 49 1517–1523

Desai, H R , Bhandarna, K A , Patel, A J , Patel, M B and Rai,A B 2006 Screening of chilli varieties for resistance to yellow mite, *Polyphagotarsonemus latus* in south Gujarat *Pest Manag Hortic Ecosyst* 12 55-62

Deshpande, R B 1933 Studies in Indian chillies The inheritance of some characters in *Capsicum annuum* (L) *Indian J Agric Sci* 3 219-300

Dhall, R K and Hundall, J S 2005 Gene action of yield and quality traits in chilli (*Capsicum annuum* L) *Indian J Agric Res* 39(4) 291-294

Doshi, K M and Shukla, P T 2000 Genetics of yield and its components in chilli (*Capsicum annuum* L) *Capsicum Eggplant Newsl* 19 78-81

Fekadu, M L , Dessalegne, C F and Sivagvald, R 2009 Heterosis and heritability in crosses among Asian and Ethiopian parents of hot pepper genotypes *Euphytica* 168 235-247

Ganesh Reddy, M , Mohan Kumar, H D and Salimath, P M , 2008 Heterosis studies in chillies (*Capsicum annuum* L) *Karnataka J Agric Sci* 21 (4) 570-571

Geleta, L F and Labuschagne, M T 2006 Combining ability and heritability for vitamin c and total soluble solids in pepper (*Capsicum annuum* L) *J Sci Food Agric* 86 1317-1320

Ghosh, A and Pugalendhi, L 2012 Studies on the improvement of chilli (*Capsicum annuum* L) for quality characters through hybridization *Electr J Plant Breed* (3) 2 811-817 [20 August 2014]

Griffing, B 1956 Concept of general and specific combining ability in relation to diallel crossing systems *Aust J Biol Sci* 9 465-493

Gupta, A M , Singh, D and Kumar, A 2009 Genetic variability, genetic advance and correlation in chilli (*Capsicum annuum* L) *Indian J Agric Sci* 79(3) 221-223

Gupta, S K 2000 Plant breeding theory and techniques *Indian J Genet Plant breed* 50 110-112

Hayes, H K , Immer, I R , and Smith, D C 1955 *Methods of Plant Breeding*, McGraw Hill Company, Inc , New York, 535p

Jagadeesha, R C and Wali, M C 2004 Genetic analysis of dry fruit yield and its component in chilli (*Capsicum annuum* L) *Veg Sci* 32 37-40

Jha, A K , Ali, M M and Dogra, J V 2001 Changes in ascorbic acid and capsaicinin developing fruits of chilli (*Capsicum annuum* L) *Indian J Plant Physiol* 6 (3) 320-322

Kadwey, S , Dadiga, A , Prajapati, S and Telugu, K R 2015 Correlation and path coefficient analysis of quantitative and qualitative traits in chilli (*Capsicum annuum* L) *Scientia Horticulturae* 10(4) 1909-1914

Kalaiyarasan, S , Sathiyananthan, V K R , Geetha, C and Muthusamy, M 2002 Screening of different chilli accessions against thrips, *Scirtothrips dorsalis* (Hood) *South Indian Hortic* 50(4) 613-615

Kamble, C , Mulge, R , Madalageri, M B and Jadeesha, R C 2009 Studies on heterosis in capsicum (*Capsicum annuum* L) for yield and quality traits *Karnataka J Agric Sci* 22(1) 155-157

KAU (Kerala Agricultural University) 2011 *Package of Practices Recommendations Crops* (14th Ed) Directorate of Extension, Kerala Agricultural University, Thrissur, 180-181p

Khurana, D S , Singh, P and Hundal, J S 2003 Studies on genetic diversity for growth, yield and quality traits in chilli (*Capsicum annuum* L) *Indian J Hortic* 60 277-282

Krishna, S S , Kumar, S and Singh, D 2013 Genetic expression of CMS based hybrids for yield and its attributing traits in chilli *(Capsicum annuum* L *) J Appl Hortic* 3 (15) 198-201

Krishnamurthy, S L , Reddy, M K and Rao, M A 2013 Genetic variation, path and correlation analysis in crosses among Indian and Taiwan parents in chilli *Veg Sci* 40(2) 210-213

Kumar, R L , Sridevi, O , Udaykumar, K , Sahmath, P M , Deepa, M and Prakash, N 2014 Heterosis studies in chilli (*Capsicum annuum* L) *Int J Hortic* 4 (8) 40- 43

Kumari, S S , Jyothi, K U , Reddy, V C , Sridhari, D , Sankar, A S and Sankar C R 2011 Character association in paprika (*Capsicum annuum* L) *J Spices and Aromat Crops* 20(1) 43-47

Kumari, S S , Jyothi, K U , Sridhari, D , Sankar, A S and Sankar, C R 2010 Variability and genetic divergence in paprika (*Capsicum annuum* L) *J Spices and Arom Crops* 19 (1 & 2) 71–75

Lankesh Kumar 2005 Heterosis and combining ability studies in chilli (*Capsicum annuum* L) M S c (Ag) thesis, University of Agricultural Sciences, Dharwad, pp 40-52

Lohithaswa, H C , Kulkarni, R S and Manjunath, A 2000 Combining ability analysis for fruit yield, capsaicin and other quantitative traits in chilli (*Capsicum annuum* L) over environments *Indian J Genet* 60 511 – 518

Malathi, G 2001 Performance of two F1 hybrids and their parents in chilli (*Capsicum annuum* L) M S c (Hort) thesis, Tamil Nadu Agricultural University, Coimbatore, 138p

Malathi, G and Veeraragavathatham, D 2004 Performance and heterosis of two hybrids of chillies *(Capsicum annuum* L) for qualitative traits in three different seasons *Capsicum Eggplant Newsl* 23 65-68

Mallapur, C P 2000 Screening of chilli genotypes against thrips and mites *Insect Environ* 5 154-155

Manju, P R 2001 Genetic cataloguing of hot chilli (*Capsicum chinense* acq) M Sc (Ag) thesis, Kerala Agricultural University Thrissur, 87p

Mathew, A G , Nambudiri, E S , Ananathakrishna, S M , Krishnamurty, N and Lewis, Y S 1971 An improved method for estimation of capsaicin in capsicum oleoresin *Laboratory Practice* 1 23-26

Mathew, N 2006 Screening for leaf curl virus disease complex resistance, genetic evaluation and molecular characterization of bird chilli (*Capsicum frutescens* L) M Sc (Ag) thesis, Kerala Agricultural University, Thrissur, 100p

Meyer, R C , Torjek, O , Bencher, M and Altmann, T 2004 Heterosis studies in chilli *U S Dep Agric Bull* 350p

Munshi, A D and Behera, T K 2000 Genetic variability, heritability and genetic advance for some traits in chilli (*Capsicum annuum* L) *Veg Sci* 27 39-41

Nagaraju, M M 2015 Development of F_1 hybrids in chilli (*Capsicum annuum* L) for commercial cultivation M Sc (Hort) thesis, Kerala Agricultural University, Thrissur, 150p

Nandadevi, R , Hosmani, R M and Salimath, P M 2003 Combining ability analysis in chilli *Karnataka J Agric Sci* 16(2) 276-281

Navhale, V C , Dalvi, V V , Wakode, M M , Sawant, A V and Dhekale, J S 2014 Combining ability analysis in chilli (*Capsicum annuum* L) *Electr J Plant Breed* 5 (3) 340-344

Nawalagatti, C M , Chetti, M B and Hiremath, S M 1999 Evaluation of chilli (*Capsicum annuum* L) genotypes for quality parameters *Crop Res* 18 (2) 218-221

NHB [National Horticulture Board] 2015 *Indian Horticulture Database* Naational Horticulture Board, Gurgaon, 303p

Pandey, V , Chura, A , Pandey, H K , Meena, H S , Arya M C , and Ahmed, Z 2012 Diallel analysis for yield and yield attributing traits in capsicum (*Capsicum annuum* L var *grossum* Sendt) *Veg Sci* 39 (2) 136-139

Panse, V G and Sukhatme, P V 1967 "*Statistical Methods for Agricultural Workers* Indian Council of Agricultural Research, New Delhi pp 152-161

Patel, A L, Kathiria, K B and Patel, B R 2014 Heterosis in mild pungent chilli (*Capsicum annuum* L) *J Spices Aromat Crops* 23 (2) 178-185

Patel, A L, Patel, M J, Patel, A D, Acharya, R R and Bhalala, M K 2001 Heterosis studies over environments in chilli (*Capsicum annuum* L) *Veg Sci* 24 107-110

Patel, K D, Patel, R B, Patel, R J and Kuchhadiya, V G 2015 Genetic variability and character association studies for green fruit yield and quality component traits in chilli (*capsicum annuum* var *longum* (dc) sendt) *J Plant Breed Crop Sci* 5(5) 68-72

Patel, M P, Patel, A R, Patel, J B and Patel, J A 2010 Heterosis for green fruit yield and its components in chilli (*Capsicum annuum* var *longicum* (D G) Sendt) over environments *Electr J Plant Breed* 1 (6) 1443-1453

Patel, P N, Fougat, R S and Sasidharan, M 2004 Evalation of quality traits in chilli (*Capsicum annuum* L) *Veg Sci* 10(3) 626-631

Patil, B T, Bhalekar, M N and Shinde, K G 2012 Heterosis studies in chilli (*Capsicum annuum* L) for earliness, growth and green fruit yield *Veg Sci* 39 (1) 73-75

Payakhapaab, S, Danai, B and Nikornpun, M 2012 Evaluation of heterosis and combining ability of yield components in chillies *J Agric Sci* 4(11) 154-161

Prasath, D and Ponnuswami, V 2008 Heterosis and combining ability for morphological, yield and quality characters in paprika type chilli hybrids *Indian J Hort* 65 (4) 441-445

Prasath, D , Ponnuswami, V and Muralidharan, V 2007 Evaluation of chilli (*Capsicum* spp) germplasm for extractable colour and pungency *Indian J Genet* 67(1) 97-98

Reddy, B S , Thammaiah, N , Nandihalli, B S , Dharmatti, P R and Patil, R V 2000 Performance of chilli genotypes under Ghataprabha command area of Northern part of Karnataka *J Maharashtra Agric Univ* 23 73-74

Reddy, G M , Mohankumar, H P and Salimath, P M 2006 Variability, correlation and path coefficient analysis in chilli (*Capsicum annuum* L) *Karnataka J Agric Sci* 2(12) 225-261

Reddy, G M , Mohankumar, H P and Salimath, P M 2008 Correlation and path coefficient analysis in chilli (*Capsicum annuum* L) *Karnataka J Agric Sci* 2(12) 225-261

Rohini, N and Lakshmanan, V 2015 Correlation and path coefficient analysis in chilli for yield and yield attributing traits in chilli *Indian J Agric Sci* 79(3) 221-223

Sadasivam, S and Manickam, A 1992 *Biochemical methods for agricultural sciences* Wiley Eastern Ltd , New Delhi, India 246p

Satish, R G and Lad, D B 2007 Heterosis studies in chilli (*Capsicum annuum* L) *Maharashtra J Agric Sci* 32 68-71

Savita, M 2005 Combining ability and heterosis for quality and quantitative traits in chilli (*Capsicum annuum* L) M Sc (Ag) thesis, University of Agricultural Sciences, Dharwad, 65p

Sekar, K and Arumugam, R 1985 Heterosis in chilli *South Indian Hort* 33 91-92

Shankarnag, B , Madalageri, M B and Mulge, R 2006 Manifestation of heterosis for growth, earliness and early green fruit yield in chilli *Indian J Hortic* 63 410-414

Sharma, V K , Punetha, S and Sharma, B B 2013 Heterosis studies for earliness, fruit yield and yield attributing traits in bell pepper Afr J Agric Res 8 4088-4098

Shekhawat, A K S , Singh, D K , Srivastava, J P and Singh, S K 2007 Genetic analysis for dry fruit yield and its component in chilli (*Capsicum annuum* L) *Prog Agric* 7 52-55

Shull, G H 1948 Concept of heterosis *Aust J Biol Sci* 33 439-446

Singh, D K and Singh, A 2011 Assessment of variability parameters and character association for quantitative traits in chilli (*Capsicum annuum* L) *Progressive Agric* 11(1) 113-116

Singh, P D S , Cheema, M S and Dhaliwal, N G 2014 Heterosis and combining ability for earliness, plant growth, yield and fruit attributes in hot pepper (*Capsicum annuum* L) involving genetic and cytoplasmic genetic male sterile lines *Scientia Hortic* 168 175-188

Singh, R and Chowdhary, A K 2005 Screening of different varieties of chilli (*Capsicum annuum* L) against chilli leaf curl virus disease in plains of West Bengal *Environ Ecol* 23 395-397

Singh, R and Hudal, J S 2001 Heterosis and combining ability studies in chilli (*Capsicum annuum* L) *Veg Sci* 28(2) 124-126

Sood, S and Kumar, N 2010 Heterotic expression for fruit yield and yield components in intervarietal hybrids of chilli (*Capsicum annuum* L) *Indian J Genet Plant breed* 42(2) 105-115

Sreelathakumary, I and Rajamony, L 2002 Variability, heritability and correlation studies in chilli (*Capsicum* spp) under shade *Indian J Hortic* 59 77-83

Sreelathakumary, I and Rajamony, L 2003 Variability, heritability and genetic advance in bird pepper (*Capsicum frutescens* L) *Capsicum Eggplant Newsl* 22 51 - 54

Srilakshmi, P 2006 Genetic diversity, heritability and genetic advance studies in chilli (*Capsicum annuum* L) for quantitative and qualitative characters M Sc (Ag) thesis, University of Agricultural Sciences, Dharwad, 122p

Tatagar, M H, Prabhau, S T and Jagadeesha, R C 2001 Screening of chilli genotypes for resistance to thrips, *Scirtothrips dorsalis* (Hood) and mite *Polyphagotarsonemus latus* (Banks) *Pest Manag Hort Ecosyst* 7(2) 133-116

Tembhurne, B V and Rao, S K 2012 Heterosis and combining ability in CMS based hybrid chilli (*Capsicum annuum* L) *J Agric Sci* 4(10) 89-96

Turner, J H 1953 A study of heterosis in upland cotton yield of hybrids compared with varieties combining ability and inbreeding effects *Agron J* 45 464-470

Varghese, T S and Giraddi, R S 2005 Integration of neem cake in the plant protection schedule for thrips and mites management in chilli *Karnataka J Agric Sci* 18(1) 154-156

EVALUATION OF HYBRIDS FOR YIELD AND QUALITY IN CHILLI (*Capsicum annuum* L.)

AISWARYA C. S

(2014 - 12 - 112)

ABSTRACT

of the thesis submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF OLERICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM – 695 522
KERALA, INDIA

2016

ABSTRACT

The research project entitled "Evaluation of hybrids for yield and quality in chilli (*Capsicum annuum* L.)" was conducted at Department of Olericulture, College of Agriculture, Vellayani during 2015-16. The objective of the study was to evaluate the yield and quality characters of F_1 hybrids of chilli.

The experimental material consisted of five parents *viz*., CA 3 (P_1), CA 5 (P_2), CA 6 (P_3), CA 8 (P_4) and CA 32 (P_5) and 10 F_1s produced in diallel mating design excluding reciprocals. The hybrid Arka Harita and variety Vellayani Athulya were used as checks for the estimation of standard heterosis. The experiment was laid out in Randomized Block Design (RBD) with 17 treatments and three replications for two seasons *viz*., May 2015 to September 2015 and October 2015 to February 2016.

Analysis of variance showed significant differences among the treatments for almost all characters studied. Among the hybrids $P_4 \times P_5$ recorded the highest fruit weight (9.66 g), flesh thickness (2.81 mm), green fruit yield plant^{-1} (962.93 g), dry fruit yield plant^{-1} (144.05 g) and yield plot^{-1} (27.72 kg). Maximum fruits plant^{-1} was recorded in the hybrid $P_3 \times P_4$ (148.76), fruit length in $P_1 \times P_5$ (12.61 cm) and fruit girth in $P_3 \times P_5$ (4.43 cm). Among the parents P_5 recorded highest fruit weight (6.73 g), flesh thickness (2.61 mm), green fruit yield plant^{-1} (448.70 g), dry fruit yield plant^{-1} (79.98 g) and yield plot^{-1} (12.91 kg). The hybrid $P_2 \times P_5$ had high quality parameters like oleoresin (18.90 %), ascorbic acid (122.66 mg/100g) and colour value (195.39 ASTA units).

The check variety Vellayani Athulya was superior for characters such as days to first flower (23.83 days), days to first harvest (42.96 days), fruit length (12.66 cm), fruit girth (6.27 cm), fruit weight (17.36 g) and flesh thickness (3.31 mm).

No incidence of white fly, bacterial wilt, leaf curl, fruit rot and mosaic were observed in the field. The incidence of thrips and mites were less in the parents and hybrid combinations.

The highest standard heterosis for green fruit yield plant $^{-1}$ among the hybrids was recorded in P_4 x P_5 (177 23 %) followed by P_3 x P_5 (147 35 %), and P_2 x P_5 (127 24 %) For fruit weight highest standard heterosis was observed in P_4 x P_5 (191 09 %) followed by P_3 x P_5 (188 12 %) and P_2 x P_5 (170 30 %) Maximum standard heterosis for yield plot $^{-1}$ was recorded in P_4 x P_5 (177 34 %), P_3 x P_5 (147 35 %) and P_2 x P_5 (127 31 %) Among the hybrids the highest standard heterosis for the quality characters such as oleoresin (36 59 %), ascorbic acid (6 05 %), and colour value (8 17 %) were recorded in P_2 x P_5

Correlation for different characters showed that green fruit yield plant $^{-1}$ had positive correlation with the primary branches plant $^{-1}$, fruits plant $^{-1}$, fruit length, fruit weight, flesh thickness and seeds fruit $^{-1}$

On the basis of the present study the hybrids CA 8 x CA 32 (P_4 x P_5), CA 6 x CA 32 (P_3 x P_5) and CA 5 x CA 32 (P_2 x P_5) were found promising for yield characters such as fruit weight, green fruit yield plant $^{-1}$, yield plot $^{-1}$ and quality Among the parents CA 32 (P_5) was found superior

The superior hybrids identified *viz* , CA 8 x CA 32 (P_4 x P_5), CA 6 x CA 32 (P_3 x P_5) and CA 5 x CA 32 (P_2 x P_5) can be subjected to multilocational trials and if found superior can be recommended for variety release