

**GENETIC STUDIES IN CHILLI (*Capsicum annum* L.)**

**SOMASHEKHAR, V. D.**

**DEPARTMENT OF GENETICS AND PLANT BREEDING  
COLLEGE OF AGRICULTURE, DHARWAD  
UNIVERSITY OF AGRICULTURAL SCIENCES,  
DHARWAD-580 005**

**DECEMBER, 2001**

ಕೆ. ಸಿ. ವಿಶ್ವವಿದ್ಯಾನಿಲಯ  
ವಿಶ್ವವಿದ್ಯಾನಿಲಯ ವೆಂಕಟಾಚಲ  
ಗಾ. ನಂ. ೨೨೯, ಬೆಂಗಳೂರು-೬೫  
30 JAN 2004  
ಅನುವಂಶೀ ಸಂ. **Th. 7183**  
ಪ. ಸಂ. ....

**GENETIC STUDIES IN CHILLI (*Capsicum annum* L.)**

*Thesis submitted to the  
University of Agricultural Sciences, Dharwad  
in partial fulfillment of the requirements for the*

*Degree of*

**Master of Science (Agriculture)**

*in*

**Genetics and Plant Breeding**

*By*

**SOMASHEKHAR, V. D.**

**DEPARTMENT OF GENETICS AND PLANT BREEDING  
COLLEGE OF AGRICULTURE, DHARWAD  
UNIVERSITY OF AGRICULTURAL SCIENCES,  
DHARWAD-580 005**

**DECEMBER, 2001**

**DEPARTMENT OF GENETICS AND PLANT BREEDING  
COLLEGE OF AGRICULTURE, DHARWAD  
UNIVERSITY OF AGRICULTURAL SCIENCES,  
DHARWAD-580 005**


*Certificate*

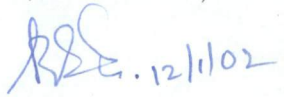
This is to certify that the thesis entitled "**GENETIC STUDIES IN CHILLI (*Capsicum annum L.*)**" submitted by **Mr. SOMASHEKHAR, V. D.** for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **GENETICS AND PLANT BREEDING** to the University of Agricultural Sciences, Dharwad is a record of research work done by him during the period of his study in this university under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

DHARWAD  
December, 2001


  
\_\_\_\_\_  
(S.A. PATIL)  
MAJOR ADVISOR

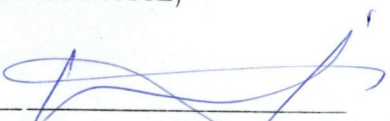
Approved by:

Chairman:   
\_\_\_\_\_  
(S.A. PATIL)

Members : 1.   
\_\_\_\_\_  
(P.M.SALIMATH)

2. \_\_\_\_\_  
(M B. CHETTI)

3.   
\_\_\_\_\_  
(M.S. PATIL)

4.   
\_\_\_\_\_  
(N. BASAVARAJ)

Affectionately Dedicated

to

My Beloved Parents

and Brothers

## ACKNOWLEDGEMENT

*At last the moment has come to look into the deeper layers of my heart which is filled with the feelings of togetherness and loveliness; consolation and satisfaction. Some are permanent and some momentary but both involve a number of persons to whom I acknowledge my warm regards.*

*At the very outset, I feel inadequacy of words to express my profound indebtedness and deep sense of gratitude to my esteemed Chairman **Dr. S.A. Patil**, Vice Chancellor, University of Agricultural Sciences, Dharwad, for his thought provoking, inspiring and valuable guidance in planning and execution of my research work. Also I owe my heartfelt thanks for his patience, critical analysis and unceasing interest shown during the course of study and completion of this investigation. It was really a great pleasure and privilege for me to be associated with him during my M.Sc. programme.*

*I avail this opportunity to express my deep sense of reverence and gratitude to the member of my Advisory Committee **Dr. P. M. Salimath**, Professor and Head, Department of Genetics and Plant Breeding, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad for his expert and inspiring guidance throughout the course of this investigation and preparation of the thesis.*

*I avail this opportunity to express my deep sense of reverence and gratitude to the members of my Advisory Committee **Dr. M.B. Chetti**, Professor and Head, Department of Crop Physiology, College of Agriculture, Dharwad and **Dr. M.S. Patil**, Associate Professor, Department of Plant Pathology, College of Agriculture, Dharwad. **Dr. N. Basavaraj**, Associate Professor, Department of Horticulture, College of Agriculture, Dharwad University of Agricultural Sciences, Dharwad for their valuable counsel, note-worthy guidance and cordial co-operation during the course of investigation.*

I avail this opportunity to express my sincere thanks to Dr. R.C. Jagadeesha, Agricultural Research Station, Devihosur, Dr. Vyakarnal, Associate Professor, Department Seeds Science and Technology and Shri. Rajakumar Jolli, Farm Superintend Agricultural Research Station, Hanamamatti University of Agricultural Sciences, Dharwad for their valuable advice and co-operation during the study and research work

I am very much lucky to have elderly advice and encouragement from Smt. Annapurna Patil and Shri. Mallikarjun Patil of Somanathhalli during the stay at Dharwad.

I am unable to acknowledge adequately selfless sacrifices and love of my parents. Yet, I shall avail of this opportunity to express my regards to my father and mother for their affection, constant enthusiastic encouragement and moral support, which insulated me against the worries of the real world. Also avail this opportunity to convey my regards to all my relatives.

I will always remember the untiring work and pains taken by the field staff of Agricultural Research Station, Hanamanamatti, at the time recording observation and all field operations. I thank all the staff of Agricultural Research Station and Shri. F. S. Lobo who were responsible for successful completion of my study for which I express heartfelt thanks to them.

Indeed, it is difficult task to express my gratitude to my beloved friends Sugoora, B.S. Raddy, Sanjay, Sunil, Somanath, Sandeep, Prabhakar, Satish, Dayanand, Santhosh, Ravinder, Vijay, Rajeshkar, Manohar, Paramesh, Nakul, Mahesh and Mallu who have been with me in all my endeavours.

Last but not least, I express my heart felt thanks to Mr. Manjunath S. Kurahatti (**SADGURU GRAPHICS**) for his dexterous typing and Mr M. J. Kumbhar for neat binding of thesis.

DHARWAD  
December. 2001

  
(**SOMASHEKHAR, V. D.**)

# CONTENTS

<b>Chapter No.</b>	<b>Title</b>	<b>Page No.</b>
<b>I.</b>	<b>INTRODUCTION</b>	<b>1-4</b>
<b>II.</b>	<b>REVIEW OF LITERATURE</b>	<b>5-17</b>
<b>III.</b>	<b>MATERIAL AND METHODS</b>	<b>18-27</b>
<b>IV.</b>	<b>EXPERIMENTAL RESULTS</b>	<b>28-50</b>
<b>V.</b>	<b>DISCUSSION</b>	<b>51-64</b>
<b>VI.</b>	<b>SUMMARY</b>	<b>65-66</b>
<b>VII.</b>	<b>REFERENCES</b>	<b>67-78</b>

## LIST OF TABLES

Table No.	Title	Page No.
1	Review of literature on variability, heritability and genetic advance for various quantitative characters in chilli	7-10
2	Review of literature on gene effects for various characters in chilli	16-17
3	Variability parameters for different characters in F <sub>2</sub> populations of the cross VN-2 x Jwala (9632)	30
4	Estimates of gene effects for 13 characters in five crosses in chilli	34-38
5	Estimates of C and D values by Mather's scaling test for various characters in chilli	45
6	Frequency of superior progenies obtained from segregating (F <sub>2</sub> ) generation in five crosses studied	47
7	Frequency of superior progenies obtained from segregating (F <sub>3</sub> ) generation in five crosses studied	49
8	Promising recombinants identified in F <sub>3</sub> population	62

# *Introduction*

---

## I. INTRODUCTION

The genus *Capsicum* belongs to family Solanaceae, which comprises nearly 30 species. The species *Capsicum annuum* L, *Capsicum frutescens* L., *Capsicum chinense* Jacquin, *Capsicum pendulum* Wilde nov and *Capsicum pubescens* Ruiz and Pavon which are strictly cultivated in central and south America have spread to tropics viz., India, Japan, Turkey, USA.

Chilli originated in tropical America (Mexico, Guatemala and Bulgaria), and its seeds were brought to old world by Columbus. It was introduced into India by Portugues in 16<sup>th</sup> century. By the end of 19<sup>th</sup> century it was cultivated throughout India (Hiremath 1997).

Broadly chillies can be classified into hot and mild types based on pungency. The African and Asian countries viz., Nigeria, Ethiopia, Uganda, India, China, Japan, Indonesia and Thailand are the leading producers and exporters of hot peppers. The European nations viz., Hungary, Spain, Romania, Bulgaria, Czechoslovakia and Slovak republics produce mild types commercially known as paprika.

Chilli or hot pepper (*Capsicum annuum* L.) is the second largest commodity after black pepper (*Piper nigrum*) in the international spice trade. Chilli is an indispensable spice essentially used in every Indian cuisine due to its pungency, spicy taste, appealing colour and flavour. The chilli fruit is a rich source of vitamins C, A and E. Dr.Szent Gyorgyi, Hungarian scientist, won Nobel Prize in 1937 for his work on

vitamin C and found chilli as its richest source. The pungency in chilli is due to a crystalline acrid volatile alkaloid called capsaicin present in the placenta and pericarp of fruit, which has diverse prophylactic and therapeutic uses in Ayurvedic and Allopathic medicines. Recently, the total flavour extracts of dried and ground chillies are concentrated in homogenous free flowing product as chilli oleoresin which has varied uses in processed food and beverage industries (eg., sauce, ketchup, stuffed meat, salad, etc.). The natural color extracts of chilli are also finding their increased value, in place of artificial colors in the food items, especially in the developed nations. Hence, chilli finds diverse utilities as spice, condiment, culinary supplement, medicine, vegetable and ornamental plant (Gaddagimath 1992).

Chilli leaf curl complex caused by feeding of thrips, *Scirtothrips dorsalis* Hood; aphid, *Aphis gossypii* Glover, white fly, *Bemisia tabaci* Genn and Mite, *Polyphogotorsionemus lotus* which transmit different viruses is one of the important causes in reducing the yield of chilli (Bidari and Reddy 1990).

An important challenge would be to develop variety/hybrid which respond well to resources with resistance to leaf curl complex. Resistant and stable Indian origin genotypes are available which could be utilized in breeding programmes. Chilli hybrids have great potential but not a single F<sub>1</sub> hybrid for dry chilli has been released from public sector.

Open pollinated varieties have traditionally dominated the commercial chilli cultivation. Although chilli tolerates inbreeding some degree of heterosis has been demonstrated for various traits (Poulus, 1994). Taking advantage of heterotic effects to increase the yield incorporation insect resistance with quality in a final hybrid would be great achievement.

In view of this the present investigation in chilli has been carried out to analyze gene effects for yield and its components along with thrips and mite resistance.

The knowledge of genetic architecture of various traits is very essential in the plant breeding programme for getting efficient results. To improve chilli crop both quantitatively and qualitatively breeding programme should be based on sound genetic knowledge.

Various biometrical approaches have been developed to decipher the genetic architecture and mode of inheritance of different characters related to yield. Generation mean analysis is one such approach which provides information about nature of gene action. It also elucidates the nature and magnitude of different gene actions involved.

Very few attempts have been made to study the genetic architecture of yield and its component characters in chilli.

In the present study, an attempt has been made to generate information on gene action of yield and its character in chilli by using generation mean analysis of five crosses with the following objectives:

1. To study the gene effects governing the expression of productivity and its associated traits.
2. To study the disease reaction of genotypes and hybrids for leaf curl complex and
3. To identify the productive segregants with high yield and leaf curl complex disease resistance.

*Review of Literature*

---

## **II. REVIEW OF LITERATURE**

The plant breeder is primarily concerned with the genetic improvement of both quantitative and qualitative characters and this is particularly true for chilli. The success of such a creative manipulation requires adequate knowledge of genetics of various characters. The chilli breeding work, since its systematic initiation in USA in the first decade of 20<sup>th</sup> century which later spread to other nations. It has paid much attention to the significant improvement in sweet peppers, whereas hot pepper breeding has gradually evolved through pure line selection of local land races. To enhance this pace of genetic improvement of chillies (hot peppers), detailed investigations to decipher the genetic architecture of fruit yield and its attributes along with resistance for leaf curl disease assuming importance.

Keeping in view of the foregoing points, the literature pertaining to the objectives of present investigation has been reviewed and presented in the following heads.

- 2.1 Genetic variability, heritability and genetic advance.
- 2.2 Residual heterosis in segregating generations.
- 2.3 Leaf curl complex disease.
- 2.4 Gene effect.

## 2.1 Genetic variability, heritability and genetic advance

The possibility of achieving efficient genetic improvement in any crop rests with the magnitude of available genetic variability. In any selection process, the question of laying emphasis in selection programmes for yield and its component characters lies solely on the heritability and genetic advance. Thus, the knowledge of these genetic parameters in germplasm as well as segregating generations is the basis for formulating selection criteria.

The comprehensive review on phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability ( $h^2$ ) and genetic advance as per cent of mean (GAM) in chilli for different quantitative traits is presented in Table 1.

A review on variability for different characters in chilli (Table 1) indicates the existence of wide range of variability for most of the characters studied. Though there are reports of high genetic variability for plant height, 50 per cent flowering, number of fruits per plant, fruit weight, fruit length, pedicel length, but reports contradicting the above and quoting medium to low variability for these characters are also available. However, most of the reviews reported high variability for number of fruits per plant, fresh fruit yield and dry fruit yield.

**Table 1. Review of literature on variability, heritability and genetic advance for various quantitative characters in chilli**

Sl. No.	Characters	Material used for the study	PCV (%)	GCV (%)	h <sup>2</sup> (%)	GA as % mean	References
1.	Plant height	F <sub>1</sub> , F <sub>2</sub> and BCs of Azamgarh local x 6004	-	-	28.33	12.34	Singh and Rai (1981)
		11 parents	32.24	26.05	81.26	37.23	Khadi (1983)
		55 F <sub>2</sub> s (from 10 x 10 diallel)	20.86	10.77	26.63	11.44	Khadi (1983)
		63 cultivars	27.17	26.56	95.58	110.4	Nair <i>et al.</i> (1984)
		F <sub>2</sub> of NP 46 x JED cross	18.78	18.16	84.38	31.63	Ghai and Thakur (1987)
		45 F <sub>2</sub> s (10 x 10 diallels)	11.74	11.71	94.43	22.84	Sahoo <i>et al.</i> (1990)
		30 biparental progenies of 3 crosses	-	-	35.03	6.42	Thangraj and Muthukrishnan (1991b)
		60 F <sub>3</sub> progenies of 3 crosses	-	-	39.04	9.45	Thangraj and Muthukrishnan (1991a)
		F <sub>2</sub> of DCA-1 x Sinahur	22.12	22.07	99.58	45.37	Gaddagimath (1992)
		F <sub>2</sub> of DCA-1 x Derrenial	20.6	20.54	99.45	42.21	Gaddagimath (1992)
	4 F <sub>2</sub> of 5 cultivars	High	High	-	-	Kumar <i>et al.</i> (1993)	
2.	Number of primary branches	F <sub>1</sub> , F <sub>2</sub> and BCs of Azamgarh local x 6004	-	-	56.86	63.95	Singh and Rai (1981)
		F <sub>2</sub> of NP 46 x JED cross	34.93	31.98	80.87	57.68	Ghai and Thakur (1987)
		6 varieties and 15 F <sub>1</sub> - hybrids	-	-	62.5	-	Bhagyalakshmi <i>et al.</i> (1990)
		30 biparental progenies of 3 crosses	-	-	44.23	2.28	Thangraj and Muthukrishnan (1991b)
		60 F <sub>3</sub> progenies of 3 crosses	-	-	46.57	0.82	Thangraj and Muthukrishnan (1991a)
		F <sub>2</sub> of DCA x Sindyhur	32.77	29.82	76.02	46.37	Gaddagimath (1992)
		F <sub>2</sub> of DCA-1 x Perrenial	29.62	25.82	76.02	46.37	Gaddagimath (1992)
		90 Byadagi selections (location 1)	17.42	6.33	13.2	4.73	Giritammannavar (1995)
		90 Byadagi selections (location 2)	17.43	5.88	11.4	4.12	Giritammannavar (1995)

Contd..

Sl. No.	Characters	Material used for the study	PCV (%)	GCV (%)	h <sup>2</sup> (%)	GA as % mean	References
3.	Fruit length	F <sub>1</sub> , F <sub>2</sub> and BCs of Azamgarh local x 6004	-	-	65.98	58.26	Singh and Rai (1981)
		F <sub>2</sub> of NP 46 x JED cross	17.49	16.4	67.03	24.31	Ghai and Thakur (1987)
		30 Biparental progenies of 3 crosses	-	-	62.23	1.18	Thangraj and Muthukrishnan (1991b)
		60 F <sub>3</sub> progenies of 3 crosses	-	-	61.66	1.23	Thangraj and Muthukrishnan (1991a)
		F <sub>2</sub> of DCA-1 x Sindhur	25.52	22.32	76.32	40.21	Gaddagimath (1992)
		F <sub>2</sub> of DCA-1 x Perrenial	28.86	21.41	55.06	32.68	Gaddagimath (1992)
		4F <sub>2</sub> of 5 cultivars	High	High	-	-	Kumar <i>et al.</i> (1993)
		90 byadgi selections (location 1)	11.14	10.03	81	18.62	Giritammannavar (1995)
		90 byadgi selection (location 2)	10.97	7.07	40.7	31.39	Giritammannavar (1995)
4.	Fruit stalk length	55F <sub>2</sub> s (11 x 11 diallel)	14.66	7.88	28.88	8.88	Khadi (1983)
		F <sub>2</sub> of DCA-1 x Sindhur	16.14	13.12	88.45	28.76	Gaddagimath (1992)
		F <sub>2</sub> of DCA-1 x Perrenial	16.31	15.61	86.76	29.28	Gaddagimath (1992)
		75 genotypes	15.76	10.13	41.3	0.34	Sirsat (1994)
		90 byadgi selections (location 1)	9.04	0.88	1	0.28	Giritammannavar (1995)
		90 byadgi selections (location 2)	2.97	0.63	4.5	0.28	Giritammannavar (1995)
		5.	Average fruit weight	F <sub>2</sub> s of NP 46 x JED cross	42.86	41.27	82.75
45 F <sub>2</sub> s (10 x 10 diallel)	67.12			26.89	92.85	53.35	Sahoo <i>et al.</i> (1991)
30 biparental progenies of 3 crosses	-			-	67.14	0.14	Thangraj and Muthukrishnan (1991)
60 F <sub>3</sub> progenies of 3 crosses	-			-	54.13	0.13	Thangraj and Muthukrishnan (1991)
F <sub>2</sub> of DCA-1 x Sindhur	29.22			28.94	98.19	59.01	Gaddagimath (1992)
F <sub>2</sub> of DCA-1 x Perrenial	25.51			23.01	90.01	47.3	Gaddagimath (1991)
90 byadgi selections (location 1)	15.78			11.14	49.19	16.46	Giritammannavar (1995)
90 byadgi selections (location 2)	21.97			15.12	47.4	21.13	Giritammannavar (1995)

Contd..

Sl. No.	Characters	Material used for the study	PCV (%)	GCV (%)	h <sup>2</sup> (%)	GA as % mean	References
6.	Number of fruits per plant	F <sub>1</sub> , F <sub>2</sub> and BCs of Anamgarh local x 6004	-	-	54.39	7.34	Singh and Rai (1981)
		55 F <sub>2</sub> s (11 x 11 diallel)	28.02	16.72	35.62	20.56	Khadi (1983)
		F <sub>2</sub> of NP 46 x JED cross	8.63	8.26	49.52	8.82	Ghai and Thakur (1987)
		45 F <sub>2</sub> s (10 x 10 diallel)	24.74	24.55	98.48	50.19	Sahoo <i>et al.</i> (1990)
		30 biparental progenies of 3 crosses	-	-	61.56	40.16	Thangraj and Muthukrishnan (1991b)
		F <sub>2</sub> of DCA-1 x Sindhur	64.07	64.01	99.94	131.9	Gaddagimath (1992)
		F <sub>2</sub> of DCA-1 x Perennial	63.51	63.91	99.94	130.76	Gaddagimath (1992)
		90 byadagi selections	22.09	21.2	92.1	41.89	Giritammannavar (1995)
7.	Dry fruit yield/plant	F <sub>1</sub> , F <sub>2</sub> and BCs of Azamgarh local x 6004	-	-	21.88	2.24	Singh and Rai (1981)
		55 F <sub>2</sub> s (10 x 10 diallel)	29.95	16.3	30.36	18.73	Khadi (1983)
		F <sub>2</sub> of NP 46 x JED cross	10.62	9.12	42.92	8.85	Ghai and Thakur (1987)
		45 F <sub>2</sub> s (10 x 10 diallel)	36.49	36.26	98.74	74.23	Sahoo <i>et al.</i> (1990)
		30 biparental progenies of 3 crosses	-	-	52.36	85.4	Thangraj and Muthukrishnan (1991b)
		F <sub>2</sub> of DCA-1 x Sindhur	61.38	57.51	87.77	110.98	Gaddagimath (1992)
		F <sub>2</sub> of DCA-1 x Perennial	59.6	53.69	81.15	99.61	Gaddagimath (1992)
8.	Days to 50% flowering	F <sub>1</sub> , F <sub>2</sub> and BCs of Azamgarh local x 6004	-	-	75	1.83	Singh and Rai (1981)
		F <sub>2</sub> of NP 46 x JED cross	15.9	15.02	52.44	17.2	Ghai and Thakur (1987)
		BC <sub>1</sub> of NP 46 x JED cross	14.9	14.03	0	0	Ghai and Thakur (1987)
		30 biparental progenies of 3 crosses	-	-	38.36	4.86	Thangraj and Muthukrishnan (1991b)
		60 F <sub>3</sub> progenies of 3 crosses	-	-	51.74	7.16	Thangraj and Muthukrishnan (1991a)
		32 diverse genotypes	6.4	6.3	98	12.9	Varalakshmi and Haribabu (1991)
		90 byadagi selections	5.01	1.27	6.4	0.66	Giritammannavar (1995)

Contd..

Sl. No.	Characters	Material used for the study	PCV (%)	GCV (%)	h <sup>2</sup> (%)	GA as % mean	References
9.	Fruit width	35 diverse varieties	33.54	32.99	96.75	66.85	Elangovan <i>et al.</i> (1981)
		F <sub>1</sub> , F <sub>2</sub> and BCs of Azamagarh local x 6004	-	-	47.06	33.11	Singh and Rai (1981)
		55 F <sub>2</sub> s (11 x 11 diallel)	11.11	3.81	11.78	3.19	Khadi (1983)
		F <sub>2</sub> of NP 46 x JED cross	15.51	13.29	80.83	26.52	Ghai and Thakur (1987)
		45 F <sub>2</sub> s (10 x 10 diallel)	12.46	9.19	54.37	13.96	Sahoo <i>et al.</i> (1990)
		30 biparental progenies of 3 crosses	-	-	60.66	0.7	Thangraj and Muthukrishnan (1991b)
		F <sub>2</sub> of DCA-1 x Sindhur	22.93	22.84	99.18	46.86	Gaddagimath (1992)
		F <sub>2</sub> of DCA-1 x Perrenial	19.78	19.68	99.05	40.36	Gaddagimath (1992)
		90 byadagi selections	32.31	31.5	95	63.33	Giritammannavar (1995)

## 2.2 Residual heterosis in segregating generations

The first segregating generation ( $F_2$ ) and subsequent generations are generally expected to show decreased performance when compared to their performance in  $F_1$  hybrids of both self and cross pollinated crops and this is referred as inbreeding depression or residual heterosis. Although considerable inbreeding depression is observed in many crops including chilli, some crosses in certain crops have the capacity to retain the enhanced performance of  $F_1$  in subsequent generations, which is often known as residual heterosis. Sprague and Tatum (1942) has reported the practice of cultivating advanced generation hybrids of maize but such reports in vegetables in general, and chilli in particular are less. However, the recent reports have been precisely presented here below.

Nagaich *et al.* (1972) observed residual heterosis over mid parental value in  $F_2$  and  $F_3$  of an interspecific hybrid over plant height and fruit number and they indicated exploitation of  $F_2$  if crossing barriers were absent. According to Soltanovskaya (1972),  $F_1$  flowered and ripened before the parents and  $F_2$  fruits ripened almost at same time as that of earlier parent. In addition, the best three hybrids exceeded both parents in yield in  $F_1$  and  $F_2$  and to a lesser extent in  $F_3$ . Papova (1973) tested two intervarietal hybrids and found lower total yields in  $F_2$  than  $F_1$ , but higher than the yield of better parent.

The maintenance of heterosis for yield in  $F_2$  of a cross involving a low yielding parent Topepo-134, was reported by Rochetta *et al.* (1976), but Singh and Singh (1976a) noticed significant inbreeding depression in respect of seed portion of fruit. However majority of the crosses manifested higher  $F_2$  values for stalk portion. The findings of Bhat (1981) revealed considerable positive residual heterosis for number of branches, seed portion and fruit yield, whereas negative residual heterosis was observed for plant height, stalk length, fruit length and fruit number in majority of the 45  $F_2$  crosses. Further, an investigation by Khadi (1983) involving 55  $F_2$  crosses indicated positive and significant residual heterosis for fresh fruit yield (upto 58.96% in Byadgi kaddi x Kathigolar cross) fruit length, fruit number and negative heterosis for plant height and fruit diameter in majority of the crosses.

Ashtankar and Jaipurkar (1988) recorded negative residual heterosis for all the characters including fruit yield. On the contrary, Patil (1990) observed higher fruit yield in  $F_2$ , but little lower than corresponding  $F_1$ s in two crosses *viz.*, CP-2 x CP-5 and CP-4 x CP-5, thus indicating the possibility of utilizing the residual heterosis in  $F_2$  for commercial purposes. After studying 45  $F_1$ s from 10 x 10 diallel, Sahoo and Mishra (1990) indicated that mean performance of 12 characters was not always reflected by residual heterosis. However the outstanding expression of fruit number and dry fruit yield were observed in two

crosses (J-218 x CA-586 and J-218 x KCS-1) which also had superior transgressive segregants.

### **2.3 Leaf curl complex disease**

Ferry and Schalk (1991) reported that resistance to thrips *Frankniella accidentalis* was confined to five commercial varieties due to mechanism of tolerance to insect feeding rather than antibiosis or antixenosis. This type of resistance may be useful in preventing plant injury due to thrips feeding but would not help in controlling tomato spotted wilt (TOSPO) virus as a serious pathogen of pepper for which *F accidentalis* is a common vector, Tewari and Anand (1977) reported that resistant high yielding chilli variety Pusa Jwala has been out come of the cross HPU6A x Pusa red. Tewari *et al.* (1986) reported that thrips is a serious pest on chilli. An yield loss of upto 50 per cent was observed in a screening programme of 132 lines. IHR-301-15-1, 308-1-13, NP-46A, S-118-2 showed high degree of resistance, 33 lines showed moderate resistance along with Jwala.

Khalid Ahmad *et al.* (2000) reported mite as a serious pest on chilli. It completes 5-6 generation on chilli, feeds on the under side of the leaf causing downward curling. Prabhu and Jagadeesha (1998) identified resistant resources for thrips and mites which cause leaf curl complex (murda). The resistance among 43 germplasm ranged from 7.19 to 51.59 and 9.87 to 37.48 per cent leaf curl index for thrips and

mites respectively. The chilli genotypes Pantc-1, LCA-304, LCA-312, LCA-301 and BI-1-1 were found promising for resistant against both chilli thrips and mites. The local check Byadagi kaddi was found susceptible and recorded 34.91 and 32.37 per cent leaf curl index for thrips and mites respectively.

The evidence so far available indicated that leaf curl complex in chilli could be due to mites, thrips and viruses transmitted by white flies (Sawant *et al.*, 1984). According to Eidari and Reddy (1990), average incidence of leaf curl complex disease in Karnataka was 53 per cent with a range of 11.8 to 94.89 per cent. High GCV with moderate to high heritability and genetic advance was reported for this character by Hiremath (1997).

#### **2.4 Gene effect**

Quantitative traits are characterized by continuous distribution. Inheritance of such characters is governed by genes which have small and cumulative effects. The choice of an appropriate breeding method for improvement of quantitative characters also depends largely on nature of gene effect. Therefore these genes must be considered together and suitable statistical methods to be used to obtain genetic information.

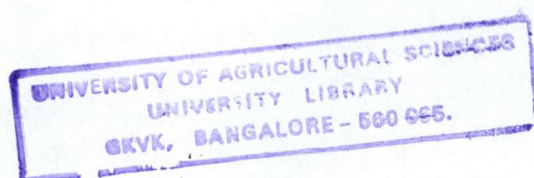
Many gene models given by various workers attempted to describe the action of genes controlling quantitative characters. Fisher

(1918) was first to attempt construction of a gene model which include dominance at a single locus. He also indicated that there may be a deviation from simple additive effects between loci if more than one locus affected a given character.

Anderson and Kempthorne (1954) in their gene model partitioned genotype value into additive, dominance and epistatic effects. Based on the theory developed by Fisher *et al.* (1932), Mather (1949) and Hayman and Mather (1957) proposed a gene model to assess the contribution of gene interaction to continuous variation.

Hayman (1958a) described a general procedure to estimate parameters referring to additive (d), dominance (h), additive x additive (i), additive x dominance (j), dominance x dominance (l) effects.

In chilli studies on gene effects through generation mean analysis are very less. Singh and Singh (1978), Jadhav and Dumbhal (1994) and Jagadeesha (2000), have reported the gene effects using generation mean analysis. Other studies to know the gene effect is through diallele analysis. A review on gene effect is enumerated in Table 2.



**Th. 7183**

**Table 2. Review of literature on gene effects for various characters in chilli**

Sl. No.	Characters	Additive	Non-additive	Additive and Non-additive
1.	Plant height	Daskalov and Mihailov (1988), Sontakke (1981), Patel <i>et al.</i> (1998)	Sharma and Saini (1977), Singh and Singh (1978), Miranda <i>et al.</i> (1988), Ahmed <i>et al.</i> (1997), Bhagyalaksmi <i>et al.</i> (1991), Mulge and Anand (1997), Ahmed <i>et al.</i> (1988)	Bhat (1981), Singh and Singh (1976b), Khadi (1983), Milkova (1986), Cao and Su (1988), Gopalkrishna <i>et al.</i> (1989), Ahmed <i>et al.</i> (1998)
2.	Number of primary branches	Bhat (1981), Khadi (1983), Gaddagimath (1992)	Singh and Singh (1976 a,b), Sontakke (1981), Patel <i>et al.</i> (1998), Bhagyalakshmi <i>et al.</i> (1991)	Cao and Su (1988), Gopalkrishnan <i>et al.</i> (1989), Milkova (1986), Ahmed <i>et al.</i> (1998), Sharma and Saini (1977)
3.	Number of secondary branches	Mulge and Anand (1997)	-	-
4.	Number of fruits/plant	Lippert (1975), Singh and Singh (1976a), Sontakke (1981), Kaul and Sharma (1988), Gopalkrishna <i>et al.</i> (1989), Miranda <i>et al.</i> (1988), Patel <i>et al.</i> (1998), Ahmed <i>et al.</i> (1998)	Singh and Singh (1976 a, b)	Gill <i>et al.</i> (1973), Milkova (1986), Mishra <i>et al.</i> (1991), Bhagyalaksmi <i>et al.</i> (1991)
5.	Fruit weight	Gopal Krishnan <i>et al.</i> (1989), Miranda <i>et al.</i> (1988), Ahmed <i>et al.</i> (1998), Ahmed <i>et al.</i> (1997)		Bhagyalaksmi <i>et al.</i> (1991)
6.	Fruit length	Lippert (1975), Singh and Singh (1976a), Singh and Singh (1978), Daskolov and Mihailo (1988), Santakke (1981), Kaul and Sharma (1988), Miranda <i>et al.</i> (1988), Ahmed <i>et al.</i> (1997)	Singh and Singh (1976 a, b), Ahmed <i>et al.</i> (1998)	Gill <i>et al.</i> (1973), Milkova (1986), Gopal Krishnan <i>et al.</i> (1989), Patel <i>et al.</i> (1998), Bhagyalakshmi <i>et al.</i> (1991)

Contd..

Sl. No.	Characters	Additive	Non-additive	Additive and Non-additive
7.	Fruit width	Lippert (1975), Milkova (1977), Sontakke (1981), Gopal Krishnan <i>et al.</i> (1989), Miranda <i>et al.</i> (1988), Ahmed <i>et al.</i> (1998), Ahmed <i>et al.</i> (1997)	Singh and Singh (1978), Patel <i>et al.</i> (1998)	Bhagyalakshmi <i>et al.</i> (1991) Kaul and Sharma (1988)
8.	Pericarp weight	Martin and Lippert (1975), Bhat (1981), Ahmed <i>et al.</i> (1998)	Gaddagimath (1992)	-
9.	Stalk length and weight	Martin and Lippert (1975), Daskalov and Mihailov (1988), Gaddagimath (1992)	Khadi (1983)	Milkova (1977), Singh and Singh (1978)
10.	Number of seeds/pod	Martin and Lippert (1975), Ahmed <i>et al.</i> (1997)	Gaddagimath (1992), Ahmed <i>et al.</i> (1998), Mishra <i>et al.</i> (1991)	Singh and Singh (1976b), Milkova (1986), Bhagyalakshmi <i>et al.</i> (1991)
11.	Ascorbic acid	-	Bhagyalakshmi <i>et al.</i> (1991)	-
12.	1000 seed weight	-	-	Mishra <i>et al.</i> (1991)
13.	Yield	Lippert (1975), Singh and Singh (1978), Patel <i>et al.</i> (1998), Mulge and Anand (1997)	Kumar and Nandapuri (1973), Sharma and Saini (1977), Singh and Singh (1976a), Ahmed <i>et al.</i> (1998), Ahmed <i>et al.</i> (1997), Bhagyalakshmi <i>et al.</i> (1991)	Sharma and Saini (1977)

*Material and Methods*

---

### III. MATERIALS AND METHODS

The present investigation on chillies was carried out during *kharif* 2000-2001 at ARS, Hanumanmatti, which is 135 km from University of Agricultural Sciences, Dharwad head quarters. It is situated in the transitional zone of Northern Karnataka. Geographically located at 14°39' N latitude and 75°33' longitude and at an attitude of 594.36 metres above mean sea level with an average annual rainfall ranging between 280-300 mm. Soils are shallow red with less clay content.

#### 3.1 Experimental Material

The experimental material for this study comprised of 8 genotypes selected based on their diversity for various traits. From these 8 genotypes, 5 crosses were effected. From these 5 crosses F<sub>1</sub>'s, F<sub>2</sub>'s and F<sub>3</sub>'s were evaluated. One check variety G<sub>3</sub> was also included for the study.

The characteristic features of the parents and check involved in this study are given here under.

The list of crosses, along with there parents are

1. 9632 - VN2 x Jwala
2. 9646 - VN2 x Arkalohit
3. 9708 - Hissar shakti x PMR 21
4. 9612 - Byadagi Kaddi x Arka lohit
5. 9623 - Byadagi Dabbi x LCA 312

**Byadagi kaddi** : Tall, late maturing, erect and having long fruits. Red colored fruit wrinkles on dry fruit.

**Byadagi dabbi** : Medium tall, late maturing, strait fruit and medium pungency. Dark red color fruit, wrinkles on dry fruit.

**VN-2** : Exotic line introduced from Vietnam, having tall, late maturing, long, stout fruit, light red color and resistant to leaf curl complex.

**Jwala** : Compact, long fruit and erect pendent. Most popular, widely grown chilli variety having resistant to leaf curl virus.

**Hissar shakti** : Medium, compact and small fruits. Fruits are born in clusters, up right suitable for bunch harvesting.

**LCA-312** : Medium tall, compact, medium size fruits and resistant to thrips and mites.

**Arka lohit** : Very tall, erect, more branch, small fruits and dark green color fruit, turn to dark red color.

**PMR-21** : Resistant to powdery mildew disease and fruits are more pungent.

**Check variety G<sub>3</sub>** : Tolerant to leaf curl disease, medium tall and medium size fruits.

### **3.2 Layout of the experiment**

The experiment was laid out during *kharif* 2000 at Agricultural Research Station, Hanumanmatti, in a randomized block design with two replications for each entry was planted in one row of 10 plants each for parents and hybrids, 20 rows of 10 plants each for F<sub>2</sub>

population and 15 rows of 10 plants each for F<sub>3</sub> population. Spacing of 60 cm x 60 cm was followed and the crop was raised as per the recommended package of practices.

### **3.3 Sampling and collection of data**

Ten random competitive plants were tagged in each entry in each replication and following observations were recorded.

#### **3.3.1 Plant height (cm)**

Height of the plant from the ground level to the top of the plant was measured in centimeter at the time of maturity.

#### **3.3.2 Number of primary branches**

Branches arising from main stalk were counted and recorded as number of primary branches.

#### **3.3.3 Number of secondary branches**

The branches on primary branches were counted and recorded as number of secondary branches.

#### **3.3.4 Number of fruits per plant**

Number of effective fruits per plant were counted few days before harvesting.

#### **3.3.5 Leaf curl complex index (%)**

The combined incidence of thrips and mites as revealed by upward and downward curling respectively and mosaic on leaf caused by different viruses was recorded at peak fruit maturity stage. The number

of plants with two symptoms resistant and susceptible were counted and leaf curl index calculated for particular treatment.

$$\text{Per cent leaf curl complex} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

#### Scale for scoring leaf curl complex

Grade	Average disease incidence	Reaction
1	0.0 – 0.0	Immune (I)
2	0.1 – 25.0	Resistant (R)
3	25.1 – 50.0	Moderately resistant (MR)
4	50.1 – 75.0	Susceptible (S)
5	75.1 – 100.0	Highly Susceptible

(Sawant *et al.*, 1984)

#### 3.3.6 Fruit length (cm)

Five fruits chosen randomly from each plant were measured in cm from apex of the fruit to the tip of the stalk and averaged as fruit length in centimeter.

#### 3.3.7 Stalk length (cm)

The stalks of the fruit chosen for measuring fruit length were measured for their length in cm and were average for fruit.

### **3.3.8 Fruit girth (mm)**

Ten fruits randomly chosen from each plant were measured in mm at the base of the attachment of stalk with the help of vernier calipers and averaged as fruit girth in mm.

### **3.3.9 Pericarp weight per fruit (g)**

Weight of pericarp (g) was taken after removing the seed and recorded.

### **3.3.10 Number of seed per fruit**

From each fruit seeds were counted.

### **3.3.11 Fruit weight (g)**

Weight of ten fruits were taken from each of the ten plants in sum and averaged.

### **3.3.12 1000 seed weight (g)**

One thousand seeds were counted in each replication and weighed in grams.

### **3.3.13 Dry fruit yield per plant (g)**

The matured fruits were harvested were sundried and brought to 8-10 per cent moisture content and weights were taken in grams.

## **3.4 Statistical analysis**

### **3.4.1 Analysis of variance**

The mean values of the genotypes were used for analysis of variance. Replication wise mean values were subjected to RBD analysis

(Snedecor and Cochran, 1967). The significance of differences among all the genotypes was tested by 'f' test.

### ANOVA

Source of variation	DF	MSS	Expectation of mean square	Variance ratio of f
Replication	r-1	RMSS		
Genotypes	g-1	GMSS	$\sigma^2_e + r\sigma^2_g$	GMSS
Error	(r-1)(g-1)	EMSS	$\sigma^2_e$	
Total	(rg-1)			

Where,

r = number of replications

g = number of genotypes

$$\text{S.Em} = \frac{\sqrt{\text{EMSS}}}{r}$$

#### 3.4.2 Estimation of variance components

Genotypic and phenotypic components of variance were estimated with the help of following formulae.

$$\text{Genotypic variance } (\sigma^2_g) = \frac{\text{GMSS} - \text{EMSS}}{r}$$

$$\text{Phenotypic variance } (\sigma^2_p) = \sigma^2_g + \text{EMSS}$$

#### 3.4.3 Coefficient of variability

Both genotypic and phenotypic coefficients of variability were computed for each character as per method suggested by Burton and Devane (1953).

$$\text{Genotypic coefficient of variability (GCV)} = \frac{\sqrt{\sigma_g^2}}{\bar{X}} \times 100$$

$$\text{Phenotypic coefficient of variability (PCV)} = \frac{\sqrt{\sigma_p^2}}{\bar{X}} \times 100$$

$$\text{Environmental Variance} = \frac{VP_1 + VP_2 + VF_1}{3}$$

Where,

$\sigma_g$  = Genotypic standard deviation

$\sigma_p$  = Phenotypic standard deviation

$\bar{X}$  = Grand mean of the character.

#### 3.4.4 Heritability in broad sense

Heritability coefficient ( $h^2$ ) was computed for each character as the ratio of genetic variance to the total variance as suggested by Johnson *et al.* (1955).

$$h^2 = \sigma_g^2 / \sigma_p^2 \times 100$$

where,  $\sigma_g^2$  and  $\sigma_p^2$  are genotypic and phenotypic variances respectively.

#### 3.4.5 Genetic advance

Genetic advance (GA) for each character was computed adopting the formula given by Johnson *et al.* (1955).

$$GA = (h^2) (K) (\sigma_p)$$

Where,

$h^2$  = Heritability coefficient (Broad sense)

K = Selection differential which is equal to 2.06 at 5 per cent selection intensity (Lush, 1949).

$\sigma^2_p$  = Phenotypic variances.

### 3.4.6 Genetic advance over mean

Genetic advance over mean (GAM) was computed by the formula.

$$\text{GAM} = (\text{GA}/X) \times 100.$$

### 3.4.7 Generation mean analysis

Five crosses were selected for this study, the means and variances were calculated from the observations of individual plants in each generation for each character according to Hayman (1958).

$$\text{SE} = \sqrt{\frac{\text{Variance of population}}{\text{Total number of plants}}}$$

#### 3.4.7.1 Scaling tests

The testing of epistasis for the estimation of components of genetic variation was detected by employing Mather's Scaling test (Mather, 1949; Hayman and Mather, 1957). The four scaling tests A, B, C and D will be used for estimation but for this experimental study C and D scaling tests are employed as  $F_3$  generations were available instead of back cross generation was not available for the study.

$$C = 4F_2 - 2F_1 - P_1 - P_2$$

$$D = 4F_3 - 2F_2 - P_1 - P_2$$

Where,

$P_1, P_2, F_1, F_2, F_3$  are the mean values of their respective generations.

To test the significance of these two scaling quantities, the respective variances were calculated. Using variance of the corresponding population mean as follows.

$$V_C = 16V(F_2) + 4V(F_1) + V(P_1) + V(P_2)$$

$$V_D = 16V(F_3) + 4V(F_2) + V(P_1) + V(P_2)$$

### 3.4.7.2 Estimation of gene effects

The mean value of all the five generation were analyzed by a model proposed by Hayman (1958), to obtain the information on the nature of gene action governing the quantitative traits under study. The notations given by Hayman (1958) are as follows.

#### Gene effects and their notations

Sl. No.	Gene effects	Notations
1	Mean	$\hat{m}$
2	Additive	$\hat{d}$
3	Dominant	$\hat{h}$
4	Additive x additive	$\hat{i}$
5	Dominant x dominant	$\hat{l}$

The estimates of m, d, h, i and l were calculated by using following statistical equations.

$$\hat{m} = F_2$$

$$\hat{d} = \frac{1}{2} P_1 - \frac{1}{2} P_2$$

$$\hat{h} = \frac{1}{6} (4F_1 + 12F_2 - 16F_3)$$

$$\hat{i} = P_1 - F_2 + \frac{1}{2}(P_1 + P_2 + h) - \frac{1}{4}l$$

$$\hat{l} = \frac{1}{3} (16F_3 - 24F_2 + 8F_1)$$

The variances of these estimates were calculated as follows.

$$V_m = VF_2$$

$$V_d = \frac{1}{4} (VP_1 + VP_2)$$

$$V_h = \frac{1}{16} (16VF_1 + 144VP_2 + 256 VF_3)$$

$$V_i = VP_1 + VP_2 + \frac{1}{4}(VP_1 + VP_2 + V_h) + \frac{1}{16}V_l$$

$$V_l = \frac{1}{9} (256VF_3 + 576VF_2 + 64VF_1)$$

Where,  $V_m$ ,  $V_d$ ,  $V_h$ ,  $V_i$  and  $V_l$  were the variances of gene effects of m, d, h, i and l, respectively and  $VP_1$ ,  $VP_2$ ,  $VF_1$ ,  $VF_2$  and  $VF_3$  were the variances of their respective generations.

Square root of the variances of the above estimates provided standard error, which were used to test the significance of gene effects. The value of each gene effect was divided with its standard error and the quotient was compared to 1.96 for significance at 5 per cent level and 2.58 for significance at 1 per cent level.

---

*Experimental Results*

## **IV. EXPERIMENTAL RESULTS**

The principal objective of the present investigation was to analyse the gene effects for yield and other characters along with leaf curl disease resistance. For this the knowledge of genetic architecture of various traits is very essential to plant breeding programme for getting efficient results. For improvement of various characters in chilli crop in desired manner the breeding programme should be based on sound genetic knowledge. The results obtained from the present investigations are presented under the following heads.

- 4.1 Variability study of the superior cross VN-2 x Jwala (9632) for F<sub>2</sub> population
- 4.2 Generation mean analysis
  - 4.2.1 Estimation of gene effects for various traits in chilli
  - 4.2.2 Estimation of scaling tests
- 4.3 Identification of superior genotypes in segregating populations of the five crosses used in study
  - 4.3.1 Identification of superior genotypes in F<sub>2</sub> populations of the five crosses
  - 4.3.2 Identification of superior genotypes in F<sub>3</sub> populations of the five crosses

#### **4.1 Variability study of the superior cross VN-2 x Jwala (9632) for F<sub>2</sub> population**

##### **4.1.1 Plant height (cm)**

GCV and PCV in the population was low for the plant height. And heritability. Genetic advance and genetic advance over mean in these populations were very low (13.43% heritability, 5.25% GAM) Table-3.

##### **4.1.2 Number of primary branches per plant**

GCV and PCV were low but heritabilities in the population was very high with 82.34 per cent. GAM over F<sub>2</sub> mean was moderately high i.e., 55.59 per cent.

##### **4.1.3 Number of secondary branches per plant**

GCV and PCV values were moderately low but heritabilities and genetic advances over mean (GAM) were high. In F<sub>2</sub> population of this cross the GAM was 66.01.

##### **4.1.4 Number of fruits per plant**

GCV and PCV were found to be very high compared to other characters. Heritability estimates were nearly 100 per cent. GAM was found to be 130.75 per cent in F<sub>2</sub> population.

##### **4.1.5 Leaf curl index**

For this trait, both GCV and PCV were found to be low. Heritability estimates was nearly 67 per cent. GAM was found to be 58.85 per cent.

**Table 3. Variability parameters for different characters in F<sub>2</sub> populations of the cross VN-2 x Jwala (9632)**

Sl. No.	Characters	GCV	PCV	Heritability (Broad sense)	GA	GAM
1.	Plant height (cm)	6.95	18.98	13.43	3.12	5.25
2.	Number of primary branches	29.74	32.77	82.3	2.41	55.59
3.	Number of secondary branches	34.19	35.73	91.52	5.38	66.01
4.	Number of fruits per plant	64.00	64.08	99.94	75.84	130.75
5.	Leaf curl index	35.83	44.94	66.56	1.53	58.85
6.	Fruit length (cm)	22.32	25.52	76.46	2.47	32.68
7.	Stalk length (cm)	13.115	16.13	86.44	0.75	28.76
8.	Fruit girth (mm)	22.84	22.93	99.18	1.91	46.85
9.	Pericarp weight per fruit (g)	27.93	31.93	76.46	0.17	50.30
10.	Number of seeds per fruit	36.07	36.87	99.50	0.29	75.57
11.	Fruit weight (g)	28.93	29.2	98.11	0.47	59.012
12.	1000 seed weight (g)	21.3	24.24	77.22	1.96	38.56
13.	Dry fruit yield per plant (g)	22.41	24.25	86.88	31.47	42.91

#### **4.1.6 Fruit length (cm)**

Both GCV and PCV were found to be low. Heritability estimates was high i.e., 76.46 per cent GAM was found to be 32.68 per cent.

#### **4.1.7 Stalk length (cm)**

GCV and PCV were found to be very low compared to other characters. Heritability estimates was high i.e. 86.44 per cent. GAM was found to be 28.76 per cent.

#### **4.1.8 Fruit girth (mm)**

GCV and PCV in the population was low for fruit girth (22.84 and 22.95%) and heritability estimates was very high i.e., 99.18 per cent. GAM was found to be 46.85 per cent.

#### **4.1.9 Peri carp weight per fruit (g)**

For the  $F_2$  populations both GCV and PCV were low. Heritability and genetic advances over mean were moderately high in the  $F_2$  population (76.46 and 50.30%, respectively).

#### **4.1.10 Number of seeds per fruit**

Both GCV and PCV were moderate (36.07 and 36.81) for this character and heritability estimates was very high (99.508). GAM were also worked out to be moderately high i.e., 75.57 per cent.

#### **4.1.11 Fruit weight (g)**

GCV and PCV values were low, while heritability estimates was moderately high i.e., 77.22 per cent. GAM was found to be 38.56 per cent.

#### **4.1.12 1000 seed weight (g)**

GCV and PCV values were low, while heritability estimates was moderately high i.e., 77.22 per cent. GAM was found to be 38.56 per cent.

#### **4.1.13 Dry fruit yield per plant (g)**

GCV and PCV for this characters were low viz., 22.41 and 24.25 respectively, while heritability estimates was high i.e., 86.88 per cent. GAM was found to be 42.91 per cent.

### **4.2 Generation mean analysis**

Five generations ( $P_1$ ,  $P_2$ ,  $F_1$ ,  $F_2$ ,  $F_3$ ) of five crosses viz., 9632 (VN-2 x Jwala), 9623 (Dabbi x LCA 312), 9646 (VN-2 x Arka lohit), 9708 (Hissar Shakti x PMR 21) and 9612 (Kaddi x Arka lohit) in chilli were used to estimate the five genetic parameters viz., mean ( $m$ ), additive effect ( $d$ ), dominance effect ( $h$ ), additive x additive effect ( $i$ ) and dominance x dominance effect ( $l$ ) for various quantitative characters (Table-4). To find the type of epistasis, signs of dominance and dominance gene effects were compared. If the signs are in the same direction it indicates complimentary type of epistasis and if in

opposite direction it indicates duplicate type of epistasis (Dabholkar, 1992).

#### **4.2.1 Estimates of gene effects for 13 characters in 5 crosses in chilli**

##### **4.2.1.1 Plant height (cm)**

The estimates of additive gene effects (d) were significant and positive in 9632, 9646 and 9623 crosses for plant height. None of the crosses showed significance for dominance effects (h). The magnitude of (l) was greater than (d) in all the crosses except the cross Dabbi x LCA 312 (9623). Additive x additive (l) was positive and significant in 9646, 9708 and 9612 crosses. Dominance x dominance gene interaction effects were positive and significant in Hissar Shakti x PMR 21 (9708). None of the crosses showed significance for all the gene effects. Majority of the crosses showed the dominance x dominance (l) gene effects followed by the additive gene effects (d).

##### **4.2.1.2 Number of primary branches per plant**

One of the cross combination (Hissar Shakti x PMR 21) had significant and positive additive (d) effects for number of primary branches. Whereas, two crosses Hissar Shakti x PMR 21 and Dabbi x LCA 312 showed significant dominance (h) effect. The additive x additive (i) interaction effects were significant in Hissar Shakti x PMR 21 (9708) cross in positive direction. Significant additive x additive (i) effects were observed in 9632 and 9623 crosses in positive directions. In general, dominance x dominance (l) and dominance (h)

**Table 4. Estimates of gene effects for 13 characters in five crosses in chilli**

Cross	M (mean)	D (Add)	H (Dom)	(Add X Add) I	(Dom x Dom) L	Type of epitasis
<b>Plant height (cm)</b>						
VN-2 X Jwala (9632)	59.52 ±0.89	12.60 ±3.34**	-24.43 ±4.60	5.96 ±8.19	22.77 ±15.63	D
VN-2 X Arkalohit (9646)	57.53 ±0.71	9.50 ±2.94**	-5.34 ±2.75	14.55 ±6.49*	26.94 ±9.78**	D
Hissar shakti X PMR 21 (9708)	57.50 ±0.55	0.80 ±2.20	6.66 ±2.94	3.08 ±5.61*	2.66 ±17.45*	C
Kaddi X Arkalohit (9612)	59.21 ±0.81	1.19 ±2.69	-5.13 ±2.26	-13.13 ±4.64	21.41 ±7.69**	D
Dabbi X LCA 312 (9623)	60.15 ±0.53	6.40 ±4.12	-2.95 ±3.61	10.64 ±9.96	3.68 ±13.39	D
<b>Number of primary branches per plant</b>						
VN-2 X Jwala (9632)	2.53 ±0.05	-0.40 ±0.18	-1.84 ±0.27	-2.44 ±0.38	3.17 ±0.87**	D
VN-2 X Arkalohit (9646)	2.52 ±0.05	0.20 ±0.20	-0.97 ±0.27	0.22 ±0.47	-0.15 ±0.98	C
Hissar shakti X PMR 21 (9708)	2.75 ±0.05	0.40 ±0.17*	0.90 ±0.22**	1.90 ±0.37**	-1.60 ±0.73	D
Kaddi X Arkalohit (9612)	2.51 ±0.05	0.10 ±0.27	-0.49 ±0.23	-0.39 ±0.54	0.51 ±0.81	C
Dabbi X LCA 312 (9623)	2.61 ±0.05	-0.50 ±0.26	0.80 ±0.22**	-1.29 ±0.37	3.14 ±0.73**	D
<b>Number of secondary branches per Plant</b>						
VN-2 X Jwala (9632)	5.54 ±0.12	-0.40 ±0.47	-1.22 ±0.70	-3.0 ±1.15	7.47 ±2.58**	D
VN-2 X Arkalohit (9646)	4.06 ±0.09	0.30 ±0.31	-1.97 ±0.48	1.12 ±0.69*	-2.32 ±1.66	C
Hissar shakti X PMR 21 (9708)	5.23 ±0.09	0.30 ±0.37	1.96 ±0.53**	1.86 ±0.88*	0.72 ±2.02	C
Kaddi X Arkalohit (9612)	5.53 ±0.12	0.40 ±0.53	0.87 ±0.45*	2.69 ±1.09*	-5.50 ±1.56**	D
Dabbi X LCA 312 (9623)	5.36 ±0.10	-0.40 ±0.50	1.63 ±0.43**	-1.76 ±0.836	4.87 ±1.46**	C

Contd..

Contd..

Cross	M (mean)	D (Add)	H (Dom)	(Add X Add) I	(Dom x Dom) L	Type of epistasis
<b>Leaf curl index (LCI)</b>						
VN-2 X Jwala (9632)	12.60 ±0.092	-0.80 ±0.20	0.50 ±0.37	-1.69 ±0.50	-0.22 ±1.31	D
VN-2 X Arkalohit (9646)	20.66 ±0.05	-0.30 ±0.22	0.27 ±0.25	-0.42 ±0.49	-2.41 ±0.77	D
Hissar shakti X PMR 21 (9708)	26.79 ±0.06	0.50 ±0.22*	0.67 ±0.31*	2.17 ±0.49**	-0.52 ±1.04	D
Kaddi X Arkalohit (9612)	28.97 ±0.07	1.00 ±0.30**	-2.22 ±0.40	-0.02 ±0.54	6.95 ±1.34**	D
Dabbi X LCA 312 (9623)	36.60 ±0.09	0.80 ±0.37*	1.08 ±0.31**	3.48 ±0.86**	-6.97 ±1.08	D
<b>Number of fruits per plant</b>						
VN-2 X Jwala (9632)	28.10 ±2.68	-42.60 ±8.0**	-48.60 ±36.30*	48.40 ±18.60*	-56.40 ±26.50	D
VN-2 X Arkalohit (9646)	40.60 ±5.79	-36.50 ±12.0*	90.50 ±26.50	95.40 ±36.49*	72.59 ±45.73	C
Hissar shakti X PMR 21 (9708)	37.50 ±19.50	-26.50 ±4.8	52.60 ±18.00	47.50 ±14.50	18.60 ±12.50	D
Kaddi X Arkalohit (9612)	50.30 ±6.19	-17.40 ±4.95	189.90 ±34.18*	64.80 ±26.69*	189.90 ±34.18*	C
Dabbi X LCA 312 (9623)	50.70 ±6.31	-11.40 ±7.01*	-37.30 ±25.80	-44.0 ±25.26	2.19 ±19.5	D
<b>Fruit girth (mm)</b>						
VN-2 X Jwala (9632)	11.75 ±0.454	1.139 ±0.502**	0.129 ±2.40	-0.319 ±2.07	15.81 ±0.615**	C
VN-2 X Arkaiohit (9646)	11.95 ±0.97	4.67 ±2.610	2.43 ±3.60	2.80 ±3.40	6.13 ±5.09	D
Hissar shakti X PMR 21 (9708)	9.65 ±0.58	4.65 ±4.12	6.10 ±4.80	3.60 ±2.80	8.10 ±3.60**	D
Kaddi X Arkalohit (9612)	8.20 ±1.31	2.60 ±0.69**	-3.60 ±1.80	-3.81 ±2.10	5.83 ±2.71	D
Dabbi X LCA 312 (9623)	10.60 ±2.60	2.823 ±0.414**	-6.82 ±2.89	-8.47 ±3.7**	11.98 ±3.44**	D

Contd..

Contd..

Cross	M (mean)	D (Add)	H (Dom)	(Add X Add) I	(Dom x Dom) L	Type of epitasis
<b>Per/carp weight per fruit (gm)</b>						
VN-2 X Jwala (9632)	5.16 ±0.61	1.71 ±0.81	-6.806 ±2.60	-4.08 ±0.86*	9.03 ±3.64*	D
VN-2 X Arkalohit (9646)	5.90 ±0.81	2.62 ±0.86**	-2.91 ±2.61	-2.09 ±1.96	4.81 ±2.94	D
Hissar shakti X PMR 21 (9708)	4.61 ±2.01	5.86 ±2.30*	-6.31 ±3.68	-4.81 ±2.60*	5.6 ±3.10	D
Kaddi X Arkalohit (9612)	4.12 ±0.81	0.56 ±0.28	-3.60 ±1.80	-1.80 ±1.02	0.01 ±1.60	D
Dabbi X LCA 312 (9623)	4.60 ±0.91	-0.28 ±0.18	-2.86 ±0.96**	-2.64 ±1.2*	3.02 ±1.62**	D
<b>Fruit Length (cm)</b>						
VN-2 X Jwala (9632)	11.35 ±0.16	-0.30 ±0.41	-0.81 ±0.46	-3.11 ±0.73	1.02 ±1.51	D
VN-2 X Arkalohit (9646)	8.5 ±0.10	-0.50 ±0.32**	2.78 ±0.35	0.28 ±0.54	678 ±1.16**	C
Hissar shakti X PMR 21 (9708)	7.09 ±0.08	0.95 ±0.31**	-1.15 ±0.38	1.70 ±0.58**	1.77 ±1.22	D
Kaddi X Arkalohit (9612)	11.99 ±0.21	1.20 ±0.35**	1.40 ±0.57*	3.20 ±0.81**	-1.99 ±2.09	D
Dabbi X LCA 312 (9623)	8.56 ±0.08	1.00 ±0.36*	0.28 ±0.35	3.48 ±0.70**	-2.01 ±1.03	D
<b>Stalk length (cm)</b>						
VN-2 X Jwala (9632)	3.92 ±0.05	0.65 ±0.10**	0.36 ±0.18*	1.49 ±0.27**	-0.74 ±0.58	D
VN-2 X Arkalohit (9646)	3.30 ±0.04	0.60 ±0.17**	-0.99 ±0.17	0.54 ±0.40**	4.99 ±0.49**	D
Hissar shakti X PMR 21 (9708)	2.37 ±0.02	-0.02 ±0.11	0.15 ±0.14	-0.12 ±0.20	2.76 ±0.44**	C
Kaddi X Arkalohit (9612)	4.01 ±0.02	-0.09 ±0.07	-0.08 ±0.11	-0.21 ±0.18	-0.93 ±0.35	C
Dabbi X LCA 312 (9623)	2.85 ±0.03	0.05 ±0.12	-0.15 ±0.15	0.69 ±0.27**	-0.88 ±0.51	C

Contd..

Contd..

Cross	M (mean)	D (Add)	H (Dom)	(Add X Add) I	(Dom x Dom) L	Type of epitasis
<b>1000 seed weight (gm)</b>						
VN-2 X Jwala (9632)	5.10 ±0.09	1.58 ±0.15**	0.80 ±0.35*	4.03 ±0.49**	-1.47 ±1.25	D
VN-2 X Arkalohit (9646)	5.21 ±0.07	1.23 ±0.15**	2.89 ±0.31**	4.88 ±0.46**	-4.64 ±1.10	D
Hissar shakti X PMR 21 (9708)	4.25 ±0.04	-0.06 ±0.07	0.06 ±0.24	-2.33 ±0.25	7.31 ±0.72**	C
Kaddi X Arkalohit (9612)	4.08 ±0.05	0.23 ±0.14*	0.78 ±0.31**	0.63 ±0.46	0.80 ±1.21	C
Dabbi X LCA 312 (9623)	5.69 ±0.07	0.19 ±0.27	3.02 ±0.30**	1.41 ±0.63*	-0.90 ±1.13	D
<b>Number of Seeds per Fruit</b>						
VN-2 X Jwala (9632)	95.38 ±1.21	13.30 ±2.73**	13.84 ±3.66**	29.34 ±6.37**	-82.83 ±11.79	D
VN-2 X Arkalohit (9646)	71.08 ±1.08	9.39 ±2.95**	5.45 ±3.17	-1.34 ±6.44**	98.77 ±10.83	C
Hissar shakti X PMR 21 (9708)	67.78 ±0.61	-1.90 ±2.05	-27.55 ±3.43	-35.45 ±4.86	59.16 ±10.21**	D
Kaddi X Arkalohit (9612)	82.71 ±0.83	-2.70 ±2.55	10.19 ±2.88**	10.69 ±4.08**	-107.26 ±8.62	D
Dabbi X LCA 312 (9623)	83.65 ±0.70	1.77 ±1.98	13.82 ±3.66**	20.42 ±4.64**	-44.67 ±12.68	D
<b>Fruit weight (gm)</b>						
VN 2 X Jwala (9632)	5.16 ±0.10	2.80 ±0.35**	-4.64 ±0.40	0.09 ±0.86	11.97 ±1.20**	D
VN-2 X Arkalohit (9646)	4.13 ±0.04	2.01 ±0.23**	-3.59 ±0.23	0.25 ±0.53	14.39 ±0.64**	D
Hissar shakti X PMR 21 (9708)	5.13 ±0.06	-0.80 ±0.18	0.54 ±0.26*	-2.03 ±0.33	1.07 ±0.89	C
Kaddi X Arkalohit (9612)	6.99 ±0.09	2.51 ±0.17**	1.42 ±0.44**	4.57 ±0.56**	1.55 ±1.52	C
Dabbi X LCA 312 (9623)	7.81 ±0.12	1.43 ±0.53**	3.72 ±0.49**	9.35 ±0.91**	-5.34 ±1.85	D

Contd..

Contd..

Cross	M (mean)	D (Add)	H (Dom)	(Add X Add) I	(Dom x Dom) L	Type of epistasis
<b>Dry fruit yield per plant (gm)</b>						
<b>VN-2 X Jwala (9632)</b>	73.34 ±1.37	7.10 ±2.25**	-2.07 ±4.59	-13.97 ±5.76	48.35 ±14.37**	D
<b>VN-2 X Arkalohit (9646)</b>	67.02 ±1.04	11.90 ±2.72**	39.51 ±3.30**	38.81 ±6.08**	-49.53 ±11.70	D
<b>Hissar shakti X PMR 21 (9708)</b>	64.21 ±1.01	4.60 ±2.31*	-9.39 ±4.67	-21.39 ±5.86	8.34 ±4.87	D
<b>Kaddi X Arkalohit (9612)</b>	62.81 ±1.29	5.5 ±3.49	10.48 ±4.71*	3.18 ±8.25	-36.26 ±16.77	D
<b>Dabbi X LCA 312 (9623)</b>	69.05 ±1.13	-20.20 ±2.85	32.8 ±4.54**	-27.90 ±6.31	2.93 ±12.87	C

gene interaction were more prevalent in the crosses studied. The crosses VN-2 x Arka lohit (9646) and Kaddi x Arkalohit (9612) expressed complimentary, while other crosses had duplicate type of epistasis.

#### **4.2.1.3 Number of secondary branches per plant**

None of the crosses were found significant for additive (d) gene effects and dominance (h) effect was significant in the crosses 9608, 9612 and 9623 in positive direction. 9632, 9612 and 9623 crosses exhibited dominance x dominance (l) gene interactions. 9646, 9708 and 9612 crosses showed additive x additive (i) gene effects in positive direction. Majority of the crosses were under the control of dominance (h) and the magnitude of the additive x additive (i) was more compared to other types of gene interaction effects. The crosses VN-2 x Jwala and Kaddi x Arkalohit had duplicate type of epistasis whereas, other three crosses i.e., 9646, 9708 and 9623 had complimentary epistasis.

#### **4.2.1.4 Leaf curl index (LCI)**

9708, 9612 and 9623 crosses showed significant additive (d) gene effects, in positive direction. Two crosses i.e., 9708 and 9623 noticed significant positive dominance (h) gene effects. The magnitude of dominance (h) was more compared to additive (d) gene effects. Additive x additive (i) gene interaction were significant in positive directions for two crosses viz., Hissar Shakti x PMR 21 and Dabbi x LCA 312. Only one cross Kaddi x Arkalohit had exhibited

highest and significant dominance x dominance (l) interaction. All the crosses studied recorded duplicate type of epistasis.

#### **4.2.1.5 Fruit length (cm)**

Different type of gene effects prevailing for fruit length are depicted in Table. Among four hybrids i.e., 9646, 9708, 9612 and 9623 shown significant additive gene (d) effect three were in positive direction and 9646 in negative direction. Significant dominance (h) gene effects were observed in Kaddi x Arkalohit hybrid in positive direction. Additive x additive (i) gene effects were significant in 9708, 9612 and 9623 crosses and all were in positive direction. Among five hybrids only one hybrid i.e., 9646 had exhibited significant dominance x dominance (l) genic interaction in positive direction. Majority of the hybrids were governed by additive (d) or additive x additive gene interaction. Only the cross VN-2 x Arkalohit (9646) showed complimentary epistasis for fruit length.

#### **4.2.1.6 Number of fruits per plant**

Three crosses i.e., 9632, 9646 and 9623 showed negative and significant additive gene (d) effects. And among the dominance (h) gene effects, 9632 cross is showing negative significant effect and another 9612 is showing positive significant dominance (h) gene effect. The magnitude of dominance (h) was more compared to additive (d) gene effects. Additive x additive (i) gene interaction were significant in 9632, 9646 and 9612 crosses. Only one cross Kaddi x Arkalohit had exhibited highest and significant dominance x

dominance (l) interaction. Three crosses i.e., 9632, 9708 and 9623 recorded duplicate and two crosses i.e., 9646 and 9612 noticed complimentary epistasis respectively.

#### **4.2.1.7 Fruit girth (mm)**

Additive gene (d) effect was significant and positive in 9632, 9612 and 9623 crosses. One cross viz., Dabbi x LCA 312 showed significant negative dominance (h) effect. The crosses Dabbi x LCA 312 showed significant negative additive x additive (h) genic interaction. While 3 crosses showed significant dominance x dominance (l) genic interaction effect of which all were in positive direction. The magnitude of dominance x dominance (l) interaction was more compared to other gene effects, complimentary epistasis was observed in 9632 cross and others exhibited duplicate epistasis.

#### **4.2.1.8 Pericarp weight per fruit (g)**

With regard to gene action for pericarp weight for fruit, additive (d) gene effect was observed in 9646 and 9708 crosses in positive direction. The crosses Dabbi x LCA 312 recorded negative and significant dominance (h) effect. 9632, 9708 and 9623 hybrids showed significant additive x additive (i) gene interaction in negative direction. Dominance x dominance (l) type of gene interaction was found to be significant and positive in 9632 and 9623 crosses. Majority of the crosses had additive type of gene effect. All the crosses had shown duplicate epistasis for this trait.

#### **4.2.1.9 Stalk length**

Additive (d) gene effects were significant in two crosses viz., VN-2 x Jwala (9632) and 9646. One cross recorded significant dominance (h) effects for stalk length in positive direction. The crosses 9646 and 9708 had significant dominance x dominance (l) interaction in positive direction. Three crosses i.e., 9632, 9646 and 9623 have shown significant additive x additive (i) interaction in positive direction. Majority of the crosses were under the control of additive (d), dominance x dominance (l) and additive x additive (i) type of genic interaction. 9708, 9612 and 9623 crosses recorded complimentary and 9632 and 9646 crosses noticed duplicate epistasis respectively.

#### **4.2.1.10 1000 seed weight**

Additive (d) gene effects were significant in 9632, 9646 and 9612 crosses, dominance (h) gene effects were observed in all crosses except 9708 in positive direction. 9632, 9646 and 9623 hybrids had exhibited additive x additive (i) gene interaction. One hybrid Hissar Shakti x PMR 21 (9708) showed significant and positive dominance x dominance (l) interaction. Majority of the crosses had additive (d) type of gene effects. The crosses 9708 and 9612 had complimentary epistasis, while others expressed duplicate type of genic interaction.

#### **4.2.1.11 Number of seeds per fruit**

Significant additive (d) gene effect was observed in 9632 and 9646 crosses in positive direction. The crosses 9632, 9612 and

9623 had significant and positive dominance (h) effect. Only the cross 9708 had dominance x dominance (l) gene effect in positive direction. All the crosses except 9708 showed significant additive x additive (i) gene effect. Majority of the crosses showed additive x additive (i) type of genic interaction. The cross 9646 had complimentary epistasis while others expressed duplicate type of interaction.

#### **4.2.1.12 Fruit weight (g)**

It could be observed from table that all crosses except 9708 exhibited positive and significant additive (d) gene effects. 9708, 9612 and 9623 crosses exhibited significant and positive dominance gene (h) effects. Two crosses 9612 and 9623 showed significant additive x additive (i) gene interaction in positive direction. Two crosses 9632 and 9646 showed positive and significant dominance x dominance (l) gene interaction effects. Additive (d) and dominance (h) gene interaction effects were predominant in majority of the crosses. Complimentary type of gene interaction effect was recorded in 9708 and 9612 cross, while other crosses showed duplicate epistasis.

#### **4.2.1.13 Dry fruit yield per plant**

Three crosses 9632, 9646 and 9708 showed significant additive gene effect (d) in positive direction. Dominance (h) gene effect was significant in 9646, 9612 and 9623 crosses in positive values. Additive x additive (i) gene interaction was significant and positive in 9646 cross. Cross 9632 showed significant for dominance x

dominance (l) gene interaction. Duplicate type of epistasis was observed in all the crosses except 9623 which had complimentary epistasis.

#### **4.2.2 Estimation of scaling test**

The existence of non allelic gene interactions (epistasis) was detected based on the study of scaling tests (C and D). The significance of C scale alone indicate the presence of additive x additive (i) type of non-allelic gene interaction and the significance of D alone was indicated the presence of dominance x dominance (l) gene interaction. But the significance of both C and D scales indicated the existence of both additive x additive (i) and dominance x dominance (l) type of non allelic gene interactions. If none of the scaling tests showing the significance was noticed then it was considered as the absence of non allelic gene interactions (Hayman and Mather, 1955). Based on the above assumption it was found that epistatic gene interaction was operating for most of the characters under study (Table 5).

#### **4.3 Identification of superior genotypes in segregating population of the five crosses used in study.**

##### **4.3.1 Identification of superior genotypes in F<sub>2</sub> populations of five crosses**

In the present investigation, the superior genotypes were scored in F<sub>2</sub> populations for dry fruit yield per plant, 1000 seed weight and disease resistance for leaf curl complex on the basis of

**Table 5. Estimates of C and D values by Mather's scaling test for various characters in chili**

Character	9632				9612				9623				9646				9708			
	C	SEm	D	SEm	C	SEm	D	SEm	C	SEm	D	SEm	C	SEm	D	SEm	C	SEm	D	SEm
Plant height	15.70**	12.18**	32.78**	8.11	9.65	6.7	9.00	7.25	0.62	12.56	3.38	8.64	-18.05*	8.57	2.15	6.45	-5.82	8.96	-3.68	5.19
No. of primary branches	0.12	0.65	2.50*	0.48	0.67	0.76	1.06*	0.59	-2.55**	0.69	-0.19	0.58	0.50	0.77	0.38	0.46	-0.60	0.56	-1.80**	0.42
No. of secondary branches	-3.02	2.02	2.57	1.10	1.75	1.42	-2.37*	1.17	-2.94*	1.34	0.70	1.10	1.27	1.26	-0.47	0.78	-3.25*	1.59	-2.70**	0.85
Leaf curl index	0.42	0.92	0.25	0.54	-2.9**	1.05	2.31**	0.74	3.19**	0.97	-2.03**	0.82	2.07**	0.63	0.26	0.54	-1.82*	0.81	-2.22**	0.55
Fruit length	4.00**	1.11	4.76**	0.99	0.37	1.35	-1.12	0.93	-0.94	0.89	-2.45**	0.85	-9.35**	0.91	-4.25**	0.76	-1.3	0.98	-0.007	0.76
Stalk length	0.35	0.37	-0.19	0.29	0.99**	0.25	0.29	0.20	-0.30	0.41	-0.97**	0.30	-3.68**	0.42	0.06	0.41	2.59**	0.34	-0.52*	0.27
1000 seed weight	-0.26	0.89	-1.37**	0.45	-1.15	0.90	-0.55*	0.35	-1.16	0.93	-1.84**	0.59	-0.20	0.72	-3.69**	0.43	2.88**	0.451	2.59	0.33
No. of seed weight	77.34**	8.03	15.22*	7.10	75.07**	6.24	-5.37	6.01	11.02	9.28	-2.29**	5.27	58.47**	8.32	15.60**	6.92	4.14	7.22	48.52**	5.85
Fruit weight	-0.96	0.92	8.01**	0.87	-0.70	1.03	0.45	0.55	-7.63**	1.63	-11.64**	1.14	6.86	0.56	3.93	0.57	-0.20	0.67	0.59	0.44
Dry fruit yield/plot	7.99	0.52	44.20**	7.27	51.07**	12.00	24.09**	0.32	-27.7**	0.32	-25.59	0.28	19.50**	0.03	17.05**	0.41	52.05	9.90	59.10**	7.11
No. of fruit/plot	86.50**	23.62	38.60	16.50	98.80**	17.50	-37.50*	8.60	-36.50	12.50	-3.00**	8.60	-10.6**	28.60	28.50**	6.50	26.50	21.50	-18.50	12.50
Per carp wt/fruit	2.14	1.88	2.54**	0.86	2.36*	0.86	1.86**	0.58	-1.40	0.76	0.17	0.42	5.30	2.38	1.08	0.96	3.60	2.60	2.10	1.60
Fruit girth	-8.60**	2.6	1.60	0.86	4.10**	42.60	3.1	1.80	-1.80	0.98	0.68	0.54	4.73**	2.16	1.08	0.96	4.60*	1.80	-2.3	1.80

\* Significant at 5% level

\*\* Significant at 1% level

their better performance than the check G<sub>3</sub> variety, The number of progenies and their percentage for dry fruit yield per plant, 1000 seed weight with disease resistance and common for all three characters are presented in Table 5.

#### **4.3.1.1 Dry fruit yield per plant (g)**

Among the five populations, the highest number of superior progenies for dry fruit yield per plant were observed in the progenies of cross VN-2 x Jwala (72), followed by the progenies of cross Dabbi x LCA 312 (47) and cross VN-2 x Arkalohit (36).

#### **4.3.1.2 1000 seed weight (g)**

Highest number of superior progenies for 1000 seed weight were observed in the progenies of cross Dabbi x LCA 312 (63) followed by the progenies of cross VN-2 x Jwala (52) and cross Hissar Sahkti x PMR 21 (48).

#### **4.3.1.3 Resistant for leaf curl complex**

Highest number of resistant plants were recovered from the progenies of cross VN-2 x Jwala (48) followed by the progenies of the cross Hissar Shakti x PMR 21 (36) and cross VN-2 x Arkalohit (34).

#### **4.3.1.4 Superior genotypes for all the above 3 characters**

Highest number of progenies with superior performance for all the three characters i.e., higher dry fruit yield per plant, higher 1000 seed weight and disease resistant for leaf curl complex

**Table 6. Frequency of superior progenies obtained form segregating (F<sub>2</sub>) generation in five crosses studied**

<b>Progenies</b>	<b>Total No. of individuals</b>	<b>Dry fruit yield per plant</b>	<b>1000 seed weight</b>	<b>Disease resistant plants</b>	<b>No. of plants common to all the character</b>
<b>Check variety (G<sub>3</sub>) mean</b>		75 (gm)	5.4 (gm)	Disease resistant	
<b>VN-2 X Jwala (9632)</b>	104	72 (45.0)	52 (32.5)	48 (30.0)	34 (21.25)
<b>VN-2 X Arka lohit (9646)</b>	64	36 (22.5)	48 (30.0)	34 (21.25)	27 (16.8)
<b>Hissar Shakti X PMR 21(9708)</b>	52	21 (13.1)	29 (18.12)	36 (22.50)	17 (22.5)
<b>Kaddi X Arkalohit (9612)</b>	65	30 (18.75)	9 (5.6)	47 (29.5)	07 (4.3)
<b>Dabbi X LCA 312 (9623)</b>	111	47 (29.373)	63 (39.3)	31 (19.37)	15 (9.375)

n= number of plants.

values in parenthesis are percentage of superior plants

were recovered in the cross VN-2 x Jwala (34), followed by the cross VN-2 x Arkalohit (27) and Hissar Shakti x PMR 21 (17).

#### **4.3.2 Identification of superior genotypes in F<sub>3</sub> populations in five crosses**

The superior genotypes were scored in F<sub>3</sub> populations for dry fruit yield per plant, 1000 seed weight and disease resistance for leaf curl virus disease on the basis of their performance than the check G<sub>3</sub> variety. The number of progenies and their percentage for dry fruit yield per plant, 1000 seed weight with disease resistance and common for all three characters are presented in Table 7.

##### **4.3.2.1 Dry fruit yield per plant (g)**

Among the five populations of F<sub>3</sub> generation, the highest number of superior progenies for dry fruit yield per plant was observed in the progenies of cross VN-2 x Jwala (56.6%) followed by the progenies of cross Dabbi x LCA 312 (34.16%) and Kaddi x Arkalohit (31.66%).

##### **4.3.2.2 1000 seed weight (g)**

Highest number of superior progenies for 1000 seed weight was observed in the progenies of the cross Dabbi x LCA 312 (45.83%) followed by the progenies of cross VN-2 x Jwala (40.83%).

##### **4.3.2.3 Resistant for leaf curl complex**

Highest number of resistant plants were recovered from the progenies of cross VN-2 x Jwala (42.5%) followed Kaddi x Arkalohit (38.33%) and Hissar Shakti x PMR 21 (31.66%).

**Table 7. Frequency of superior progenies obtained form segregating (F<sub>3</sub>) generation in five crosses studied**

<b>Progenies</b>	<b>Total No. of individuals</b>	<b>Dry fruit yield per plant</b>	<b>1000 seed weight</b>	<b>Disease resistant plants</b>	<b>No. of plants common to all the character</b>
<b>Check</b>			5.4 (gm)	Disease resistant	
<b>VN-2 X Jwala (9632)</b>	98	68 (56.6)	41 (40.83)	51 (42.5)	35 (29.16)
<b>VN-2 X Arka lohit (9646)</b>	66	31 (25.8)	49 (40.83)	36 (30.0)	25 (20.83)
<b>Hissar Shakti X PMR 21(9708)</b>	54	23 (19.16)	31 (25.8)	38 (31.66)	19 (15.83)
<b>Kaddi X Arkalohit (9612)</b>	76	38 (31.66)	8 (6.66)	46 (38.33)	18 (15.00)
<b>Dabbi X LCA 312 (9623)</b>	96	41 (34.16)	55 (45.83)	32 (26.66)	17 (14.16)

values in parenthesis are percentage of superior plants

#### **4.3.2.4 Superior genotypes for all the above three characters**

Highest number of progenies with above three desirable characters i.e., higher dry fruit yield per plant, higher 1000 seed weight and disease resistant for leaf curl complex disease were recovered in the cross VN-2 x Jwala (29.16%) followed by VN-2 x Arkalohit (20.83%) and Hissar Shakti x PMR 21 (15.83%).

*Discussion*

---

## **V. DISCUSSION**

Karnataka has the highest area under chilli cultivation in India, but the productivity is very low (268-300kg/ha) compared to that of national average (Jagadeesha 2000). The low yield is attributed to prevalence of leaf curl complex and non-availability of high yielding disease resistant varieties and hybrids. So there is a need of constant and continued research efforts to increase the productivity. The challenge would be to develop variety/hybrid that respond well to resources with resistance to leaf curl complex. Genetic improvement can be made through hybrids by incorporation of disease or pest resistance without losing quality attributes. Meagre attempts have been made in this direction. Another approach would be the identification of resistant sources and incorporation of resistant genes into the native lines without losing the quality traits. The development of multiple resistant variety is one of the eco-friendly means of reducing the crop loss (Prabhu and Jagadeesha 1998).

Investigation was undertaken in chilli with a view to obtain information on gene effects particularly on epistasis involved in the inheritance of different traits. The precise knowledge of the nature of gene action for characters related to productivity helps in the choice of breeding methods to accelerate the pace of genetic improvement. The study also aimed at eliciting information on the nature of inheritance of leaf curl disease in the material studied as

it is an important biotic constraint causing considerable yield losses.

The economic characters in chilli are under the control of polygenes and hence the analysis of such characters requires a separate biometrical approach (Singh and Choudhary, 1997). Among the various methods available for study of quantitative inheritance, the generation mean analysis (Hayman, 1958b) was chosen in the present study as it precisely estimates types of gene effects viz., additive, dominance and epistasis.

### **5.1 Generation mean analysis**

Generation mean analysis is a potential tool for determining the magnitude and type of epistasis besides main gene effects. This was carried out in the crosses VN-2 x Jwala, VN-2 x Arkalohit, Hissar Shakti x PMR 21, Kaddi x Arkalohit and Dabbi x LCA 312 for 13 growth and yield parameters.

All the three gene effects, additive, dominance and epistasis were important in the control of plant height, number of primary branches, number of secondary branches, leaf curl index (LCI), fruit length, stalk length, 1000 seed weight, number of seeds per fruit, fruit weight and dry fruit weight per plant. The importance of additive and non additive effects in the inheritance of growth and yield parameters of the chilli was also reported by Milkova (1984), Thakur (1987) and Jagadeesha (2000).

### **5.1.1 Plant height (cm)**

9632 and 9646 crosses showed predominance of additive (d) gene effect. The magnitude of dominance gene effect (h) and dominance x dominance (l) was quite high indicating the predominance of dominance effects and epistasis. Similar results were reported by Sharma and Talukdar (1998), Meshram and Mukewar (1986), Arnonben Chaim and Ilan Paran (2000), Saraladevi and Arumugam (1999), Khadi (1983) and Thakur (1987). Jadhav and Dhumal (1994) reported that both additive and non additive gene effects were important. Since plant height was predominantly under the control of non additive gene effects with duplicate type of gene interaction it is obvious that selection should be effected in later generations.

### **5.1.2 Number of primary branches**

9632 and 9623 crosses were under the control of dominance x dominance (l). The magnitude of (l) component was more compared to others with duplicate type of epistasis.

Primary branches having high magnitude of (l) component indicated the predominance of non additive gene effects. The prevalence of duplicate type of gene interaction was seen which is expected to hinder the progress in selection. So selection should be delayed to later generations. These results are in confirmation with the earlier findings of Saraladevi and Arunugam (1999),

Lohithashwa *et al.* (1999), Gadagimath (1992) and Pandian and Shanmugavelu (1992).

### **5.1.3 Number of secondary branches**

For this character, 9632,9612,and9623 crosses showed predominance of dominance x dominance (I) gene action. The high magnitude of (I) component indicated the predominance of non additive gene effects. The prevalence of duplicate type of gene interaction was also seen which would hinder the progress in selection. So selection should be delayed to later generation till the fixation of sufficient epistatic interaction. Similar results were noticed by Saraladevi and Arumugam (1999), Lohitashwa *et al.* (1999), Gadagimath (1992) and Pandian and Shanmugavelu (1992).

### **5.1.4 Leaf curl index**

Scaling tests revealed the operation of epistasis for leaf curl complex indicating the role of non allelic interaction for the manifestation of resistance. The additive gene effects were significant and negative in two crosses. Negative values for resistance are required to reduce the incidence. The role of additive gene effects for imparting resistance is observed. Additive gene effects were predominant in crosses 9632, 9612 and 9623.

Among the interaction components, the contribution of additive x additive gene effects had a significant role in the inheritance. When both resistant parents are involved in the cross viz., VN-2 x Jwala, additive type gene effects was prevailing. When

both the parents have resistance, the level of resistance increased. Duplicate type of epistasis was noticed in majority of the crosses. It is advisable to go for recurrent selection programme .

#### **5.1.5 Fruit length(cm)**

The gene action was conspicuously additive (d) and additive x additive (i) in the expression of this character. This revealed that the trait is governed by additive genes. The cross VN-2 x Arkalohit (9646) exhibited complimentary epistasis whereas others showed duplicate epistasis. This observation is in agreement with previous studies of Arnonben Chaim and Ilan Paran (2000), Jadhav and Dhumbal (1994), Krishnamurthy and Deshpande (1997) and Jagadeesha (2000).

#### **5.1.6 Stalk length**

Additive gene effects were non significant in 9708, 9612 and 9623. However, additive x additive (i) interactions were predominant. Complimentary epistasis was predominant in many of the crosses. Similar results were reported by Singh and Singh (1976) and Jagadeesha (2000).

#### **5.1.7 Number of fruits per plant**

Additive (d), dominance (h) and additive x additive (i) gene effects prevailed in the expression of this character and both duplicate and complimentary type of epistasis also prevailed. The magnitude of (d) was less than (h) indicating that fruits per plant is

governed mainly by dominance gene effects. The contribution of additive genes as indicated by the presence of significant additive x additive interaction (i) was also observed. Similar results were observed by Lohitashwa *et al.* (1999), Sharma and Talukdar (1999), Jadhav and Dhum al (1994) and Krishnamurthy and Deshpande (1997). Therefore selection for this character has to be delayed till the dominance gets dissipated with selfing in advanced generations.

#### **5.1.8 Fruit girth(mm)**

The study of gene effects confirmed the importance of additive (d) and dominant x dominant (l) gene effects in the crosses studied. Both duplicate and complimentary types of epistasis were predominant thereby indicating that this trait is controlled by dominance effects. Krishnamurthy and Deshpande (1997), Saraladevi and Arumugam (1999), Jagadeesha (2000) and Arnon-ben Chaim and Ilan-Pavan (2000) also recorded similar results. Hence for improving this character selection in segregating generation could be followed.

#### **5.1.9 Pericarp weight (g)**

The main purpose in chilli improvement is to combine maximum dry fruit yield with maximum pericarp content of fruit. This is based on the value of the extractable carotenoids as a natural food colouring and these carotenoids are concentrated in the endocarp (Martin and Lippert, 1975).

Endocarp (pericarp) comprises approximately 55-58 per cent of the total dry weight, seed 29-40 per cent of seed weight, 6-10 per cent of pedicel and 4-5 per cent of placenta. Increase in endocarp per cent are generally associated with a decrease in seed content.

Additive (d) and additive x additive (i) gene effect was observed for this trait indicating the important role for the expression of this trait. Similar reports were obtained by Martin and Lippert (1975) and Sharma and Saini (1977). Duplicate type of epistasis was observed in all the crosses as they had (h) and (l) with opposite signs. Hence, pedigree selection breeding procedure would be much more effective for improving the economically important traits of chilli.

#### **5.1.10 Seed related traits**

Many of the crosses showed additive gene effects for number of seeds per fruits. Both additive (d) and additive x additive (i) type of gene effects was also observed and the majority of the crosses had duplicate type of genic interaction for this character. This inferred that this character is governed by additive genes.

1000 seed weight is governed by additive (d), dominance (h) and additive x additive (i) type of gene effect. The magnitude of the non additive type of gene effects was less. Majority of the crosses had duplicate type of gene effects.

Since all seed related traits were controlled by the additive gene effects, selection in segregating materials can be followed towards negative direction in order to increase the

corresponding increase in the pericarp area or weight. To improve seed related traits, hybridization followed by selection in segregation generation can be adopted. Singh and Singh (1976) reported both additive and non-additive gene effects for seed portion.

#### **5.1.11 Dry fruit yield per plant**

The present investigation revealed the importance of dominance gene effects (d) in the inheritance of this trait. Higher magnitude of dominance gene effect was observed as compared to additive gene effect. Among the interaction components, additive x additive (i) was more predominant than other types of interactions. Majority of the crosses showed duplicate type of epistasis.

Although the dominance gene effects were present, it cannot be exploited because of the opposite signs of h and l in all the crosses except in 9623. Whenever, these gene effects (h and l) co-existed it indicates the presence of duplicate epistasis. But, the contribution made by additive genes cannot be neglected. Earlier studies also indicated the complexity of inheritance of these yield component characters. Sharma and Talukdar (1998) and Pandian and Shanmugavelu (1992) obtained similar results, while Lohitashwa *et al.* (1999) reported the existence of over dominance. Ozo (1984) reported significant hybrid vigour, Jadhav and Dhumal (1994) also reported the dominance gene effects.

Heterosis breeding in this crop is feasible because of prevalence of the high magnitude of non additive gene effects for

most of the characters studied. Dominance (h) gene effect was significant and additive x additive (i) component were observed, which suggests that the selection for yield would be delayed in later generations till dominance and epistatic components are reduced due to selfing. This would warrant the exploitation of fixable and non fixable variations through additional cycles of intermating in segregating generations.

The generation mean analysis has brought out that individual crosses greatly differ for the gene action and on an overall basis all the types of gene action, additive, dominance and epistasis are important. The latter two types predominating for many characters thereby indicating that epistasis cannot be ignored. Similar conclusions have been reported by Zuberi *et al.* (1972) in *Brassica* species, Singh (1980) in peas, Fawole *et al.* (1982) in dry beans, Wilson and George (1983) in cotton and Sherif and Subramanyan (1983) in pigeon pea. The presence of significant amounts of all types of gene action, additive, dominance and epistasis for most of the important traits has indicated that a method designed to utilize all of them such as recurrent selection, multiple cross or diallele selective mating system of Jensen (1970) has to be adopted in the breeding programme.

## **5.2 Variability study in superior cross 9632**

The estimates of variability parameters (Table) and genotypic and phenotypic coefficients of variability were moderate to

high while, the heritability (broad sense) was very high for all the 13 characters studied. However, the genetic advance over mean was very higher for number of fruits per plant (131.8%) and seed weight per fruit (75.57%). For yield and the other fruit components, genetic advance over mean was moderately high. Similar reports have been made by Elangovan *et al.* (1981), Joshi and Singh (1983), Gupta and Yadav (1984) and Thakur (1988).

All the observations made in  $F_2$  populations have clearly indicated the potentiality of the populations with respect to yield and yield related characters. Recurrent selection procedure could further help in building up very productive population for isolation of pure lines.

### **5.3 Transgressive segregants**

Eventhough the segregating populations are usually assessed using their means and variability, these parameters alone will not indicate the relative worth of different approaches for creating variability. It was therefore considered necessary to compare the variability generated by different methods in their ability to release transgressive segregants. In the present study, extent of transgressive segregants were identified in different segregating populations.

#### **5.3.1 Transgressive segregants for individual traits**

In general,  $F_3$  populations showed higher percentage of transgressive segregants compared to their corresponding

populations for dry fruit yield per plant, 1000 seed weight and disease resistance plants. Hence, the  $F_3$  populations can be expected as source of population for isolating high yielding genotypes. The higher frequency of transgressive segregants in  $F_3$  populations for most of the characters could be attributed to the increased opportunity of recombination.

### **5.3.2 Promising recombinants identified in $F_3$ family**

The main criteria for selection was laid on identifying genotypes free from murda complex, more number of branches, growth habit, fruit set, fruit shape and colour. During *kharif* 2000, 160 plants were raised in 16 rows of 10 plants each for each cross. 93 plants were selected for different purposes, again out of those 93 plants, 20 were found more useful for deriving pure lines. The promising recombinants were derived from the crosses 9632, 9646 and 9608, which, were free from leaf curl complex having more fruits per plant with dark red fruits and suitable for dry chilli purposes. The recombinants with VN-2 as female parent had resistance to leaf curl complex, light red colour fruits at maturity or light green to green fruits at intermediate stage indicating their suitability for vegetable purpose. The cross combinations 9632-8, 9632-56 and 9646041 appear to be promising dry chilli purposes. Further, the advancement of progenies viz., 9608-7, 9632-67, 9646-18 and 9646-47 appear to be promising for deriving leaf curl resistant and high yielding genotypes.

**Table 8. Promising recombinants identified in F<sub>3</sub> population**

Sl. No.	Recombinants	Cross	Growth habit prostrate compact erect	Fruit shape Kaddi K <sub>1</sub> K <sub>2</sub> K <sub>3</sub> Dabbi D <sub>1</sub> D <sub>2</sub> D <sub>3</sub>	Fruit colour At mature stage Light red Red Dark red	Fruit set (3: low 5: Inter med 7 : High)	Murda Complex X Susca 3 MR 5 Resistant 7	Branch habit Sparse Intermediate Dense
1.	9632-8	VN-2 x Jwala	Erect	D <sub>1</sub>	Red	Intermediate	Res	Intermediate
2.	9632-56	VN-2 x Jwala	Erect	D <sub>1</sub>	Red	Intermediate	Res	Intermediate
3.	9632-67	VN-2 x Jwala	Erect	D <sub>2</sub>	Light red	High	Res	Intermediate
4.	9632-90	VN-2 x Jwala	Erect	D <sub>1</sub>	Red	Intermediate	MR	Intermediate
5.	9632-101	VN-2 x Jwala	Erect	D <sub>1</sub>	Red	Intermediate	Res	Intermediate
6.	9632-115	VN-2 x Jwala	Erect	D <sub>2</sub>	Light red	High	Res	Intermediate
7.	9632-116	VN-2 x Jwala	Erect	D <sub>1</sub>	Red	Intermediate	MR	Intermediate
8.	9646-12	VN-2 x Arkalohit	Erect	D <sub>2</sub>	Dark red	Intermediate	MR	Intermediate
9.	9646-18	VN-2 x Arkalohit	Erect	D <sub>2</sub>	Dark red	Intermediate	R	Intermediate
10.	9646-68	VN-2 x Arkalohit	Erect	D <sub>2</sub>	Dark red	High	MR	Intermediate
11.	9646-47	VN-2 x Arkalohit	Erect	D <sub>2</sub>	Dark red	High	MR	Intermediate
12.	9646-81	VN-2 x Arkalohit	Erect	D <sub>1</sub>	Dark red	Intermediate	R	Intermediate
13.	9708-7	Hissar shakti x PMR21	Compact	K <sub>2</sub>	Red	Intermediate	MR	Dense
14.	9708-17	Hissar shakti x PMR21	Compact	K <sub>2</sub>	Red	Intermediate	MR	Dense
15.	9708-64	Hissar shakti x PMR21	Compact	K <sub>1</sub>	Red	Intermediate	MR	Dense
16.	9708-81	Hissar shakti x PMR21	Compact	K <sub>2</sub>	Red	Intermediate	MR	Intermediate
17.	9623-12	Dabbi x LCA 312	Erect	D <sub>3</sub>	Dark red	Intermediate	MR	Intermediate
18.	9623-86	Dabbi x LCA 312	Erect	D <sub>3</sub>	Dark red	Intermediate	MR	Intermediate
19.	9612-46	Kaddi x Arkalohit	Erect	K <sub>2</sub>	Dark red	Intermediate	MR	Dense
20.	9612-52	Kaddi x Arkalohit	Erect	K <sub>2</sub>	Dark red	Intermediate	MR	Dense

#### 5.4 Suggested breeding strategy

Knowledge gained thus far in the present investigation include :

1. Sources of resistance to leaf curl viruses are VN-2 and LCA 312.
2. All 3 types of gene action, additive, dominance and epistasis are important for major quantitative characters.

This information is utilized to draw up an effective breeding strategy to develop resistant chilli. The breeding programme suggested is basically a backcross – inter cross scheme using a chilli genotype resistant to different viruses as a donor parent and a commercial chilli cultivars are included in the scheme in order of funnel in new genes responsible for fruit quality and resistance to other viral, fungal and bacterial pathogens. The F<sub>2</sub> population should be large enough (2500 plants) to obtain sufficient number of commercial chilli type plants with resistance to leaf curl virus. Selection for resistance is to be done in nursery stage after artificial inoculation of the viruses. After the final inter cross, selfing and selection for resistance and other desirable traits should be carried on for 5 to 6 generations for fixing these characters. Comprehensive yield trials and multi locational trials have to be conducted during the final stages of the programmes to isolate the high yielding, resistant and stable genotypes. The few selected plants after the last

round of selfing can be used for seed multiplication with controlled pollination.

### **5.5 Future line of work**

Two parents Byadagi Kaddi, Byadagi Dabbi are popularly cultivated local varieties and Byadagi kaddi was known for its quality, whereas VN-2 from Vietnam and Jwala had high level of resistance to major biotic stress like leaf curl complex caused by thrips and mites. Hence these lines can be used as parents with other elite cultivar in future breeding programme. Potential crosses identified for green and red chilli should be advanced to select the elite pure line having high fruit yield along with resistance to leaf curl complex.

Studies on genetics of powdery mildew, fruit rot, colour and capsaicin content has to be initiated to tailor the breeding programme.

Studies on characters which impart resistance to thrips and mites for easy selection in breeding programme may be initiated.

Recurrent pedigree selection programme may be employed to derive resistant line and widening genetic base.

*Summary*

---

## VI. SUMMARY

The present investigation was conducted at Agricultural Research station, Hanumanmatti during *kharif* in 2000. mainly to study the gene effects for quantitative and qualitative trait including resistance to leaf curl complex disease in 5 crosses ie., VN-2× jwala, VN-2 × Arkalohit, Hissar shakti × PMR-21 , Kaddi × Arkalohit and Dabbi× LCA 312 by generation mean analyses and also study the disease reactions for the parents and hybrids for leaf curl virus. By considering above important objective, the salient findings are summerised below.

The generation mean analysis indicated that individual crosses greatly differ for the gene action and on an overall basis all the types of gene action, ie., additive, dominance and epistases are important. The latter two types predominated for many characters thereby indicating that epistasis cannot be ignored. The presence of significant amounts of all types of gene action, ie., additive, dominance and epistasis for most of the important traits has indicated that a method designed to utilize all of them such as recurrent selection, multiple cross or diallele selective mating system of Jensen (1970) has to be adopted in breeding programme.

The scaling tests were also significant indicating the presence of epistasis. Both additive and non-additive gene action was prevailing for growth related traits like plant height, number of branches were under the control of duplicate type of gene action.

The analysis of variance revealed significant differences for all the 13 characters studied for superior  $F_2$  population (9632). Phenotypic and genotypic coefficient of variability, heritability in broad sense and genetic advance were computed.

The phenotypic coefficient of variability for 9632  $F_2$  population was more than the genotypic coefficient of variability for all the characters under study. Phenotypic and genotypic coefficient of variability were low for plant height, stalk length and 1000 seed weight moderate to high for all other traits.

Selection done in  $F_3$  in all the crosses has revealed the frequency of promising selections with respect to dry fruit 1000 seed weight and disease resistance to higher in VN2 X Jwala. Twenty promising selections have been short listed and in view of their resistance in addition to higher dry fruit yield they should be evaluated further in multilocation trials with a view to release one or two of them for commercial cultivation to boost production and productivity of the crop.

Taking into account of all the above findings, a back cross-intercross programme involving one chilli genotype (resistant to leaf curl viruses) as a donor parent and three commercial chilli cultivars as a recurrent parents is formulated to develop multiple virus resistant high yielding chilli varieties.

## *References*

---

ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ  
ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ  
ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ-65

30 JAN 2004

ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ  
ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ ಶ್ರೀ

## VII. REFERENCES

- AHMED, N., KHAN, S.H. AND TANKI, M.I., 1997, Combining ability analysis for fruit yield and its component character in sweet pepper (*Capsicum annuum* L.). *Capsicum Newsletter*, **16** : 72.
- AHMED, N., SHAH, F.A., ZARGAR, G.H. AND WANI, S.A., 1998, Line x tester analysis for the study of combining ability in hot pepper (*Capsicum annuum* L.). *Capsicum Newsletter*, **17** : 38.
- ANDERSON, V.L. AND KEMPTHORNE, O., 1954, A model for the study of quantitative inheritance. *Genetics*, **39**: 883-898.
- ARNON BEN-CHAIN AND ILAN PARAN., 2000, Genetic analysis of quantitative traits in pepper (*Capsicum annuum* L.). *Journal of American Society for Horticulture Science*, **125**: 66-70.
- ASHTANKAR, C.M. AND JAIPURKAR, M.A., 1988, Heterosis and inbreeding depression in chilli (*Capsicum annuum* L.). *Annals of Plant Physiology*, **2**: 193-203.
- BHAGYALAKSHMI, P.V., RAVISHANKAR, C., SUBRAMANYA, B. AND BABU, V.G., 1990, Study on heritability, genetic advance and character association in chilli (*Capsicum annuum* L.). *South Indian Horticulture*, **38** : 15-17.
- BHAGYALAKSHMI, P.V., RAVISHANKAR, C.R., SUBRAMANYAM, D. AND BABU, V.G., 1991, Heterosis and combining ability studies in chillies. *Indian Journal of Genetics and Plant Breeding*, **51** : 420-423.

- BHAT, B.N., 1981, Genetic analysis and characteristic association of fruit yield and its components in chilli (*Capsicum annuum* L.). *Ph.D. Thesis*, University of Agricultural Sciences, Bangalore, India.
- BIDARI, V.B. AND REDDY, H.R., 1990, Identification of naturally occurring viruses on commercial cultivars of chilli. *Mysore Journal of Agricultural Sciences*, **24** : 45-51.
- BURTON, G.W. AND DEVANE, 1953, Quantitative inheritance in grasses. *Proceedings of 6<sup>th</sup> International Grassland Congress*, **1** : 277-283.
- CAO, J.S. AND SU, Z.Y., 1988, A study on heterosis and combining ability in hot pepper. *Acta Horticulture. Sinica*, **15** : 57-63.
- DABHOLKAR, A.R., 1992, Elements of biochemical genetics, concept publishing company, New Delhi, pp.38-95.
- DASKALOV, S. AND MIHAILOV, L., 1988, A new method for hybrid seed production based on CMS combined with a lethal gene and a female sterile polleniger in *Capsicum annuum* L. *Theoretical and Applied Genetics*, **76**(4) : 530-32.
- ELANGOVAN, M., SUTHANTHIRAPANDIAN, I.R. AND SAYED, S., 1981, Genetic variability in certain metric traits of *Capsicum annuum*. *South Indian Horticulture*, **29** : 224-225.
- FAWOLE, I., GABLEMANN, W.H., GERLOFF, G.C. AND NORDHEIM, E.V., 1982, Heritability of efficiency in 'P' utilization in beans (*Phaseolus vulgaris* L.) grown under phosphorous stress. *Journal American Society for Horticulture Science*, **107** : 94-97.

- FERRY, R.L. AND SCHALK, S.M., 1991, Resistance in pepper (*Capsicum annuum* L.) to western flower thrips *Frankliniella occidentalis* (Pergande). *Horticulture Science*, **26** : 1073-1074.
- FISHER, R.A., 1918, The correlation between relatives on the supposition of Mendelian inheritance. *Transactions of Royal Society of Edinburgh*, **52** : 399-433.
- FISHER, R.A., IMMDER, F.R. AND TEDIN, O., 1932, The genetical interpretation of statistics of the third degree in the study of qualitative inheritance. *Genetics*, **17**:107-124.
- GADDAGIMATH, N.B., 1992, Studies related to genetics of economic and quality traits and exploitation of heterosis in chilli (*Capsicum annuum* L.). *Ph.D. Thesis*, University of Agricultural Sciences, Dharwad, India.
- GHAI, I.R. AND THAKUR, M.R., 1987, Variability and correlation studies in an intervarietal cross of chilli. *Punjab Horticulture Journal*, **27** : 80-83.
- GILL, H.S., THAKUR, P.C. AND THAKUR, T.C., 1973, Combining ability in sweet pepper (*Capsicum annuum* L.) var *grossum*. *Indian Journal of Agricultural Sciences*, **43**: 913-94.
- GIRITAMMANAVAR, V.A., 1995, Studies on genetic variability and purification of Byadgi chilli (*Capsicum annuum* L.) genotypes. *M.Sc. (Agri.) Thesis*, University Agricultural Sciences, Dharwad, India.
- GOPALAKRISHNA, T.R., GOPALKRISHNAN, P.K. AND PETER, K.V., 1989, Heterosis and combining ability analysis in chilli. *Indian Journal of Genetics and Plant Breeding*, **41**: 205-209.

- GUPTA, C.R. AND YADAV, R.D.S., 1984, Genetic variability and path analysis in chilli (*Capsicum annuum* L.) *Genetics*, **38** : 425-432.
- HAYES, H.K., IMMER, F.F. AND SMITH, D.C., 1955, *Methods of Plant Breeding*, McGraw Hill Book Co., Inc., New York, pp.551.
- HAYMAN, B.I., 1958a, The separation of epistatic from additive and dominance variation in generation mean. *Heridity*, **12** : 371-390.
- HAYMAN, B.I., 1958b, The theory and analysis of diallel crosses. *Genetics*, **43** : 63-85.
- HAYMAN, B.I. AND MATHER, K., 1957, The description of genetics interaction in continuous variation. *Biometrics*, **11** : 371-390.
- HIREMATH, N.V., 1997, Genetics of fruit yield, yield components and reaction to major biotic stress in chilli (*Capsicum annuum* L.). *Ph.D. Thesis*, University of Agricultural Sciences, Dharwad.
- JADHAV, M.G. AND DHUMAL, S.A., 1994, Genetic studies of some quantitative characters in chilli. *Journal of Maharashtra Agricultural Universities*, **19** : 62-64.
- JAGADEESHA R.C., 2000, Genetics of yield, yield components and fruit quality parameters in chilli (*Capsicum annuum* L.) *P.hd Thesis*, University of Agricultural Sciences, Dharwad.

- JENSEN, N.F., 1970, A diallele selective mating system in cereal breeding. *Crop Science*, **10** : 629-635.
- JOHNSON, H.W., ROBINSON, H.E. AND COMSTOCK, R.S., 1955, Estimates of gentic and environmental variability in soybean. *Agronomy Journal*, **47** : 314-318.
- JOSHI, S. AND SINGH, G., 1983, Variability studies in sweet pepper (*Capsicum annuum* L.). *Haryana Journal of Horticulture Science*, **12** : 124-129.
- KAUL, B.L. AND SHARMA, P.P., 1988, Heterosis and combining ability studies for some fruit characters in bell pepper. *Vegetable Science*, **15** : 171-180
- KHADI, B.M., 1983, Genetic studies on Ascorbic acid content, fruit yield, yield components and accumulation of some mineral elements in chilli (*Capsicum annuum* L.). *Ph.D. Thesis*, University of Agricultural Sciences, Bangalore, India.
- KHALID AHMED, RAO, N.H.P. AND PURNA CHADRA RAO, 2000, Biology of yellow mites polyphagatarsonemus latus (Banks) on chillies. *Pestology*, **26** : 20-22.
- KRISHNAMURTHY, H.M. AND DESPHANDE, A.A., 1997, Genetics and yield attributes in chilli (*Capsicum annuum* L.). *Vegetable Science*, **24** : 118-122.
- KUMAR, B.P., SANKAR, C.R. AND SUBRAMANYAM, D., 1993, Variability heritability and genetic advance in the segregating generations. of chilli (*Capsicum annuum* L.). *South Indian Horticulture*, **41** :198-200.

- LIPPERT, L.F., 1975, Heterosis and combining ability in chilli peppers by diallel analysis. *Crop Science*, **15**: 323-325.
- LOHITASHWA, H.C., MANJUNATH, A. AND KULKARNI, R.S., 1999, Inheritance of fruit yield and its component traits in chilli. *Journal of Maharashtra Agricultural Universities*, **24**: 31-33.
- LUSH, J.L., 1949, Heritability of quantitative characters in farm animals. In proceedings of 85<sup>th</sup> covgrcos on Genetics. *Hereditous (Supplement)*, pp. 356-357.
- MARTIN, V.C. AND LIPPERT, L.F., 1975, Combining ability analysis of anatomical components of the dry fruit in chilli pepper. *Crop Science*, **15**: 326-329.
- MATHER, K., 1949, *Biometrical Genetics*, Methuen, London.
- MESHARAM, L.N. AND MUKEWAR, A.M., 1986, Heterosis studies in chilli. *Scientia Horticulture*, **28** : 213-225.
- MILKOVA, L., 1977, General and specific combining ability for plant characters in pepper diallel cross. *Genetic Selection*, **10** : 324-327.
- MILKOVA, L., 1984, Genetics of quantitative characters in sweet pepper. *Acta Universities Agriculture. Brno A.*, **32** : 379-384.
- MIRANDA, J.E.C., DECOSTA, C.P. AND CRUZ, C.D., 1988, Diallel analysis in sweet pepper. I. Combining ability. *Revista Brasillirea de Genetics*, **11**: 431-440.

- MISHRA, B.N., SAHOO, S.C., LOTHAN, A.R. AND MISHRA, R.S., 1991, Heterosis and combining ability for seed character in chilli (*Capsicum annuum* L.). *Indian Journal of Agricultural Sciences*, **61**: 123-125.
- MULGE, R. AND ANAND, M., 1997, Prediction of heterosis and combining ability for yield and yield characters at seedling stages in sweet pepper. *Indian Journal of Genetics and Plant Breeding*, **57**: 180-185.
- NAGAICH, B.B., SETHI, J. AND CHAUBEY, I.D., 1972, Inheritance of characters and heterosis in *Capsicum* sp. *Haryana Journal of Horticulture Science*, **1** : 69-75.
- NAIR, P.M., GEORGE, M.K., MOHANKUMARAN, N., NAIR, V.G. AND SARASWATHY, P., 1984, Studies on correlation and path analysis in *Capsicum annuum* L. *South Indian Horticulture*, **32**: 212-218.
- OZO, J.D., 1984, Hybrid Vigour and gene action of two qualitative traits of flavour peppers in Nigeria. *Scientia Horticulture*, **22**: 321-326.
- PANDIAN, I.R.S. AND SHANMUGAVELU, K.G., 1992, Combining ability for yield and yield components in chillies (*Capsicum annuum* L.). *South Indian Horticulture*, **40** : 202-206.
- PAPOVA, D., 1973, Heterosis in sweet pepper. *Edatelstovana B' Igurskata Akademna Nankitep*, pp.153.

- PATEL, J.A., SHUKLA, M.K., DOSHI, K.M., PATEL, S.B. AND PATEL, S.A., 1998, Hybrid vigour of quantitative traits in chilli (*Capsicum annuum* L.). *Vegetable Science*, **24** : 107-110.
- PATIL, H.B., 1990, Exploitation of residual heterosis in F<sub>2</sub> for better performance and fruit rot (*Colletotrichum capsici* (Syd) Butler and Bisby) resistance in chillies (*Capsicum annuum* L.). *Ph.D. Thesis*, University of Agricultural Sciences, Bangalore, India.
- POULOS, J.M., 1994, Pepper breeding *capsicum* Spp. Achievements, challenges and possibilities. *Plant Breeding Abstracts*, **64** : 143-151.
- PRABHU, S.T. AND JAGADEESHA, R.C., 1998, Identification of resistance sources against thrips. *Scirtothrips dorsalis* Hood and mites *polyphagatorsonomous latus* banks in chilli *Capsicum annuum* germplasm. *Biodiversity Conservation and Utilization Spice Medicinal and Aromatic Plants. National Seminar on Biodiversity Conservation of Spices, Medicinal Plant, IISR Calicut*, **99** : 911-915.
- ROCHETTA, G., GIORGI, G. AND GIOVANELLI, G., 1976, Correlation analysis between morphological traits and productivity in cultivated *Capsicum* for an understanding of the heterosis phenomenon. *Genetica Agraria*, **30** : 355-374.
- SAHOO, S.C. AND MISHRA, S.N., 1990, Mean performance and residual heterosis of F<sub>2</sub> diallel crosses in chilli (*Capsicum annuum* L.). *Orissa Journal Agricultural Research*, **3** : 87-92.

- SAHOO, S.C., MISHRA, S.N. AND MISHRA, S.M., 1990, Genetic variation in F<sub>2</sub> generation of chilli. *Capsicum Newsletter*, **8-9** : 29-30.
- SARALADEVI, D. AND ARUMUGAM, 1999, Genetics of yield components in F<sub>1</sub> generation of chillies (*Capsicum annuum* L.) 1999. *Crop Research*, **18** : 108-111.
- SAWANT, D.M., MEMANE, S.A., JO, M.B. AND KALE, R.N., 1984, Screening of chilli varieties against leaf curl complex. *Vegetable Science*, **13** : 219-222.
- SHARMA, A. AND TALUKDAR, P., 1998, Gene effects in chilli *Capsicum annuum* L. *Crop Improvement*, **25**(2) : 220-222.
- SHARMA, P.P. AND SAINI, S.S., 1977, Heterosis and combining ability for yield and agronomic characters in pepper (*Capsicum annuum* L.). *Vegetable Science*, **4** : 43-48.
- SHERIFF, M.N. AND SUBRAMANIAN, A., 1983, Genetic analysis of yield components in red gram. *Madras Agricultural Journal*, **70** : 71-74.
- SINGH, A. AND SINGH, H.N., 1976a, Genetics of quality components in chilli. *Indian Journal of Genetics and Plant Breeding*, **36** : 84-95.
- SINGH, A. AND SINGH, H.N., 1976b, Combining ability in chilli. *Indian Journal of Genetics and Plant Breeding*, **36**: 420-424.

- SINGH, A. AND SINGH, H.N., 1978, Heterosis and inbreeding depression in three traits in chilli (*Capsicum annuum* L.). *Indian Journal of Agricultural Research*, **10** : 105-110.
- SINGH, R.H. AND CHOUDHARY, B.D., 1979, Biochemical methods in quantitative genetic analysis, Kalyani publishers, Ludihana.
- SINGH, R.H. AND RAI, J.N., 1981, Note on heritability and genetic advance in chilli (*Capsicum annuum* L.). *Progressive Horticulture*, **13** : 89-92.
- SINGH, R.P., 1980, Genetics of important components contributing to yield of pea. *Crop Improvement*, **7** : 49-53.
- SIRSAT, S., 1994, Genetic variability and divergence studies in chilli (*Capsicum annuum* L.) genotypes. *M.Sc.(Agri.) Thesis*, University Agricultural Sciences, Dharwad, India.
- SNEDECOR, G.W. AND COCHRAN, W.G., 1967, *Statistical Methods*, 8<sup>th</sup> Edition, Iowa State College Press, Ames, Iowa, USA.
- SOLTANOVSKAYA, G., 1972, Breeding white fruited varieties of sweet pepper in the Crimea. *Genet. Sel.*, **47** : 227-229.
- SONTAKKE, M.B., 1981, Genetic studies in chillies (*Capsicum annuum* L.). *Ph.D. Thesis*, University of Agricultural Sciences, Bangalore.
- SPRAGUE, G.F. AND TATUM, L.A., 1942, General vs specific combining ability in single crosses of corn. *Journal of American Society of Agronomy*, **34** : 923-932.

- TEWARI, G.C., DESPHANDE, A.A. AND ANAND, N., 1986, Screening chilli pepper germplasm for resistance against *Scirtothrips dorsalis* Hood. *Vegetable Science*, **13** : 359-364.
- TEWARI, V.P. AND ANAND, G.P.S., 1977, Incorporation of virus resistance in improved chillies. *Madras Agricultural Journal*, **64** : 822-827.
- THAKUR, P.C., 1987, Gene action, an index for heterosis breeding in sweet pepper. *Capsicum Newsletter*. **6** : 41-42.
- THAKUR, P.C., 1988, Heritability in sweet pepper. *Capsicum Newsletter*. **7** : 42-43.
- THANGARAJ, T. AND MUTHUKRISHNAN, C.R., 1991a, Estimates on heritability and genetic advance in BIP and F<sub>3</sub> progenies of chilli (*Capsicum annum* L.). *South Indian Horticulture*, **39**: 130-133.
- THANGARAJ, T. AND MUTHUKRISHNAN, C.R., 1991b, Phenotypic and genotypic coefficients of variation of F<sub>3</sub> and BIP progenies of chilli (*Capsicum annum* L.). *South Indian Horticulture*, **39** : 184-187.
- TURNER, J.H., 1953, A study of heterosis in upland cotton. *Agronomy Journal*, **45** : 484-486.
- VARALAKSHMI, B. AND HARIBABU, K., 1991, Genetic divergence, heritability and genetic advance in chilli (*Capsicum annum* L.). *Indian Journal of Genetics and Plant Breeding*, **51**:174-178.

WILSON, F.D. AND GEORGE, B.W., 1983, A genetic and breeding study of pink bollworm resistance and agronomic properties in cotton. *Crop Science*, **23** : 1-4.

ZUBERI, M.I., JOADER, O.I. AND EUNUS, A.M., 1972, Inheritance of some quantitative characters in *Brasica compestris*. *Indian Journal of Genetics*, **32** : 247-256.

# **GENETIC STUDIES IN CHILLI (*Capsicum annum* L.)**

**SOMASHEKHAR V.D.**

**2001**

**Dr. S. A. PATIL**

Major Advisor

## **ABSTRACT**

Investigations were carried out to know the nature and magnitude of gene effects for VN2 X Jwala, VN2 X Arkalohit, Hissar Shakti X PMR21, Byadagi Kaddi X Arkalohit and Byadagi Dabbi X LCA312 crosses for qualitative and quantitative characters and selection of superior segregants in F<sub>3</sub> of five crosses in chilli during *kharif* 2000-2001. The study also involves identification of promising recombinants from F<sub>3</sub> populations in five crosses.

To understand the nature and magnitude of gene effects five crosses were analysed through generation mean analysis for 13 characters. The study indicated that the growth related traits were found to be under the control of dominance and additive x additive type of gene interaction.

Fruit related traits were under the control of additive, additive x additive type of gene interaction. Resistance to thrips and mites was under the control of additive gene and additive x additive effects i.e., it suggest that inclusion of parents having high level of resistance for the development pure lines. Dry fruit yield was under the control of dominant and additive type of gene action.

In order to exploit non-additive gene action development of hybrid is suggested. For the development of variety recurrent pedigree selection programme is suggested involving the parents having high level of resistance with high fruit quality traits.

Among the superior segregants identified in five segregation population, more number of superior segregants recovered from the VN2 X Jwala cross followed by the VN2 X Arkalohit cross. In VN2 X Jwala cross, 9632-8 and 9632-56 are found to be dry chilli purpose. 9608-7, 9632-67, 9646-18 and 9646-47 appear to be promising for deriving leaf curl complex resistant genotypes recovered from the five crosses studied with high yielding ability.