Indian J. Hort. 67(Special Issue), November 2010: 203-207

# Generation mean analysis for yield traits in okra

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## ABSTRACT

**Generation 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 yield and yield attributing traits. The studies were undertaken on Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University Varanasi during the year 2006 & 2007. The analysis showed the presence of additive, dominance gene effects and epistatic interactions in almost all the cases indicating the importance of both additive and non-additive gene actions in the expression of the characters. For majority of characters, duplicate type of gene action was observed. Biparental mating which could exploit both additive and non-additive type of gene effects was suggested for the improvements of the traits in the crosses studied.**

**Key words:** Generation mean analysis, okra, gene action, duplicate.

## INTRODUCTION

Okra is one of the important vegetable crop grown during spring summer and rainy season. It has a prominent position among vegetables due to its wide adaptability, year round cultivation, export potential and high nutritive value. The knowledge of gene effects for different traits in okra is of prime importance before starting a breeding programme. Determination of the most important suitable method and selection strategy for improvement of a trait would depend on the knowledge of gene action operating in the breeding population, especially about the components of genetic variance viz., additive, dominance and epistasis. Generation mean analysis is an efficient tool to understand the nature of gene effects involved in the expression of the characters. Though, generation mean analysis has been extensively used to understand the gene effects in different crops, but very few reports are available on the use of this technique for understanding the gene effects in okra crop. In view of this, the present study has objective to estimate different kinds of gene effects in the inheritance of fruit yield and its important traits.

## MATERIALS AND METHODS

Five crosses (HRB-55 x Parbhani Kranti, Larm-1 x P-7, Larm-1 x Pusa Sawani, Larm-1 x Parbhani Kranti and BO-2 x Parbhani Kranti) involving six diverse varieties were made during kharif (rainy season) 2006 and their $F_2$, $B_1$ and $B_2$ were developed during spring 2007. Six generations ($P_1$, $P_2$, $F_1$, $F_2$, $B_1$ and $B_2$) of each of five crosses were evaluated in Randomize Block Design with three replications during rainy season of 2007 at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University Varanasi (U.P.). Each row of parents and $F_1$s and two rows of back crosses and four rows of $F_2$s were grown in 8 meter rows. Row to row and plant to plant distance were 60 cm and 45 cm, respectively. Recommended horticultural practices were followed for raising a good crop. The data were recorded on 5 competitive plants in parents and $F_1$s, 15 plants in back crosses and 20 plants in $F_2$'s in each plot of each replication. Their average was used for the analysis purpose. Observation were recorded on days to first flowering, first flowering node, plant height, number of branches per plant, number of fruits per plant and fruit yield per plant. In order to estimate additive, dominance and interaction (additive x additive, additive x dominance and dominance x dominance) parameters, generation mean analysis was carried out following Hayman, (6) and Jink and Jones (7). This procedure led to estimation of six genetic parameters which gave the relative magnitude of various gene effects for different traits.

## RESULTS AND DISCUSSION

All the five crosses were subjected to A, B, C and D scaling test given by Mather, (10) to sort out interacting and non interacting crosses (Table 1). The A and B scaling tests provided the evidence for the presence of

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'i' (additive x additive), 'j' (additive x dominance) and 'l' (dominance x dominance) type of gene interactions. The C scaling tests provided for 'l' type of epistasis whereas 'D' scaling test gave information about 'i' type of gene interaction. The presence of epistatic interaction for most of the characters was also evident from the results of analysis of digenic epistatic model for five crosses. The A, B, C and D scaling test carried out in five crosses indicated the presence of non-allelic interactions into all the characters except days to first flowering, plan height, number of branches per plant. For days to first flowering in the crosses Larm-1 x Pusa Sawani and HRB-55 x Parbhani Kranti; for first flowering node in the crosses Larm-1x Pusa Sawani and BO-2 x Parbhani Kranti; for plant height and number of branches per plant in the crosses HRB-55 x Parbhani Kranti and Larm-1 x Pusa Sawani; for number of fruits per plant in the crosses Larm-1 x Parbhani Kranti and BO-2 x Parbhani Kranti; for fruit length in the crosses HRB-55 x Parbhani Kranti, Larm-1 x P-7, Larm-1 x Pusa Sawani, Larm-1 x Parbhani Kranti and BO-2 x Parbhani Kranti and for fruit yield in the crosses HRB-55 x Parbhani Kranti and Larm-1 x Parbhani Kranti. In all other cases, the additive dominance model found to be inadequate to explain gene action.

Estimates of components of generation means for different characters in okra were presented in Table 2. In case of days to first flowering, all the crosses exhibited significantly additive x additive and additive x dominance and dominance x dominance type of gene effects except in the cross Larm-1 x Pusa Sawani in type of gene effects (Table 2) and additive x dominance and dominance x dominance type of gene effects in the cross of Larm-1 x Parbhani Kranti indicating that yield in this case could be improved by simple selection procedure. All the genetic components were also important in the all crosses. Dominance gene action for days to first flowering was reported by many workers Kulkarni *et al.* (9) and Rao and Sathyavathi, (14). The epistasis for days to first flowering was found to be duplicate type in all the cases except in the crosses Larm-1 x Pusa Sawani and Larm-1 x Parbhani Kranti confirming the complex nature of inheritance of yield.

For first flowering node, additive and dominance gene effects were found to be importance for all cross except in the cross Larm-1 x Pusa Sawani. All the epistasis interaction except 'l' was found to be significant in all the crosses. The additive x additive and additive x dominance type of interaction were found to be important. Additive x additive and additive x dominance was found to be significant in all the crosses whereas dominance x dominance type of gene interaction significantly exhibited by only in the crosses of HRB-55 x Parbhani Kranti and Larm-1 x P-7. Duplicate type of epistasis was observed for first flowering node in the crosses HRB-55 x Parbhani Kranti and Larm-1 x P-7. Importance of both additive and non-additive gene effects for this character was reported by Singh and Singh, (15) and Elangovan *et al.* (5).

For plant height, all the crosses exhibited additive and dominance type of gene effects except additive in the cross HRB-55 x Parbhani Kranti and dominance in the crosses of larm-1 x Pusa Sawani and BO-2 x Parbhani Kranti. Whereas, epistasis type of gene interaction such as additive x additive, additive x dominance and dominance x dominance found to be significant all the crosses except the additive x additive in the cross Larm-1 x Pusa Sawani, additive x dominance in HRB-55 x Parbhani Kranti and dominance x dominance in the cross Larm-1 x Pusa Sawani. Duplicate type of gene interaction were exhibited in all the crosses except HRB-55 x Parbhani Kranti and Larm-1 x Parbhani Kranti, in this regard importance of non-additive gene action was reported by Kulkarni *et al.* (9), Panda and Singh (11), Rao and Ramu, (13) and Elangovan *et al.* (5).

Additive and dominance gene effect was found to be relatively more important in all the crosses for number of branches per plant. All type of the gene interaction was significant in all the crosses except dominance x dominance type of gene effects in the crosses of HRB-55 x Parbhani Kranti and BO-2 x Parbhani Kranti. All the crosses showed duplicate type of epistasis except in the crosses of HRB-55 x Parbhani Kranti and BO-2 x Parbhani Kranti. Importance of epistasis interaction in control of this character was also reported by Korla and Sharma (8).

Greater importances of additive and dominance gene effects were observed for number of fruits per plant in all the crosses. These results were number to Arumugam and Muthukrisnan (3). Among epistasis, additive x additive, additive x dominance and dominance x dominance exhibited significant value in the all crosses except additive x dominance in the cross Larm-1 x Pusa Sawani. Duplicate type of epistasis was observed in all the crosses for this trait. Importance of epistasis in the control of this character was reported by Arora (2).

For fruit length the additive gene effects were found to be relatively more important in the crosses, HRB-55 x Parbhani Kranti, Larm-1 x P-7, Larm-1 x Pusa Sawani and BO-2 x Parbhani Kranti. Dominance and additive x additive type of epistasis were found to be significant in the crosses HRB-55 x Parbhani Kranti, Larm-1 x P-7 and Larm-1 x Pusa Sawani. Additive x dominance type of gene interaction were significantly exhibited in all cross except HRB-55 x Parbhani Kranti and Larm-1 x Parbhani

**Table 1.** Test of significance of A, B, C, and D scales for seven characters in okra.

| Crosses | Scales | Days to first flowering | First flowering node | Plant height (cm) | No. of branches /plant | No. of fruits /plant | Fruit length (cm) | Fruit yield /plant (g) |
|---|---|---|---|---|---|---|---|---|
| HRB-55 x Parbhani Kranti | A | 0.31 | 2.43** | 21.25** | 0.20 | 2.08** | 0.77 | 19.73** |
| | B | 0.23 | -0.63* | -0.65 | -1.43** | -7.88** | -3.33** | -64.48 |
| | C | -4.04** | -2.44** | -18.66** | -2.88** | -3.84** | -0.44 | -59.66 |
| | D | -2.29** | -2.12** | -19.63** | -0.82** | 0.98* | 1.06** | -7.46 |
| Larm-1x P-7 | A | 2.42** | 2.18** | 30.54** | 1.33** | 2.53** | 0.32 | 38.36** |
| | B | 4.63** | -0.40 | 6.38** | -0.46** | -4.69** | 1.00* | -22.60** |
| | C | -12.91** | -2.12** | 18.46** | -1.40** | -8.06** | -0.27 | -69.21** |
| | D | -9.98** | -1.95** | -9.23** | -1.13** | -2.95** | -0.79* | -42.49** |
| Larm-1x Pusa Sawani | A | 1.79* | -1.30** | -3.33* | -0.75** | -2.12** | 0.21 | -20.83** |
| | B | 0.68 | -0.06 | 0.51 | 0.20 | -1.31* | 0.50 | -11.18** |
| | CD | 1.54-0.46 | -2.04**-0.34** | -3.44-0.31 | -1.99**-0.72** | -2.51**0.46* | -3.06**-1.88** | -46.64**-7.32** |
| Larm-1x Parbhani Kranti | A | 2.25** | 0.70** | 40.56** | 1.07** | 4.00** | -0.66 | 34.87** |
| | B | 2.59** | -1.36** | -8.93** | -1.02** | -9.11** | -2.80** | -71.41** |
| | C | 12.02** | -1.43** | 39.97** | -1.27** | -1.15 | -4.35** | 2.38 |
| | D | 3.59** | -0.38* | 4.17** | -0.66** | 1.98** | -0.44 | 19.46** |
| BO-2 x Parbhani Kranti | A | 6.32** | 1.59** | 6.63** | 0.24 | 0.92 | -0.72 | 6.75** |
| | B | 3.23** | -0.12 | 26.48** | -0.94** | -6.90** | -0.34 | -64.90** |
| | C | 3.13* | 3.26** | 54.55** | -1.50** | 4.41** | 0.20 | 48.82** |
| | D | -3.21** | 0.90** | 10.72** | -0.40** | 5.19** | 0.63* | 53.48** |

**Table 2**. Estimates of components of generation means for different characters in okra.

| Character | Crosses | Gene effects | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | m | [d] | [h] | [i] | [j] | [l] | epistasis |
| Days to first flowering | HRB-55 x Parbhani Kranti | 40.12** | -4.13** | 11.28** | 4.58** | 0.04 | -5.12* | Duplicate |
| | Larm-1x P-7 | 25.68** | -1.40** | 43.20** | 19.95** | -1.10* | -27.00** | Duplicate |
| | Larm-1x Pusa Sawani | 42.85** | 0.46 | 2.06 | 0.93 | 0.55 | -3.39 | - |
| | Larm-1x Parbhani Kranti | 53.71** | -2.30** | -13.74** | -7.18** | -0.17 | 2.34 | - |
| | BO-2 x Parbhani Kranti | 38.90** | -3.52** | 19.85** | 6.42** | 1.55** | -15.97** | Duplicate |
| First flowering node | HRB-55 x Parbhani Kranti | 0.35 | -0.76** | 10.52** | 4.24** | 1.53** | -6.04** | Duplicate |
| | Larm-1x P-7 | 0.98** | -0.84** | 9.35** | 3.90** | 1.29** | -5.68** | Duplicate |
| | Larm-1x Pusa Sawani | 3.46** | -0.12 | -0.38 | 0.69** | -0.62** | 0.67 | - |
| | Larm-1x Parbhani Kranti | 3.93** | -0.67** | 1.92* | 0.77* | 1.03** | -0.10 | - |
| | BO-2 x Parbhani Kranti | 6.06** | -1.10** | -0.74 | -1.79** | 0.86** | 0.33 | - |
| Plant height (cm) | HRB-55 x Parbhani Kranti | 55.23** | 2.06 | 110.37** | 39.26** | 10.95 | -59.86** | - |
| | Larm-1x P-7 | 63.81** | -10.87** | 89.13** | 18.46** | 12.08** | -55.38** | Duplicate |
| | Larm-1x Pusa Sawani | 74.73** | -3.95** | 0.51 | 0.62 | -1.92* | 2.20 | Duplicate |
| | Larm-1x Parbhani Kranti | 90.26** | -10.51** | 50.59** | -8.34** | 24.75** | -23.29** | - |
| | BO-2 x Parbhani Kranti | 117.29** | 3.42** | 8.15 | -21.44** | -9.92** | -11.67* | Duplicate |
| Number of branches per plant | HRB-55 x Parbhani Kranti | 0.95** | -0.36** | 2.80** | 1.65** | 0.81** | -0.42 | - |
| | Larm-1x P-7 | 0.30 | -0.69** | 5.36** | 2.26** | 0.89** | -3.12** | Duplicate |
| | Larm-1x Pusa Sawani | 0.79** | -0.36** | 1.99** | 1.45** | -0.47** | -0.90** | Duplicate |
| | Larm-1x Parbhani Kranti | 1.10** | -0.54** | 2.24** | 1.31** | 1.04** | -1.36** | Duplicate |
| | BO-2 x Parbhani Kranti | 1.69** | -0.47** | 1.07* | 0.80** | 0.59** | -0.10 | - |
| Number of fruits per plant | HRB-55 x Parbhani Kranti | 13.42** | -2.02** | -5.41* | -1.95* | 4.98** | 7.75** | Duplicate |
| | Larm-1x P-7 | 4.04** | -2.20** | 12.94** | 5.90** | 3.61** | -3.74** | Duplicate |
| | Larm-1x Pusa Sawani | 10.02** | -1.36** | -4.43** | -0.92* | -0.40 | 4.35** | Duplicate |
| | Larm-1x Parbhani Kranti | 14.58** | -2.88** | -8.93** | -3.96** | 6.55** | 9.07** | Duplicate |
| | BO-2 x Parbhani Kranti | 21.94** | -1.94** | -25.55** | -10.39** | 3.91** | 16.36** | Duplicate |
| Fruit length (cm) | HRB-55 x Parbhani Kranti | 10.73** | -0.77** | -4.95** | -2.11** | 2.05** | 4.67** | Duplicate |
| | Larm-1x P-7 | 6.51** | 0.70** | 5.73** | 1.59* | -0.34 | -2.91* | Duplicate |
| | Larm-1x Pusa Sawani | 5.43** | -0.39** | 6.48** | 3.76** | -0.15 | -4.46** | Duplicate |
| | Larm-1x Parbhani Kranti | 8.21** | -0.30 | -0.46 | 0.89 | 1.07** | 2.58* | - |
| | BO-2 x Parbhani Kranti | 9.26** | -1.38** | -2.41 | -1.25* | -0.19 | 2.31* | - |
| Fruit yield per plant (g) | HRB-55 x Parbhani Kranti | 81.91** | -23.46 | 22.30** | 14.91** | 42.10** | 29.84** | Complimentary |
| | Larm-1x P-7 | -4.79* | -17.28** | 200.25** | 84.97** | 30.48* | -100.73** | Duplicate |
| | Larm-1x Pusa Sawani | 59.77** | -11.50** | 9.93 | 14.63** | -4.83** | 17.37** | - |
| | Larm-1x Parbhani Kranti | 130.51** | -28.69** | -94.97** | -38.91** | 53.14** | 75.45** | Duplicate |
| | BO-2 x Parbhani Kranti | 199.48** | -27.78** | -255.20** | -106.97** | 35.83** | 165.12** | Duplicate |

Kranti whereas, dominance x dominance type of gene interaction were showed by all the crosses. Importance of additive and non-additive gene action for this character was reported by Pratap and Dhankar (12). Duplicate type of gene interaction was significantly exhibited in the crosses of HRB-55 x Parbhani Kranti, Larm-1 x P-7 and Larm-1 x Pusa Sawani.

Additive gene effects were found to be significant in all the crosses except HRB-55 x Parbhani Kranti for fruit yield per plant whereas, dominance gene effects were important for this trait in all the crosses except Larm-1 x Pusa Sawani. Among non allelic interactions additive x additive, additive x dominance and dominance x dominance gene effects were exhibited for fruit yield per plant. The crosses Larm-1 x P-7, Larm-1 x Parbhani Kranti and BO-2 x Parbhani Kranti observed duplicate type of epistasis whereas HRB-55 x Parbhani Kranti recorded complimentary type of epistasis. Importance of non-additive gene effects for this trait was also observed by Chaudhary *et al.* (4) and Aher *et al.* (1).

The estimation of different type of gene effects provide a test for gene action and were useful for analyzing genetic architecture of important traits which will suggest the future breeding strategy for improvement of desired traits. In the present study greater magnitude of dominant gene effects as compare to additive effects for most of the traits studied suggest that hybrid breeding may be more useful. At the same time significant additive effects will be beneficial for the improvement through selection

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Received: December, 2009; Revised: March, 2010
Accepted: August, 2010