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Generation mean analysis in bottle gourd [*Lagenaria siceraria* (Mol) Standl.]

SN Deokar, VS Jagtap, SA Samindre, SB Gaikwad and PR Sargar

Abstract
The present investigation was conducted at experimental research farm Department of Horticulture, College of Agriculture, Latur, in 2022 with a view to study the genetics of yield and yield components through generation mean analysis. The scaling test exhibited that, there was presence of epistatic gene interaction. The duplicate epistasis were observed in number of branches per vine, Days required for first female flower, node at which first female flower, number of female flower per vine, number of fruit per vine, fruit yield per vine, fruit yield per plot, fruit yield per hectar, downey mildew infestation in all three crosses *viz* LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local , LTR-3 (Chandrapur Local) x LTR-4 (karjat Local) and LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local). This suggest that the need of specific breeding procedure such as intermating of most desirable segregants followed by selfing and selecting superior genotypes coupled with progeny testing to exploit the population under study. Selection in early generation would be effective when additive effect are larger than non- additive ones. Further if the non- additive portions are larger than additive one, the improvement of the character need intensive selection through later generation.

Keywords: Additive, complementary epistasis, dominance, duplicate epistasis, epistasis, gene action

Introduction
Bottle gourd [*Lagenaria siceraria (*Mol) Standl.] the name "Lagenaria" and "siceraria" are derived from Latin words 'Lagena' for bottle and "sicera" for drinking utensil. Bottle gourd is one of the very popular vegetable crop belongs to family cucurbitaceae with a diploid chromosome number 2n=2x=22. Bottle gourd is also known as calabash gourd, locally known as Doothi in Gujrati, Bottle squash, White flowered gourd (English name) Zucca melon, Trumpt gourd, Lauki and Ghiya (in hindi). It is grown in both rainy and summer season and its fruits available in the market throughout the year. The importance of additive and non-additive genetic effects is well established in controlling many traits in bottle gourd. For genetic improvement of the crop, the breeding method to be adopted depends on the nature of gene action involved in the expression of quantitative traits Dhakne *et al*., (2021) [3]. The presence or absence of epistasis can be detected by the analysis of generation means using the scaling test, which measures epistasis accurately, whether it is complimentary or duplicate at the digenic level (Sargar *et al*., 2021) [14] and (Shinde *et al*., (2021) [16]. Two genetic models (Cavalli 1952: and Hayman, 1958) [1, 6] were simultaneously used for determining the nature of gene action involved in the inheritance of yield and yield contributing characters. The information regarding gene action involved in control of inheritance for yield and yield contributing characters through generation mean analysis is of immense use to the plant breeder to decide suitable breeding strategy for improvement of these characters.

Materials and Methods
The present investigation was conducted at experimental research farm Department of Horticulture, College of Agriculture Latur, VNMKV Parbhani (M.S.) during *summer*-2021 and *kharif* 2021. By hand emasculation and pollination, two crosses involving three genetically diverse parents *viz*., LTR-1 (Aurangabad Local), LTR-2 (Ahmbednagar Local), LTR-3 (Chandrapur Local), LTR-4 (Karjat Local), LTR-5 (Buldhana Local) were affected in summer, 2021. For advance the F2's and to prepare BC1 and BC2 crosses, the F1's and parents were grown in kharif 2021. Thus, seed of six generation, P_1, P_2, F_1, F_2, BC_1 and BC_2 of three crosses were produced. In Randomized Block Design three different bottle gourd crosses were sown during kharif 2021, from the experimental material comprised of six generations *viz*., P_1, P_2, F_1, F_2, BC_1 and BC_2 and replicated twice.

Five plants are selected from each generation, except F2, from which twenty plants are selected. From all the selected plants which are chosen randomly in each genotype, fourteen observations of quantitative character were recorded. Data were first evaluated for non-allelic interaction by individual scaling tests (A, B, C, D) as described by Hayman and Mather (1955) [18] were used to check the adequacy of additive dominance model in each cross. Further, the chi- square value for fourteen characters in all the crosses were calculated as per the method of Joint scaling test proposed by Cavalli (1952) [1]. If Chi-square value for character was nonsignificant, it indicated the absence of higher order interaction and linkage. In presence of non-allelic interactions various gene effects were estimated using six parameter model suggested by Hayman (1958) [6].

Result and Discussion

The results of generation mean analysis of six genetic populations (P1, P2, F1, F2, BC1 and BC2) of three crosses (LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local), LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local) and LTR-3 (Chandrapur Local) x LTR-4 (karjat Local)) for fourteen different traits in bottle gourd are discussed here. Scaling tests were significant suggesting the presence of digenic interaction in the inheritance of these characters are presented in Table 1 and 2. The individual scaling tests A, B, C and D revealed the presence of epistasis for most of the traits in all the crosses. The generation means, a six parameter model involving three digenic interaction parameters proposed by Hayman (1958) [6] was applied. The highly significant mean values from the generation mean analysis in three crosses showed that, the six generation differed from each other and these all studied traits are quantitatively inherited. The additive (d) effect found significant and positive for length of vine, number of female flower per vine, number of fruit per vine, fruit yield per plot, fruit yield per hectar in cross, LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local). The additive (d) effect was found positively significant for number of node per plant and length of vine in cross, LTR-3 (Chandrapur Local) x LTR-4 (karjat Local). Similar results was noted with previous findings by Quamruzzaman *et al*. (2010) [12], Adarsh *et al*. (2016) [19], Gautam and Yadav (2017) [4]. For number of branches per vine, days require for first female flower, node at which first female flower, days require for first harvest, the additive (d) effect found significant and negative in cross, LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local). For length of vine, node at which first female flower, downy mildew the additive (d) effect found negatively significant in crosses, LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local). The additive component of variation can be exploited by simple pedigree selection.

The hybrid showing positive and significant dominance (h) effects for length of vine, number of branches per vine, node at which first female flower, number of node per plant, number of female flower per vine, number of fruit per vine, fruit yield per vine, fruit yield per plot, fruit yield per hectar was observed in crosses, LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local). Similar results was noted with previous findings by Jha *et al*. (2017), Mishra *et al*. (2018) [20], Hadiya *et al*. (2020), Maurya *et al*. (2020). For number of branches per vine, node at which first female flower, number of female flower per vine, number of fruit per vine, fruit yield per vine, fruit yield per plot, fruit yield per hectar of cross, LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local) exhibited positive and significant dominance (h) gene effect. For the traits, length of vine, number of branches per vine, node at which first female flower, number of female flower per vine, number of fruit per vine, fruit yield per vine, fruit yield per plot, fruit yield per hectar cross, LTR-3 (Chandrapur Local) x LTR-4 (karjat Local) exhibited positively significant dominance (h) gene effect. The hybrid shows negative and significant dominance (h) effects for number of node per plant was observed in cross, LTR-3 (Chandrapur Local) x LTR-4 (karjat Local). Greater importance of dominance effect in the expression of all the studied traits, was estimated through result by estimating magnitude of dominance (h) component, which was higher than that of additive (d) gene effect. For the exploitation of dominance effect non-conventional breeding procedure might be adopted. Epistasis gene effects are known to contribute a sizable part of variation in the genetic makeup of character which shows higher estimate of dominance effects (Gamble, 1962). In the present investigation also, high estimate of dominance (h) effect for above traits were associated with significant epistasis interaction in the respective crosses.

For length of vine, number of branches per vine, number of node per plant, number of female flower per vine, number of fruit per vine, fruit yield per vine, fruit yield per plot, fruit yield per hectar for additive x additive (i) gene effect found positive and significant in all three cross, LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local), LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local) and LTR-3 (Chandrapur Local) x LTR-4 (karjat Local). For node at which first female flower for additive x additive (i) gene effect found positive and significant in cross, LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local) and LTR-3 (Chandrapur Local) x LTR-4 (karjat Local) and days to require first harvest for additive x additive (i) gene effect found positive and significant in cross LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local). For number of node per plant for additive x additive (i) gene effect found significant and negative in all three cross, LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local) and LTR-3 (Chandrapur Local) x LTR-4 (karjat Local).

For length of vine, number of female flower per vine, number of fruit per vine and fruit yield per hectar for additive x dominance (j) gene effect found positive and significant in cross, LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local). For days to require first female flower for additive x dominance (j) gene effect found positively significant in cross, LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local). For length of vine and number of node per plant for additive x dominance (j) gene effect found positive and significant in cross, LTR-3 (Chandrapur Local) x LTR-4 (karjat Local).For number of branches per vine, node at which first female flower and days to require first harvest for additive x dominance (j) gene effect found significant and negative in cross, LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local). For length of vine and downy mildew for additive x dominance (j) gene effect found negatively significant in cross, LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local).

The sign of dominance x dominance (l) effects were negative for number of branches per vine, number of node per plant, number of female flower per vine, days to require first harvest, number of fruit per vine, fruit yield per vine, fruit yield per plot and downey mildew in cross, LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local). For length of

vine, number of branches per vine, days to require first female flower, number of female flower per vine, fruit yield per vine, fruit yield per plot, fruit yield per hectar and downy mildew for dominance x dominance (l) effects were negative in cross LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local).

The sign of dominance x dominance (l) effects were found positively significant in length of vine and fruit yield per hectar, in cross, LTR-1 (Aurangabad Local) x LTR- 75 5 (Buldhana Local) and for number of node per plant in cross, LTR-3 (Chandrapur Local) x LTR-4 (karjat Local) dominance x dominance (l) effects were positively significant.

The sign of dominance (h) and dominance x dominance (l) parameter being opposite indicates involvement of duplicate type of epistasis in the inheritance of a trait. Such type of gene action also observed for various traits in the present investigation. The presence of duplicate epistasis would be detrimental for rapid progress, making it difficult to fix genotypes with increased level of character manifestation because the opposite effect of one parameter would be cancelled out by the negative effect of another parameter. The duplicate epistasis were observed in number of branches per vine, days require for first female flower, node at which first female flower appeared, number of female flower per vine, number of fruit per vine, fruit yield per vine, fruit yield per plot, fruit yield per hectar and downy mildew in all three crosses, LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local), LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local) and LTR-3 (Chandrapur Local) x LTR-4 (karjat Local). In cross, LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local) and LTR-3 (Chandrapur Local) x LTR-4 (karjat Local), duplicate epistasis were observed for traits like number of node per plant, days to require first harvest. In cross, LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local and LTR-3 (Chandrapur Local) x LTR-4 (karjat Local) duplicate epistasis was observed for trait length of vine.

The involvement of complementary epistasis in the expression of a trait indicated by the similar sign of dominance (h) and dominance x dominance (l) parameter. Complementary epistasis were observed for number of node per plant and days to require first harvest in cross, LTR-1 (Aurangabad Local) x LTR-5 (Buldhana Local. For length of vine, complementary epistasis was observed in crosses LTR-2 (Ahemdnagar Local) x LTR-4 (karjat Local). Similar results was noted with previous findings by Quamruzzaman *et al*. (2010) [12], Adarsh *et al*. (2016) [19], Gautam and Yadav (2017) [4].

Table 1: Scaling test and joint scaling test for different characters in three crosses in bottle gourd.

Crosses	A	B	C	D	X^2 values
Length of vine (cm)					
Aurangabad Local x Buldhana Local	351.56**±24.42	174.38**±32.74	-334.89**±16.72	-430.42**±19.93	S
Ahemdnagar Local x Karjat Local	-444.69**±16.86	46.52±18.81	-626.87**±29.33	-99.35**±7.37	S
Chandrapur Local x Karjat Local	350.54**±15.17	-342.81**±10.40	-172.13**±9.16	-89.93**±10.06	S
Number of branches per vine					
Aurangabad Local x Buldhana Local	-1.30±0.16	3.50**±0.23	-6.40±0.34	-4.30*±0.12	
Ahemdnagar Local x Karjat Local	0.70±0.10	0.10±0.60	-9**±0.16	-4.90**±0.30	S
Chandrapur Local x Karjat Local	6.10**±0.41	4.80**±0.20	0	-5.45**±0.20	S
Days required for first female flower					
Aurangabad Local x Buldhana Local	-3.55±1.50	12.80**±0.30	7.05±0.56	-1.10±0.74	S
Ahemdnagar Local x Karjat Local	9.00**±0.20	-3.80±0.10	-1.60±0.14	-3.40±0.10	S
Chandrapur Local x Karjat Local	12.20**±1.23	7.50±0.72	7.70±1.85	-6.00±0.90	S

Crosses	A	B	C	D	X^2 values
Node at which first female flower					
Aurangabad Local x Buldhana Local	351.56**±24.42	174.38**±32.74	-334.89**±16.72	-430.42**±19.93	S
Ahemdnagar Local x Karjat Local	-444.69**±16.86	46.52±18.81	-626.87**±29.33	-99.35**±7.37	S
Chandrapur Local x Karjat Local	350.54**±15.17	-342.81**±10.40	-172.13**±9.16	-89.93**±10.06	S
Number of node per plant					
Aurangabad Local x Buldhana Local	46.20**±2.81	45.10**±2.34	12.90**±0.57	-39.20**±1.82	S
Ahemdnagar Local x Karjat Local	-5.60±1.25	-3.60±1.65	7.00±3.25	8.10*±1.27	S
Chandrapur Local x Karjat Local	-6.80±4.41	-65.00**±4.05	-30.40**±2.33	20.70**±2.91	S
Number of female flower flower per vine					
Aurangabad Local x Buldhana Local	7.51**±0.81	-2.14±0.69	-7.63**±0.35	-6.50**±0.52	S
Ahemdnagar Local x Karjat Local	4.40**±0.08	3.10*±040	-730**±0.08	-7.40**±0.20	S
Chandrapur Local x Karjat Local	2.40**±0.09	2.50**±0.35	-4.30**±0.34	-4.60**±0.22	S

Crosses	A	B	C	D	X^2 values
Fruit yield per plot (kg)					
Aurangabad Local x Buldhana Local	16**±1.36	4.85**±1.20	-19.39±1.56	-20.12**±0.67	S
Ahemdnagar Local x Karjat Local	0.99±1.91	2.89±0.22	-37.40**±1.31	-20.64**±0.71	S
Chandrapur Local x Karjat Local	8.76±0.96	7.01±0.95	-29.95**±1.57	-22.86**±0.61	S
Fruit yield per hectar (q)					
Aurangabad Local x Buldhana Local	80**±6.80	23.75±5.87	-101.25**±7.91	-102.50**±3.37	S
Ahemdnagar Local x Karjat Local	4.95±9.55	14.45±1.11	-189.70**±6.55	-104.55**±3.53	S
Chandrapur Local x Karjat Local	43.80±4.80	34.55±4.68	-149.75**±7.89	-114.05**±3.01	S
Downy mildew(%)					
Aurangabad Local x Buldhana Local	1.40*±0.08	1.90**±0.05	2.6**±0.10	-0.35±0.04	S
Ahemdnagar Local x Karjat Local	-1.30**±0.05	1.80**±0.08	1.60*±0.08	0.55±0.04	S
Chandrapur Local x Karjat Local	1.55*±0.05	2.15*±0.09	2.30*±0.12	-0.70±0.04	S

Crosses	A	B	C	D	X^2 values
Days to require first harvest					
Aurangabad Local x Buldhana Local	1.20±0.20	24.10**±1.4	25.70**±1.25	0.20±0.92	S
Ahemdnagar Local x Karjat Local	18.50**±0.70	20.70**±0.71	13.70*±0.57	-12.75**±0.47	S
Chandrapur Local x Karjat Local	11.80**±0.67	12.10**±0.69	7.40±1.64	-8.25±0.59	S
Number of fruit per vine					
Aurangabad Local x Buldhana Local	2.40**±0.34	-0.70±0.07	-2.80*±0.15	-2.25**±0.17	S
Ahemdnagar Local x Karjat Local	-1.10±0.10	-0.20±0.01	-6.40**±0.15	-2.55**±0.06	S
Chandrapur Local x Karjat Local	0.70±0.22	-1.10±0.20	-5.20**±0.21	-2.40**±0.17	S
Fruit yield per vine (kg)					
Aurangabad Local x Buldhana Local	1.60**±0.13	0.48±0.12	-2.02*±0.15	-2.05**±0.06	S
Ahemdnagar Local x Karjat Local	0.10±0.19	0.29±0.02	-3.77**±0.13	-2.08**±0.07	S
Chandrapur Local x Karjat Local	0.88±0.09	0.70±0.09	-2.99**±0.16	-2.29**±0.06	S

*and** significant at 5 and 1 per cent level, respectively.

Table 2: Estimates of gene effects in three crosses for different characters in bottle gourd.

Crosses	m	d	h	I	j	*l*	Types of Epistasis
Length of vine (cm)							
Aurangabad Local x Buldhana Local	410.00**±1.60	104.58**±19.67	809.69**±40.60	860.84**±39.86	88.59**±19.69	1386.78**±80.44	Duplicate
Ahemdnagar Local x Karjat Local	402.75**±1.40	-118.90**±6.81	18.68±20.60	198.700**±14.74	-230.60**±8.08	229.47±40.05	Complementary
Chandrapur Local x Karjat Local	476.96**±2.16	262.20**±9.07	215.55**±20.17	179.86**±404.86	346.68**±9.19	-187.59**±37.45	Duplicate
Number of branches per vine							
Aurangabad Local x Buldhana Local	14.90**±0.04	-2.50**±0.07	8.60*±0.28	8.60*±0.24	-2.40*±0.12	-10.80*±0.45	Duplicate
Ahemdnagar Local x Karjat Local	12.60**±0.03	-1.30±0.30	7.70**±0.61	9.80**±0.61	0.30±0.30	-10.60*±1.21	Duplicate
Chandrapur Local x Karjat Local	11.87**±0.004	0.40±0.20	11.15**±0.41	10.90**±0.40	0.65±0.22	-21.80**±0.83	Duplicate

Crosses	m	d	h	I	j	*l*	Types of Epistasis
Days required for first female flower							
Aurangabad Local x Buldhana Local	71.10**±0.04	-8.10**±0.74	4.52±1.51	2.20±1.49	-8.17±0.75	-11.45±3.01	Duplicate
Ahemdnagar Local x Karjat Local	67.45**±0.06	2.30±0.10	7.30±0.21	6.80±0.21	6.40*±0.11	-12.00±0.42	Duplicate
Chandrapur Local x Karjat Local	73.60**±0.35	-1.20±0.57	11.45±3.65	12.00±1.81	2.35±0.57	-31.70**±2.94	Duplicate
Node at which first female flower							
Aurangabad Local x Buldhana Local	4.95**±0.03	-4.66**±0.18	4.84*±0.47	2.88±0.38	-3.68*±0.33	-1.32±0.92	Duplicate
Ahemdnagar Local x Karjat Local	5.37**±0.004	-2.10**±0.07	6.40**±0.02	6.30**±0.15	-1.60±0.09	-5.90±0.32	Duplicate
Chandrapur Local x Karjat Local	4.87**±0.02	-0.20±0.03	5.85**±0.11	4.90**±0.10	0.25±0.05	-2.80±0.18	Duplicate

Crosses	m	d	h	I	j	*l*	Types of Epistasis
Number of node per plant							
Aurangabad Local x Buldhana Local	25.35**±0.07	-0.30±1.82	86.75**±3.66	78.40**±3.65	0.55±1.82	-169.70**±7.31	Complementary
Ahemdnagar Local x Karjat Local	55.10**±0.56	2.70±0.60	-7.10±2.80	-16.20*±2.54	-1.00±0.63	25.40±4.04	Duplicate
Chandrapur Local x Karjat Local	48.05**±0.23	28.20**±2.87	-43.90**±5.93	-41.40**±5.83	29.10**±2.92	113.20**±11.75	Duplicate
Number of female flower flower per vine							
Aurangabad Local x Buldhana Local	10.25**±0.04	6.20**±0.52	11.06**±1.06	13.00**±1.05	4.82**±0.53	-18.37**±2.11	Duplicate
Ahemdnagar Local x Karjat Local	7.95**±0.008	-1.50±0.20	13.45**±0.40	14.80**±0.40	0.65±0.20	-22.30**±0.81	Duplicate
Chandrapur Local x Karjat Local	6.45**±0.07	0.50±0.16	9.35±**0.45	9.20**±0.44	-0.05±0.17	-14.10**±0.74	Duplicate

Crosses	m	d	h	I	j	*l*	Types of Epistasis
Days to require first harvest							
Aurangabad Local x Buldhana Local	85.90**±0.30	-11.00**±0.70	-0.55±1.86	-0.40±1.85	-11.45**±0.70	-24.90**±3.07	Complementary
Ahemdnagar Local x Karjat Local	78.87**±0.07	-1.70±0.44	11.80±0.97	25.50**±0.94	-1.10±0.49	-64.70**±1.88	Duplicate
Chandrapur Local x Karjat Local	80.62**±0.27	-0.30±0.21	10.55±1.77	16.50±1.18	-0.15±0.22	-40.40**±1.84	Duplicate
Number of fruit per vine							
Aurangabad Local x Buldhana Local	6.02**±0.02	1.50*±0.16	4.65**±0.35	4.50**±0.34	1.55*±0.16	-6.20*±0.68	Duplicate
Ahemdnagar Local x Karjat Local	5.72**±0.02	-0.60±0.04	3.85**±0.14	5.10**±0.12	-0.45±0.07	-3.80±0.24	Duplicate
Chandrapur Local x Karjat Local	5.50**±0.04	0.40±0.14	4.80**±0.34	4.80**±0.34	0.90±0.15	-4.40±0.60	Duplicate

Crosses	m	d	h	I	j	*l*	Types of Epistasis
Fruit yield per vine (kg)							
Aurangabad Local x Buldhana Local	3.77**±0.007	0.79±0.06	3.99**±0.15	4.11**±0.13	0.55±0.07	-6.19**±0.31	Duplicate
Ahemdnagar Local x Karjat Local	3.97**±0.003	-0.44±0.07	4.51**±0.15	4.16**±0.14	-0.09±0.09	-4.55*±0.31	Duplicate
Chandrapur Local x Karjat Local	3.84**±0.02	0.11±0.04	4.83**±0.13	4.58**±0.12	0.08±0.05	-6.16**±0.22	Duplicate
Fruit yield per plot (kg)							
Aurangabad Local x Buldhana Local	37.96**±0.03	7.95*±0.67	39.11**±1.56	40.24**±1.35	5.57±0.76	-61.09**±3.10	Duplicate
Ahemdnagar Local x Karjat Local	39.78**±0.03	-4.40±0.70	44.84**±1.56	41.28**±1.42	-0.95±0.96	-45.16**±3.12	Duplicate
Chandrapur Local x Karjat Local	38.47**±0.22	1.10±0.40	48.28**±1.38	45.72**±1.22	0.87±0.58	-61.49**±2.25	Duplicate

Crosses	m	d	h	I	j	*l*	Types of Epistasis
Fruit yield per hectar (q)							
Aurangabad Local x Buldhana Local	188.75**±0.36	40.00**±3.30	199.37**±7.79	205.00**±6.75	28.12*±3.78	308.75**±15.38	Duplicate
Ahemdnagar Local x Karjat Local	198.22**±0.06	-22.00±3.53	226.90**±7.79	209.10**±7.07	-4.75±4.80	-228.50**±15.58	Duplicate

Chandrapur Local x Karjat Local	192.35**±1.14	5.75±1.96	240.92**±6.84	228.10**±6.03	4.62±2.87	-306.45**±11.14	Duplicate
Downy mildew (%)							
Aurangabad Local x Buldhana Local	1.90**±0.01	-0.35±0.03	0.40±0.10	0.70±0.09	-0.25±0.04	-4.00**±0.18	Duplicate
Ahemdnagar Local x Karjat Local	3.05**±0.008	-1.45**±0.03	-1.40±0.09	-1.10±0.08	-1.55**±0.04	0.60±0.17	Duplicate
Chandrapur Local x Karjat Local	4.30**±0.01	-0.20±0.02	2.15±0.09	1.4±0.08	-0.30±0.04	-5.10*±0.15	Duplicate

*and** significant at 5 and 1 per cent level, respectively

Conclusion

In crosses for some characters duplicate epistasis were involved. This suggests the need of specific breeding procedure such as intermating of most desirable segregants followed by selfing and selecting superior genotypes coupled with progeny testing to exploit the population under study. Also, these traits might be improved through recurrent selection in bi-parental progenies that would help in exploiting the duplicate type of non-allelic interaction and allow recombination and concentration of gene having cumulative effects in population as this method is helpful in breaking up undesirable linkage. When additive effects are larger than non-additive ones, selection in early generation would be effective, while if the non-additive portions are larger than additive one, the improvement of the character need intensive selection through later generations. Also, the characters controlled by additive gene effect can be improved by pedigree method of selection. In contrast to it other characters were controlled by or non-additive gene effects in different crosses, hence those could be successfully improved by heterosis breeding or hybridization.

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