Electronic Journal of Plant Breeding, 8(1): 105-110 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00015.1

Research Article

Generation mean analysis in chilli (*Capsicum annum* L.)

V.C. Navhale*, V.V. Dalvi, M.M. Wakode, S.G. Bhave and M.M. Burondkar
Department of Agricultural Botany, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli 415712, Maharashtra
E-mail: vikgroundnut@yahoo.com

(Received: 31 March 2016; Revised: 08 March 2017; Accepted: 15 March 2017)

Abstract
The generations mean analysis involving six generations (P_1, P_2, F_1, F_2, B_1 and B_2) was carried out to study the nature and magnitude of gene effects for 13 characters in chilli. The study was conducted at Departmental Farm of Agricultural Botany, College of Agriculture, Dr. B.S.K.K.V., Dapoli during year 2011-12. The Mather's individual scaling tests and Cavalli's joint scaling tests were used to detect the presence or absence of the epistatic interactions. The results obtained showed the importance of additive, dominant and all three types of epistatic interactions for three crosses and thirteen characters *viz.*, Days to first flowering, days to first picking, plant height (cm), number of branches per plant, fruit length (cm), fruit diameter (mm), number of seed per fruit, number of fruits per plant (green), green fruit yield per plant (g), number of fruits per plant (red), red fruit yield per plant (g), days to last picking and capsaicin content. For majority of crosses duplicate epistasis was observed. While the complimentary epistasis was observed for the cross Jwala x DPL-C-5 for days to first flowering, number of red fruit per plant and days to last picking, fruit diameter and fruit length for the cross Jwala x Parbhani Tejas and number of seed per fruit in the cross Jwala x AKC-08-95-05.

Key words
Chilli, gene action, scaling test, epistatic interactions

Introduction

Chilli (*Capsicum annum* L.) is grown worldwide as spice and vegetable crop and world's second most important solanaceous vegetable after tomato. Owing to its high cash value and consumption rate the annual trade of chilli is approximately 17 per cent of total spice trade in the world. In India, its introduction is believed to be through the Portuguese in the 16^{th} century. Chilli is an indispensable spice essentially used in every Indian cuisine due to its pungency, spice, taste, appealing colour and flavour. Chilli fruits are rich source of carbohydrates, proteins, minerals, ascorbic acid and vitamins C, A and E. Pungency of chilli is due to a crystalline acrid volatile alkaloid called 'capsaicin', present in the placenta of fruit which has diverse prophylactic and therapeutic uses in allopathic and ayurvedic medicine. Chilli and its possessed foods are used very effectively in Indian medicine. The efforts of crop improvement have been constrained mainly by a lack of adequate information on the genetic control of characteristics of the yield and yield related traits in chili. To increase the yield, genetic information and efficient breeding methods to be used are very important. The explanations for the relative importance of additive and non-additive gene effects in planning more efficient breeding programs could be obtained from a comparative assessment of the linear components, *viz*., additive (d), dominance (h), additive x additive (i), additive x dominance (j) and dominance x dominance (l) gene effects. Understanding of the inheritance of yield and yield related traits in advance would be important to maximize the use of genetic potential in an effective breeding program. Such genetic information about chilli germplasm is rarely available, so that it creates a problem for the planning of a sound breeding program to improve the basic yield and associated plant traits of the crop. Considering the importance of chilli and in view of the above mentioned constraints, the present invesigation was undertaken to study the inheritance pattern of quantitative traits related to yield.

Materials and methods

A total of three crosses (Jwala x DPL-C-5, Jwala x AKC-08-95-05 and Jwala x Parbhani Tejas) involving four diverse parents were made during *Rabi* 2011 and their F_2, B_1 and B_2 were developed during *Kharif* 2012. All the six generations *i.e.* P_1, P_2, F_1, F_2, B_1 and B_2 were evaluated in randomized block design with three replications at farm of Department of Agricultural Botany, College of Agriculture, Dr. B.S.K.K.V., Dapoli during *Rabi* 2012. Each of two rows of P_1, P_2 and F_1, four rows of B_1 and B_2 and ten rows of F_2 were grown with row length of three meters and spacing 60 x 45 cm. The data was recorded on 10 competitive plants in parents and F_1, 40 plants in F_2 and 20 plants in backcrosses in each replication. The observations were recorded for 13 characters *viz*., days to first flowering, days to first picking, plant height (cm), number of branches per per plant, fruit length (cm), fruit diameter (mm), number of seed per fruit, number of fruits per plant (green), green fruit yield per plant (g), number of fruits per plant (red), red fruit yield per plant (g), days to last picking and capsaicin content (ppm). The data was subjected to A, B, C and D scaling tests developed by Mather (1949) and Cavalli (1958) joint scaling test.

Electronic Journal of Plant Breeding, 8(1): 105-110 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00015.1

Results and discussion

Mathers scaling test and Cavalli's joint scaling test were applied to the data to detect the presence or absence of non allelic interactions. In order to estimate additive, dominant and all the three types of interactions the generation mean analysis was carried out following the procedures given by Hayman (1958) and Jinks and Jones (1958). The results obtained and the estimates of these three tests and 'm','d', 'h', 'i', 'j', and 'l' parameters are given in the table 1 and 2.

For Days to first flowering, all the scaling test for all the crosses were highly significant except scale B in the cross Jwala x AKC-08-95-05 and scale A in the cross Jwala x Parbhani Tejas, which indicated the three parameter model was not adequate to explain the genetic variation for these trait in these crosses. The joint scaling test confirmed the result of individual scaling test with significant x^2 values, also the 'm', 'd', and 'h' parameters of joint scaling test for all the crosses showed significance, excluding 'h' for the cross Jwala x Parbhani Tejas. Due to significance of these tests the three parameter model was extended to Hymens (1958) six parameter model. The estimates of best fit six parameter model are presented in table 2 indicated the significance of all the parameters *i.e.* m', 'd', 'h', 'i', 'j', and 'l' except 'j' for the cross Jwala x DPL-C-5 and 'l' in the cross Jwala x AKC-08-95-05, where in 'l' is non-significant indicating presence of additive, dominance and epistasis gene action and interaction in these crosses. The opposite sign of estimates of 'h' and 'l' recorded for the cross Jwala x Parbhani Tejas indicate duplicate gene action, while complementary epistasis observed in crosses 1 ('h' and 'l' with same sign). The results of the present investigation are in complete agreement with the earlier results obtained by Patel *et al.* (2003) and Singh and Chaudhari (2005).

The significance of scaling test and joint scaling test for days to first picking indicated the presence of non- allelic gene interactions and additive - dominance model is inadequate to describe the variations between the genotypes under study. The significant mean (m),'d' (additive) and 'h' (dominance) values indicated the role of additive and dominant gene action in three crosses. Where, 'd' were non significant in the cross Jwala x AKC-08-95-05 and Jwala x Parbhani Tejas. The significance of additive x additive, additive x dominant and dominant x dominant gene action indicated the presence of 'i', 'j' and 'l' type of interaction. The lower value of the 'j' indicated its lesser importance in governing the trait. The higher values of 'i' and 'l' and lower values of 'j' interaction are in line with the earlier findings of Patel *et al.* (2003) and Hasanuzzaman and Faruq Golam (2011).

In the present investigation plant height was confirmed by non-significant scaling test and joint scaling test were recorded in the cross Jwala x Parbhani Tejas. Similarly, the dominant gene action observed non-significant and additive gene action found significant in these crosses which indicate the plant height were governed by the additive gene action and dominant gene action were absent in these crosses. The absence of significant scaling test, joint scaling test and dominant gene action and presence of additive gene action were also reported by Somashekhar *et al.* (2010) and Mohitepatil (2011). The significance of 'j' interaction, while significance of additive x additive gene interaction were confirmed by the report from Patel *et al.* (2003).

The presence of significant scaling test for number of branches per plant was confirmed by joint scaling test indicated the presence of non-allelic gene interactions and the additive dominance model need to be further extended for estimation of epistatic effects of gene action. The significance of dominant gene action and its higher magnitude over the additive variance and negative dominance were observed in the present investigation, which is in conformity with the reports from Patel *et al.* (2003) and Singh and Chaudhari (2005). The presence of significant and higher magnitude of additive x additive and dominant x dominant and lower magnitude for additive x dominant were observed in the study which is in fully agreement with earlier reports by Singh and Chaudhari (2005). The presence of opposite signs of dominance and dominance x dominance component was indicated in the present investigation which indicates the duplicate gene action. Similarly, the opposite sign of the additive x additive and dominant x dominant interaction indicated the presence of duplicate epistasis which are in line with the results reported by Somashekhar *et al*. (2010).

On the basis of significant individual scaling test and joint scaling test for fruit length, it was observed that the additive and dominant gene action was significant for all crosses, indicating the preponderance of 'd' and 'h' type of gene action. Among epistatic gene action for fruit length, additive x additive and dominant x dominant type of gene interaction was recorded in most of the crosses except 'l', while additive x dominant type of interaction were significant in all crosses. The higher magnitude of dominant x dominant type of interaction was observed in most of the cases in present study which is confirmed by the earlier work reported by Mohitepatil (2011). The complementary epistasis for the cross Jwala x Parbhani Tejas, while, duplicate epistasis for the cross Jwala x DPL-C-5 and Jwala x AKC-08-95-05 was envisaged. The complementary and duplicate epistasis for this traits also envisaged by Somashekhar *et al*. (2010).

 DOI: 10.5958/0975-928X.2017.00015.1

The results obtained for significance of scaling and joint scaling tests for fruit diameter indicated the presence of epistatic gene interaction for fruit diameter inheritance. The estimates of six parameter model indicated the significance for mean, additive gene action and dominant gene action and higher magnitude of dominant gene action, the negative sign of dominant gene action indicated the dominance towards the parents with lower fruit diameter and positive and higher 'h' indicated dominance towards the higher fruit diameter parent while, the absence of significance in 'd' were recorded in the cross Jwala x Parbhani Tejas, indicating non significant role of additive gene action. These results are in complete agreement with the results reported by Mohitepatil (2011). The significance of additive x additive (i), dominance x dominance (l) and additive x dominance (j) type of interaction recorded in present investigation. The complimentary gene action observed in the cross Jwala x Parbhani Tejas and opposite signs of the 'i' and 'l' type of interaction indicating digenic duplicate interaction observed in remaining crosses. Similar results are also reported by Singh and Chaudhari (2005).

The estimates of significant additive and dominant gene action were involved in the inheritance of number of seeds per fruits. The larger magnitude of dominant gene action was recorded in present investigation. The results can be confirmed by the findings Patel *et al.* (2003) and Mohitepatil (2011). However, preponderance of dominant gene action followed by the additivity was also observed in the cross Jwala x AKC-08-95-05 and 3 which are confirmed with the findings reported by Anandhi and Khader (2011). The interaction components *i.e.* significance of 'i', 'j' and 'l' indicated, additive x additive, additive x dominant and dominant x dominant non allelic gene interactions. The opposite signs of 'h' and 'l' and 'i' and 'l' component was indicated that the duplicate and digenic duplicate epistasis were recorded in the cross Jwala x DPL-C-5, while complementary gene action observed in the cross Jwala x AKC-08-95-05 in inheritance of this trait. The similar results were also obtained and reported Singh and Chaudhari (2005).

On the basis of significant individual scaling test and joint scaling test for red number of fruits per plant, it was observed that the additive gene action was significant for the cross Jwala x Parbhani Tejas and dominant gene action observed in all the crosses, indicating the preponderance of 'd' and 'h' type of gene action. These results are in conformity with the results obtained by Hasanuzzaman and Faruq Golam (2011). Among epistatic gene action for red number of fruits per plant, additive x additive, additive x additive and dominant x dominant type of gene interaction was recorded in all crosses. The higher magnitude of dominant x dominant type of interaction was observed in most of the cases in present study which is confirmed by the earlier work reported by Somashekhar *et al*. (2010). The complementary epistasis for the cross Jwala x DPL-C-5 while, duplicate epistasis for remaining crosses. The complementary and duplicate epistasis for this traits also envisaged by Ajith and Anju (2005).

The estimates of significant additive and dominant gene action were involved in the inheritance of red fruit yield per plant. The higher proportion of additive gene action and its corresponding non-significant dominant gene action indicated the predominance of additivity in crosses Jwala x DPL-C-5 and Jwala x AKC-08-95-05. The results are confirmed by the findings of Hasanuzzaman and Faruq Golam (2011). The interaction components *i.e.* significance of 'i', 'j' and 'l' indicated, additive x additive, additive x dominant and dominant x dominant non allelic gene interactions. The opposite signs of 'h' and 'l' and 'i' and 'l' component was indicated that the duplicate and digenic duplicate epistasis was operative in inheritance of this trait. The similar results were also obtained and reported by Singh and Chaudhari (2005).

For number of green fruits per plant joint scaling test was registered significance. The presence of additive, dominant, additive x additive, additive x dominant and dominant x dominant gene action indicated their role in inheritance of the trait under study. The presence of duplicate 'h' and 'l' has apposite sign was also recorded the results in close conformity with the report Patel *et al.* (2003). The presence of significant 'm' 'd' 'h' 'i' 'j' and 'l' parameters of six parameter model clued by significant scaling and joint scaling test indicated the preponderance of additive, dominant and all the cases of epistatic gene action. The opposite sign of 'h' and 'l' in all the crosses indicated the duplicate epistasis, is operative in inheritance of this trait. The evidence for presence of all the three types of gene actions *viz*., additive (d), dominance (h) and epistatic gene effects [additive x additive (i), additive x dominance (j) and dominance x dominance (l)] for inheritance of number of green fruits per plant was given by Patel *et al.* (2003).

For green fruits yield per plant the cross Jwala x AKC-08-95-05 recorded non-significant scaling test and additive gene effects were significant indicating the additive gene action only control the inheritance, while in all other cases additive and dominant gene actions were important in governing this trait. In the cross Jwala x DPL-C-5 dominant effect were higher than additive one and in negative direction indicating preponderance of dominant effect of parent with lower mean values. In other cases additive gene action recorded higher magnitude indicating its preponderance. Among non-allelic interactions additive x additive type of interaction were of higher magnitude indicating its preponderance in governing the trait. The duplicate gene action observed in green fruits yield per plant. The similar results were also obtained and reported by Singh and Chaudhari (2005), and Hasanuzzaman and Faruq Golam (2011).

The significance of scaling test for days required for last picking indicated the involvement of epistatic gene action in inheritance of the trait. The significance of additive (d) parameter and dominant (h) parameter indicated the respective gene action. The larger magnitude of dominant gene action was recorded in the present experiment. The evidences for additive gene effect were also reported by Patel *et al*. (2003) and Hasanuzzaman and Faruq Golam (2011). In the present investigation, significant additive x additive, additive x dominant and dominant x dominant interaction were recorded. Similarly, the duplicate epitasis in the cross Jwala x AKC-08-95-05 and complementary epistasis was recorded in the cross Jwala x DPL-C-5 and which was identified as similar signs of 'h' and 'l' (complementary) and opposite signs of 'h' and 'l' (duplicate). The additive x additive and additive x dominant type of inter-allelic gene interactions also reported by Singh and Chaudhari (2005) and complementary and duplicate gene action by Patel *et al.* (2003) and Singh and Chaudhari (2005).

The positive sign of additive x additive (i) indicates the association of the alleles while negative sign indicates the dispersion of the alleles in the parents (Khodambashi *et al.* 2012). The allelic dispersion was noticed in present investigation for all the traits studies and in most of the crosses, while, association of the alleles (positive signs of 'i') was evident for some crosses. The negative signs of the dominant x dominant (l) type of interaction indicated the ambidirectional dominance for most of the crosses and traits with few exceptions which indicated both the parental alleles operating to reducing magnitude of the traits, while its positive sign indicated the increasing dominance of the parental alleles towards the respective parents (Hasanuzzaman and Golam, 2011 and Mohitepatil, 2011).

Conclusion

The signs of significant dominance (h) gene effects shows dominance direct and unidirectional which mean positive signs of 'h' increasing alleles include dominant phenotype, otherwise negative alleles for reducing alleles involving the dominant phenotype (Hasanuzzaman and Golam 2011 and Mohitepatil (2011). Most of the characters and crosses showed either positive or negative dominance depending on the cross. These results indicated the relative relationship as reported by Mohitepatil (2011) in chilli.

References

Ajith, P.M. and Anju, P.M. 2005. Generation mean analysis of yield and anthracnose resistance in chilli (*Capsicum annum* L.). *Veg. Sci.,* **32:** 76-77.

Anandhi, K. and Abdul Khader, K.M. 2011. Gene effect of fruit yield and leaf curl virus resistance in interspecific cross of chilli (*Capsicum annum* L. and *C. friutenscens* L.). *J. of Tropical Agric.*, **49:** 107-109.

Hasanuzzaman, M. and Golam, F. 2011. Gene actions involved in yield and yield contributing traits of chilli (*Capsicum annum* L.). *Australian J. Crop Sci.*, **5:** 1868-1875.

Hayman, B.I. 1958. The separation of epistasis from additive and dominance variation in generation means. *Heredity*, **12**: 371-391.

Jinks, J.L. and Jones, R.M. 1958. Estimation of components of heterosis. *Genetics*, **43**: 223-24.

Khodambashi, M., Bitaraf, N. and Hoshmand, S. 2012. Generation mean analysis for grain yield and its related traits in lentil. *J. Agr. Sci. Tech.*, **14**: 609-616.

Mather, K. 1949. *Biometrical Genetics*. Mathuen and Co. Ltd. London.

Mohite Patil, D.P. 2011. Heterosis, Combining ability and inbreeding depression in Chilli (*Capsicum annum* L.). Ph.D. Thesis, Dr. BSKKV, Dapoli (MS).

Patel, J.A., Patel, M.J., Acharya, R.R., Bhanvadia, A.S. and Bhalala, M.K. 2003. Hybrid vigor, gene action and combining ability in chilli (*Capsicum annum*L.) hybrids involving male sterile lines. *Indian J. Genet*., **64**(1): 81-82.

Patil, B.T., Bhalekar, M.N., Shinde, K.G. and Dhumal, S.S. 2012. Studies on gene action and gene effects for fruit and seed attributes in chilli (*Capsicum annum* L.). *J. Progressive Agric.*, **12**(1): 209-213.

Singh, A.K. and Chaudhary, B.R. 2005. Combining ability and generation mean analysis in *Capsicum*. *Indian J. Genet*., **65**(2): 151-152.

Somashekhar, Patil, S.A. and Salimath. 2010. Estimation of gene effect for Fruit yield and its components in chilli (*Capsicum annum* L.). *Karnataka J. Agric. Sci.*, **21**(2): 181-183

Electronic Journal of Plant Breeding, 8(1): 105-110 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00015.1

Table 1. Scaling and joint scaling test for yield and yield contributing traits in chilli

Traits	Crosses	A	B	C	D	m	d	h	x^2
Days to first flowering	C_1	11.33**	12.67**	35.00**	5.50**	78.58**	-0.91**	-1.33**	239.14**
	C_2	19.93**	0.60	41.27**	10.37**	79.08**	2.08**	3.59**	593.825**
	C_3	-0.73	-18.00**	-7.80**	5.47**	80.04**	-3.70**	1.02	231.729**
Days to first picking	C_1	4.80**	11.80**	47.00**	15.20**	86.84**	0.39	3.89**	783.388**
	C_2	7.00**	5.27**	1.07	-5.60	86.13**	0.14	0.14	74.368**
	C_3	-1.33	-14.73**	-4.40*	5.83**	90.65**	-4.78**	-2.78**	187.55**
Plant height (cm)	C_1	-7.17**	-7.73**	-16.67**	-0.88	62.41**	1.68*	-2.27	19.574**
	C_2	-8.47**	-4.13	3.07	7.83**	63.11**	1.55	1.28	19.789**
	C_3	-7.40*	-1.93	-5.43	1.95	62.58**	1.67*	-1.21	6.882
No. of branches per plant	C_1	-0.33	-1.50**	-0.27	0.78*	7.14**	-0.03	-1.95**	17.77**
	C_2	-2.13**	-1.83**	0.27	2.12**	6.58**	0.28*	-0.43	45.153**
	C_3	1.60**	-1.07*	4.83**	2.15**	6.81**	0.68**	-0.84**	8.645*
Fruit length (cm)	C_1	-2.74**	6.56**	-1.67**	-2.74**	6.31**	0.83**	-0.14**	2541.441**
	C_2	2.79**	-1.38**	-3.41**	-2.41**	6.82**	1.58**	-1.29**	840.401**
	C_3	-3.06**	-1.43**	-6.33**	-0.92**	6.37**	0.96**	-0.70**	701.829**
Fruit Diameter (mm)	C_1	2.45**	-3.97**	-4.13**	-1.30**	9.16**	1.46**	0.85**	1319.184**
	C_2	-2.08**	-0.707*	-0.26	1.263**	10.00**	-1.05**	0.24*	198.898**
	C_3	-0.83**	-2.23**	-3.23**	-0.08	9.76**	-0.37**	1.79**	193.215**
No. of seeds per fruit	C_1	-25.00**	1.53	-22.13**	0.67	72.84**	6.06**	-12.52**	223.326**
	C_2	6.80**	34.53**	51.40**	5.03**	83.33**	2.01**	-8.88**	404.472**
	C_3	2.27	6.07**	11.00**	1.33	83.49**	1.65**	0.01	15.871**
No. of fruits per plant (red)	C_1	33.93**	16.07**	59.67**	4.83**	71.94**	-8.98**	5.82**	347.105**
	C_2	41.80**	20.13**	45.93**	-8.00**	74.03**	-9.88**	6.04**	447.336**
	C_3	4.63**	-38.53**	12.60**	23.25**	71.22**	-10.01**	5.80**	532.159**
Red fruit yield per plant (g)	C_1	-9.70**	-16.37**	-28.70**	-1.32	45.12**	-6.52**	-8.92**	186.627**
	C_2	28.33**	5.87**	40.45**	3.13*	44.72**	2.62**	7.75**	464.6**
	C_3	20.03**	37.53**	28.73**	-14.42**	50.74**	-7.79**	4.54**	743.151**
No. of green fruits per plant	C_1	-57.13**	-39.27**	-83.33**	6.53**	131.22**	2.51**	8.72**	1434.319**
	C_2	-2.20	-3.80*	1.47	3.73*	147.42**	0.19	-2.04	10.868*
	C_3	-37.40**	-45.00**	-64.00**	9.20**	142.48**	-1.58**	-15.25**	804.15**
Green fruit yield per plant (g)	C_1	154.91**	-98.08**	188.82**	32.09**	393.79**	12.94**	-19.61**	415.176**
	C_2	-13.59**	-7.71**	-4.56**	8.37**	421.66*	4.40*	-10.88**	4.193
	C_3	102.32**	106.43**	-159.69**	24.53**	407.42**	4.67*	-39.56**	314.014**
Days to last picking	C_1	14.53**	26.00**	68.00**	13.73**	124.78**	-1.64**	4.32**	630.665**
	C_2	15.13**	-9.20**	33.40**	13.73**	123.04**	0.71	2.38**	290.236**
	C_3	5.93**	4.07**	15.20**	2.60**	128.23**	-7.13**	6.29**	16.536**
Capsaicin content (ppm)	C_1	-0.028	-0.15**	-0.062**	0.12**	0.67**	0.00	0.11**	258.891**
	C_2	-0.188**	-0.133**	-0.285**	0.018	0.743**	0.024**	-0.087**	261.586**
	C_3	-0.028	-0.053**	-0.141**	-0.03	0.752**	0.046**	0.115**	44.989**

C1 = Jwala x DPL-C-5, C2= Jwala x AKC-08-95-05 and C3=Jwala x Parbhani Tejas, i= additive x additive type gene interaction, j= additive x dominance type gene interaction and l= dominance x dominance type gene interaction, Significant value of A and B indicates the presence of i, j and l type of gene interaction. Significant value of C indicates the presence of l type of gene interaction. Significance valued of D indicates the presence of presence of i type of gene interaction, and significant of both C and D scales indicate i and l type of gene interaction. A significant $\chi 2$ value indicates the inadequacy of three parameter model. * P<0.05, ** P<0.01 respectively.

DOI: 10.5958/0975-928X.2017.00015.1

Table 2. Estimates of gene effects for yield and yield contributing traits in chilli using six parameter model

Traits	Crosses	m	d	h	i	j	l	Epistasis gene action
Days to first flowering	C_1	82.98**	-1.80*	-15.47**	-11.00**	-0.67	13.00**	Complementary
	C_2	85.82**	9.00**	-21.73**	-20.73**	9.67**	0.20	-
	C_3	80.85**	2.83**	-7.60**	-10.93**	8.63**	29.67**	Duplicate
Days to first picking	C_1	95.78**	-2.23**	-30.60**	-30.40**	-3.50**	13.80**	Duplicate
	C_2	85.13**	0.87	10.13**	11.20**	0.87	-23.47**	Duplicate
	C_3	90.02**	0.20	-13.23**	-11.67**	6.70**	27.73**	Duplicate
Plant height (cm)	C_1	60.32**	1.65	1.47	1.77	0.28	13.13*	-
	C_2	65.52**	0.07	-13.70**	-15.67**	-2.17	28.27**	-
	C_3	61.98**	-0.20	-4.17	-	-	-	-
No. of branches per plant	C_1	6.35**	0.35	-3.33**	-1.57*	0.58*	3.40**	Duplicate
	C_2	6.78**	0.15	-4.33**	-4.23**	-0.15	6.78**	Duplicate
	C_3	7.28**	1.73**	-5.50**	-4.30**	1.33**	3.77**	Duplicate
Fruit length (cm)	C_1	5.64**	-2.86**	5.28**	5.49**	-4.65**	-9.31**	Duplicate
	C_2	5.37**	3.09**	3.39**	4.82**	2.09**	-6.22**	Duplicate
	C_3	5.22**	0.31**	1.78**	1.84**	-0.81**	2.65**	Complementary
Fruit Diameter (mm)	C_1	8.97**	3.27**	3.65**	2.61**	3.21**	-1.09*	Duplicate
	C_2	10.43**	-1.41**	-2.06**	-2.53**	-0.69**	5.31**	Duplicate
	C_3	10.37**	0.13	2.32**	0.17	0.70**	2.89**	Complementary
No. of seeds per fruit	C_1	64.83**	-3.53**	-10.60**	-1.33	-13.27**	24.80	Duplicate
	C_2	84.57**	-8.37**	-25.10**	-10.07**	-13.87**	-31.27	Complementary
	C_3	84.80**	0.27	-3.70	-2.67	-1.90	-5.67	-
No. of fruits per plant (red)	C_1	80.55**	-1.53	-14.67**	-9.67**	8.93	-40.33	Complementary
	C_2	79.38**	-1.23	12.33**	16.00**	10.83**	-77.93**	Duplicate
	C_3	80.02**	6.38**	-38.50**	-46.50**	21.58**	80.40**	Duplicate
Red fruit yield per plant (g)	C_1	38.14**	-4.37**	-3.13	2.63	3.33**	23.43**	-
	C_2	52.71**	10.63**	-3.25	-6.25*	11.23**	-27.95**	-
	C_3	52.26**	-14.17**	27.15**	28.83**	-8.75**	-86.40**	Duplicate
No. of green fruits per plant	C_1	130.02**	-3.03**	4.97	-13.07**	-8.93**	109.47**	-
	C_2	147.32**	0.77	-9.10*	-7.47*	0.80	13.47**	Duplicate
	C_3	131.22**	1.23	-24.57**	-18.40**	3.80**	100.80**	Duplicate
Green fruit yield per plant (g)	C_1	380.71**	-9.02*	-25.56	-64.17	-28.42	317.16	Duplicate
	C_2	417.40**	1.96	-25.86	-	-	-	-
	C_3	379.19**	2.00	-66.96**	-49.06**	2.05	257.80**	Duplicate
Days to last picking	C_1	137.95**	-6.37**	-28.17**	-27.47**	-5.73**	-13.07	Complementary
	C_2	130.52**	10.83**	-27.13**	-27.47**	12.17**	21.53	Duplicate
	C_3	134.13**	-6.13**	132.93**	-5.20	0.93	-4.80	-
Capsaicin content (ppm)	C_1	0.75	0.01	-0.008	-0.25	-2.48	5.51	-
	C_2	0.672	0.002	-0.097	-0.036	-0.028	0.357	-
	C_3	0.675	0.053	-0.056	0.06	0.012	0.021	-

C1 = Jwala x DPL-C-5, C2= Jwala x AKC-08-95-05 and C3=Jwala x Parbhani Tejas, m=mean, d=additive effect, h= dominance effect, i= additive x additive type gene interaction, j= additive x dominance type gene interaction and l= dominance x dominance type gene interaction. * $P<0.05$, ** $P<0.01$ respectively.