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Generation mean analysis with respect of yield and percent incidence of fruit borer and yellow vein mosaic virus (YVMV) in Okra (*Abelmoschus esculents* L. Moench.)

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Abstract

The nature and magnitude of gene action was analyzed by six generation mean for yield and percent incidence of fruit borer and yellow vein mosaic virus (YVMV) contributing characters in six inter varietals crosses of okra. The results revealed that both additive (d) and dominance (h) gene effects were significant for majority of the traits in all the six crosses studied, however the magnitude of dominance (h) gene effects was much higher than the additive (d) effects in all the crosses for majority of the traits which indicated pre-dominant role of dominance (h) gene effects in the inheritance of yield and its related traits. Study indicated that dominance gene effects for yield and yield contributing characters were of prime importance. All the characters recorded significant additive (d) and dominance (h) gene effect but the magnitude of dominance (h) gene effect was higher. Among the non-allelic interactions, additive x additive (i) and dominance x dominance (l) were found significant, the opposite sign of dominance (h) and dominance x dominance interaction (l) indicated that both the characters are controlled by duplicate type of epistasis. So, further improvement could be expected through bi-parental mating or reciprocal recurrent selection.

Keywords: Okra, *Abelmoschus esculents*, generation mean analysis, YVMV, gene effects, epistasis

Introduction

Okra is one of the important vegetables grown for its immature non-fibrous edible pods in tropical and sub-tropical parts of the world. Study of nature and magnitude of gene effects governing the inheritance of quantitative characters is of prime importance in formulating breeding methods used for crop improvement programme. In self-pollinated crops an approach based on generation mean analysis has particular suitability as in addition to additive (d) and dominance (h) gene effect, it also estimate the type of epistasis present. In present investigation, an attempt has been made to estimate gene effects operative for control of yield and percent incidence of fruit borer and yellow vein mosaic virus (YVMV) contributing characters by using six generation means in six inter varietals crosses of okra.

Materials and Methods

The experimental material in present investigation comprises the five parents viz., Parbhani Kranti, Parbhani Bhendi, Pusa A-4, Punjab-8 and IC-282273 of the six inter varietal crosses of *Abelmoschus esculentus* (L.) Moench viz. Parbhani Kranti x Punjab-8, Parbhani Bhendi x Punjab-8, Parbhani Bhendi x IC-282273, Pusa A-4 x IC-282273, Punjab-8 x IC-282273, their respective parents, F₂'s, BC₁ and BC₂ populations. The material was grown in randomized block design (RBD) with two replications on Instructional-cum Research Farm, Department of Horticulture, College of Agriculture, Latur, during the *Kharif* season of 2014 and analysis during 2015. The experimental plot size is 1.8 m x 1.5 m. and spaced at 30 cm x 15 cm between rows and plants in separate RBD for each crosses and replication. Recommended all agronomical practices was followed for okra. Simple scaling test A, B, C and D of Hayman (1958) ^[7] was used to detect presence of the epistasis. Chi-square value for 10 characters in all the crosses were calculated as per the method of Joint scaling test proposed by Cavalli (1952) ^[6] and presented in it was observed that character's Chi-square value was non-significant indicating absence of higher order interaction and linkage. Six parameter model given by Hayman (1958) ^[7] used to obtain estimate of m, d, h, i, j and l parameters.

Result and Discussion

Before any model is fitted to estimate gene actions involved in yield and percent incidence of fruit borer and yellow vein mosaic virus (YVMV), scaling tests were performed as given by

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Hayman (1958)^[7]. The scaling tests A, B, C and D (Table 1), indicated presence of appreciable amount of epistasis in different characters, except in cross Parbhani Kranti x Punjab-8 for initiation of first flowering bud, number of days first for harvest and yield per hectare (tonnes); in Parbhani Bhendi x Punjab-8 for fruits yield per plant(g) and percent incidence of fruit borer; in cross Parbhani Bhendi x IC-282273 for number of days first for harvest and fruits yield per plant(g) and in cross Pusa A-4 x IC-282273 for initiation of first flowering bud, number of days first for harvest and yield per hectare (tonnes). Presence of epistatic gene action for yield and its related traits have been reported earlier by Panda and Singh (2003)^[11], Akhtar *et al.* (2010)^[3], Mistry (2013)^[10] and Soher *et al.* (2013)^[16] which supported the present results.

The chi square (χ^2) values were significant according to joint scaling test for the all traits in each crosses studied. The significant value of chi square for all the traits in all the crosses indicated that the three parameter model did not adequately explain the genetic variability for this trait. The inadequacy of the model also indicated the presence of epistasis (non-allelic gene interaction), which is also inferred from the generation means. As the three parameter model did not satisfactorily explain the genetic variability for all the traits, therefore, a six parameter model was applied to accommodate epistatic interactions.

Based upon the present findings the gene actions involved in the inheritance of various characters affecting yield and its components are discussed in (Table 2) below.

Table 1: Scaling test for 10 characters in 5 crosses of okra.

Character and crosses	A	B	C	D	X ² values
Initiation of first flowering bud					
Parbhani kranti x Punjab-8	-1.00±0.66	1.50±1.01	-16.50**±0.68	-8.50**±0.68	S
Parbhani Bhendi x Punjab-8	8.00**±0.33	5.50**±0.37	8.50**±0.76	-2.50**±0.37	S
Parbhani Bhendi x IC-282273	4.00**±0.33	10.00**±0.33	20.00**±0.81	3.00**±0.33	S
Pusa A-4 x IC-282273	9.50**±0.68	1.50±1.01	-4.00**±1.35	-7.50**±0.89	S
Punjab-8 x IC-282273	6.50**±0.16	4.50**±0.37	4.00**±1.35	-3.50**±0.68	S
Number of days first harvest					
Parbhani kranti x Punjab-8	3.00**±0.74	6.00**±0.57	10.00**±1.52	0.50±0.76	S
Parbhani Bhendi x Punjab-8	6.00**±0.47	8.00**±0.57	5.00**±1.05	-4.50**±0.37	S
Parbhani Bhendi x IC-282273	8.00**±0.47	7.00**±0.33	18.00**±2.05	1.50±1.01	S
Pusa A-4 x IC-282273	7.50**±0.50	3.00**±0.47	1.50±0.76	-4.50**±0.16	S
Punjab-8 x IC-282273	8.00**±0.52	4.00**±0.40	3.00**±0.91	-4.50**±0.37	S
Fruit yield per plant (g)					
Parbhani kranti x Punjab-8	129.82**±5.82	40.41*±16.08	269.27**±6.85	49.52**±8.13	S
Parbhani Bhendi x Punjab-8	36.78**±6.30	-72.08**±10.90	-26.19±16.91	4.55±10.01	S
Parbhani Bhendi x IC-282273	1.03±4.54	-33.81**±11.88	47.50**±11.27	40.14**±7.92	S
Pusa A-4 x IC-282273	-22.93**±7.61	11.42*±5.17	-109.83**±20.43	-49.16**±10.93	S
Punjab-8 x IC-282273	-33.65**±2.39	-58.30**±7.98	-145.37**±4.94	-26.70**±4.18	S
Yield per hectare (tonnes)					
Parbhani kranti x Punjab-8	-2.03**±0.06	1.05**±0.31	0.07±0.19	0.53**±0.14	S
Parbhani Bhendi x Punjab-8	-3.20**±0.14	-4.60**±0.46	4.12**±0.50	5.96**±0.10	S
Parbhani Bhendi x IC-282273	-0.89*±0.33	-3.06**±0.21	-5.60**±0.18	-0.82**±0.18	S
Pusa A-4 x IC-282273	-2.06*±0.79	-1.63*±0.60	-3.79**±0.79	-0.05±0.60	S
Punjab-8 x IC-282273	-0.83**±0.23	-2.54**±0.14	0.71**±0.16	2.04**±0.12	S
Incidence of fruit borer (%)					
Parbhani kranti x Punjab-8	-9.53**±0.48	-5.43**±0.04	-1.02**±0.17	6.97**±0.23	S
Parbhani Bhendi x Punjab-8	-6.28**±0.16	-2.26**±0.02	0.90±0.86	4.72**±0.43	S
Parbhani Bhendi x IC-282273	-1.05**±0.37	-2.68**±0.31	8.70**±0.37	6.22**±0.18	S
Pusa A-4 x IC-282273	-7.49**±0.39	-3.63**±0.23	3.46**±0.38	7.29**±0.17	S
Punjab-8 x IC-282273	-7.09**±0.37	-7.07**±0.42	-0.95**±0.19	6.60**±0.28	S
Incidence of YVMV (%)					
Parbhani kranti x Punjab-8	-3.07**±0.15	-2.07**±0.03	-2.32**±0.08	1.41**±0.08	S
Parbhani Bhendi x Punjab-8	2.07**±0.20	1.56**±0.08	7.41**±0.16	1.89**±0.08	S
Parbhani Bhendi x IC-282273	-5.51**±0.03	-0.99**±0.06	-1.75**±0.08	2.37**±0.00	S
Pusa A-4 x IC-282273	-2.99**±0.02	-2.93**±0.01	-2.55**±0.07	1.68**±0.03	S
Punjab-8 x IC-282273	-3.61**±0.02	-2.78**±0.03	-6.15**±0.04	0.12**±0.00	S

*, **significance at 5% and 1 % respectively.

Table 2: Estimates of gene effects of 5 crosses for 10 characters in okra.

Character and crosses	m	d	h	i	j	l	Types of epistasis
Initiation of first flowering bud							
Parbhani kranti x Punjab-8	35.50**±0.16	-3.50**±0.60	17.75**±1.37	17.00**±1.37	-1.25**±0.60	-17.50**±2.50	Duplicate
Parbhani Bhendi x Punjab-8	41.50**±0.16	0.50**±0.16	4.25**±0.76	5.00**±0.74	1.25**±0.25	-18.50**±1.01	Duplicate
Parbhani Bhendi x IC-282273	43.50**±0.16	-4.00**±0.00	-9.00**±0.70	-6.00**±0.66	-3.00**±0.23	-8.00**±0.81	Complimentary
Pusa A-4 x IC-282273	39.00**±0.33	2.50**±0.60	17.00**±1.79	15.00**±1.79	4.00**±0.61	-26.00**±2.75	Duplicate
Punjab-8 x IC-282273	42.00**±0.33	0.50**±0.67	7.00**±1.37	7.00**±1.37	1.00**±0.20	-18.00**±1.50	Duplicate
Number of days first harvest							
Parbhani kranti x Punjab-8	48.00**±0.33	-3.50**±0.37	-2.00±1.57	-1.00±1.52	-1.50**±0.40	-8.00**±2.13	Complimentary
Parbhani Bhendi x Punjab-8	48.50**±0.16	0.50**±0.16	4.50**±0.85	9.00**±0.74	-1.00**±0.28	-23.00**±1.24	Duplicate
Parbhani Bhendi x IC-282273	51.50**±0.50	-0.50**±0.16	-7.00**±2.04	-3.00±2.02	0.50±0.28	-12.00**±2.16	Complimentary
Pusa A-4 x IC-282273	49.00**±0.00	0.50**±0.16	9.75**±0.50	9.00**±0.33	2.25**±0.25	-19.50**±1.01	Duplicate
Punjab-8 x IC-282273	50.50**±0.16	0.50**±0.16	8.50**±0.80	9.00**±0.74	2.00**±0.31	-21.00**±1.13	Duplicate
Fruit yield per plant (g)							
Parbhani kranti x Punjab-8	199.22**±0.47	53.66**±8.08	-97.43**±16.60	-99.04**±16.27	44.70**±8.37	-71.19**±33.04	Complimentary
Parbhani Bhendi x Punjab-8	144.73**±4.03	58.35**±5.93	35.31±20.18	-9.11±20.02	54.43**±6.13	44.41±29.15	Complimentary
Parbhani Bhendi x IC-282273	144.31**±2.59	32.91**±5.98	-44.42**±15.99	-80.28**±15.84	17.42**±6.33	113.06**±26.47	Duplicate
Pusa A-4 x IC-282273	105.74**±5.03	14.06**±4.26	104.19**±21.93	98.33**±21.86	-17.17**±4.59	-86.82**±26.61	Duplicate
Punjab-8 x IC-282273	92.62**±0.88	23.88**±3.79	90.16**±8.55	53.41**±8.37	12.32**±4.16	38.55**±15.96	Complimentary
Yield per hectare (tonnes)							
Parbhani kranti x Punjab-8	10.77**±0.02	-1.57**±0.13	0.02±0.30	-1.06**±0.29	-1.54**±0.16	2.04**±0.58	Complimentary
Parbhani Bhendi x Punjab-8	12.52**±0.03	1.18**±0.07	-10.39**±0.31	-11.93**±0.20	0.70**±0.23	19.73**±0.57	Duplicate
Parbhani Bhendi x IC-282273	10.35**±0.01	1.20**±0.18	2.99**±0.38	1.65**±0.37	1.08**±0.19	2.30**±0.75	Complimentary
Pusa A-4 x IC-282273	10.70**±0.18	1.57**±0.48	-2.09±1.22	0.10±1.21	-0.21±0.50	3.59±2.08	Duplicate
Punjab-8 x IC-282273	10.87**±0.01	0.66**±0.12	-3.55**±0.26	-4.09**±0.25	0.85**±0.13	7.46**±0.51	Duplicate
Incidence of fruit borer (%)							
Parbhani kranti x Punjab-8	11.13**±0.01	-1.11**±0.23	-16.25**±0.47	-13.94**±0.46	-2.05**±0.24	28.90**±0.94	Duplicate
Parbhani Bhendi x Punjab-8	9.66**±0.21	-3.35**±0.05	-11.29**±0.86	-9.45**±0.86	-2.01**±0.08	17.99**±0.89	Duplicate
Parbhani Bhendi x IC-282273	13.17**±0.00	1.22**±0.18	-12.89**±0.41	-12.44**±0.36	0.81**±0.22	16.18**±0.81	Duplicate
Pusa A-4 x IC-282273	11.97**±0.00	-1.60**±0.17	-15.96**±0.40	-14.59**±0.35	-1.93**±0.19	25.72**±0.80	Duplicate
Punjab-8 x IC-282273	10.20**±0.03	-0.07±0.27	-15.38**±0.57	-13.21**±0.57	-0.00±0.28	27.37**±1.12	Duplicate
Incidence of YVMV (%)							
Parbhani kranti x Punjab-8	2.95**±0.07	-0.04±0.07	-4.08**±0.16	-2.82**±0.16	-0.50**±0.08	7.96**±0.31	Duplicate
Parbhani Bhendi x Punjab-8	7.12**±0.01	0.15±0.08	-0.05±0.19	-3.78**±0.17	0.25**±0.10	0.14±0.37	Duplicate
Parbhani Bhendi x IC-282273	2.19**±0.00	-2.01**±0.00	-5.75**±0.04	-4.75**±0.01	-2.26**±0.03	11.25**±0.08	Duplicate
Pusa A-4 x IC-282273	0.85**±0.01	-0.01**±0.00	-6.34**±0.06	-3.37**±0.06	-0.03±0.01	9.29**±0.07	Duplicate
Punjab-8 x IC-282273	0.09**±0.00	-0.07**±0.00	-3.49**±0.02	-0.24**±0.00	-0.41**±0.02	6.63**±0.04	Duplicate

*, **significance at 5% and 1 % respectively.

Initiation of first flowering bud: The initiation of first flowering bud, the additive component (d) was negatively significant in two crosses *i.e.* Parbhani Kranti x Punjab-8 and Parbhani Bhendi x IC-282273. While, in the three crosses *viz.*, Parbhani Bhendi x Punjab-8, Pusa A-4 x IC-282273 and Punjab-8 x IC-282273 observed positively significant effect. Dominance (h) and additive x additive (i) interaction was positively significant in all crosses, except in the cross Parbhani Bhendi x IC-282273 (-6.00) which was observed to be negatively significant. The similar results reported by Singh *et al.* (2012) [15]. Additive x dominance interaction (j) was negatively significant in two crosses Parbhani Kranti x Punjab-8 and Parbhani Bhendi x IC-282273. While, the three crosses *viz.* Parbhani Bhendi x Punjab-8, Pusa A-4 x IC-282273 and Punjab-8 x IC-282273 positively significant. Dominance x dominance interaction (l) effect was negatively significant in all crosses. Duplicate type of interaction was observed to be present in four crosses and the cross Parbhani Bhendi x IC-282273 indicating complimentary type of gene effect.

Number of days for first harvest: The additive (d), dominance (h) and additive x additive (i) were positively significant in three crosses. While, the additive x dominance (j) interaction was highly negatively significant in two crosses, whereas, the two crosses found positively significant. Dominance x dominance interaction (l) was negatively significant in all crosses. The predominance of non-allelic

gene action for number of days for first harvest was reported by Singh *et al.* (2012) [15]. The duplicate type of interaction was observed in three crosses and in the two crosses Parbhani Kranti x Punjab-8 and Parbhani Bhendi x IC-282273 found complimentary type of gene effect.

Fruit yield per plant (g): As regards, fruit yield per plant (g), the inheritance study for the trait revealed that highly positively significant values of additive (d) gene interaction. Dominance (h) component and additive x additive (i) was negatively significant in two crosses Parbhani Kranti x Punjab-8 and Parbhani Bhendi x IC-282273. The two crosses Pusa A-4 x IC-282273 and Punjab-8 x IC-282273 were observed positively significant.

This trait was governed by both additive (d) gene effects in all five crosses, and the dominance (h) components play important role in the two crosses, thereby indicating the chance for population development through recurrent selection. Among the epistasis, additive x dominance (j) interaction was positively significant this gene effect were important in the four crosses, while, the cross Pusa A-4 x IC-282273 negatively significant. Dominance x dominance interaction (l) effect was negatively significant in two crosses *i.e.* Parbhani Kranti x Punjab-8 and Pusa A-4 x IC-282273. The two crosses Parbhani Bhendi x IC-282273 and Punjab-8 x IC-282273 which showed positive significances, which indicate the possibility of selection in these crosses. These results were in agreement with Aher (2003), Abdul *et al.* (2009), Bassay *et al.* (2010), Patel *et al.* (2010) and Singh

(2010). Complimentary type of interaction was observed to be present in three crosses. In the two crosses Parbhani Bhendi x IC-282273 and Pusa A-4 x IC-282273 are indicating duplicate type of gene effect (Mistry and Vashi, 2011)^[9].

Yield per hectare (tonnes): The additive (d) was found positively significant in four crosses. While, the dominance (h) gene effects was observed positively significant the cross Parbhani Bhendi x IC-282273 (2.99). Thereby indicating the scope for selection, exploitation of hybrid vigour and selection of plants for recurrent selection. The similar result was reported by Yadav *et al.* (2010)^[17].

As regards the estimates for epistatic gene effects additive x additive (i) interaction was found positively significant the cross Parbhani Bhendi x IC-282273 (1.65). Additive x dominance (j) interaction the three crosses were observed positively significant. While, the four crosses was found positively significant in dominance x dominance (l) interaction. The isolation of this kind of superior segregants for further utility has been reported by Aher (2003)^[2], Panda and Singh (2003)^[11], Panda and Singh (2005)^[12], Akhtar *et al.* (2010)^[3] and Mistry and Vashi (2011)^[9]. The duplicate type of interaction was observed in three crosses and in the two crosses *viz.*, Parbhani Kranti x Punjab-8 and Parbhani Bhendi x IC-282273 genetic components (h) and (l) were having same sign there by indicating complimentary type of gene effect (Kulkarni *et al.* 1998)^[8].

Incidence of fruit borer (%): For the incidence of fruit borer, the inheritance study revealed that additive (d) component and additive x dominance (j) was negatively significant in three crosses *viz.*, Parbhani Kranti x Punjab-8, Parbhani Bhendi x Punjab-8 and Pusa A-4 x IC-282273. The cross Parbhani Bhendi x IC-282273 shows positively significant. Dominance component (h) and additive x additive (i) was negatively significant in all crosses. Dominance x dominance interaction (l) was highly positively significant in all crosses. Duplicate type of interaction was observed to be present in all crosses due to having opposite signs of dominance (h) and dominance x dominance (l) components. The similar result was reported by Balakrishnan and Sreenivasan (2013)^[4].

Incidence of YVMV (%): Additive component (d) was negatively significant in three crosses *viz.*, Parbhani Bhendi x IC-282273, Pusa A-4 x IC-282273 and Punjab-8 x IC-282273. Dominance component (h) and additive x additive (i) was negatively significant in all crosses, except the cross Parbhani Bhendi x Punjab-8 was found negatively non significant in (h). Additive x dominance (j) interaction was negatively significant in the three crosses *viz.*, Parbhani Bhendi x Punjab-8, Parbhani Bhendi x IC-282273 and Punjab-8 x IC-282273. While, the cross Parbhani Bhendi x Punjab-8 positively significant. The dominance x dominance interaction (l) was highly positively significant, except the cross Parbhani Bhendi x Punjab-8 were found positively non significant in (l) gene interaction. Duplicate type of interaction was observed to be present in all crosses due to having opposite signs of dominance (h) and dominance x dominance (l) components.

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