

Research Article**Genetic architecture of fruit yield and its contributing quantitative traits in *Abelmoschus esculentus* (L.) Moench****Khanorkar S.M. and K. B. Kathiria****Abstract:**

The genetic architecture of fruit yield and its related quantitative traits *viz.*, days to first flowering, days to first picking, plant height, primary branches per plant, stem girth, fruit length, fruit girth, fruit weight, fruits per plant and fruit yield per plant studied through generation mean analysis using six basic generations (P_1 , P_2 , F_1 , F_2 , BC_1 and BC_2) of six crosses HRB-55 x AOL-05-4, VRO-5 x Red Long, VRO-6 x AOL-05-3, GO-2 x AOL-04-3, Arka Anamika x AOL-03-1 and Parbhani Kranti x AOL-03-6 in two environments (E_1 and E_2). Among the generations within the crosses, the sum of squares showed significant differences for all characters. Fixable type of gene effects *viz.*, additive [d] and additive x additive [i] found significant for days to first flowering in crosses HRB-55 x AOL-05-4 (E_1), VRO-5 x Red Long (E_2) and GO-2 x AOL-04-3 (E_1). The similar kind of gene effects also observed for days to first picking (E_1) and fruit weight (E_2) in the cross GO-2 x AOL-04-3. In another case, dominance [h] and dominance x dominance [l] which non-fixable gene effects were significant for days to first flowering in crosses VRO-5 x Red Long (E_2) and GO-2 x AOL-04-3 (E_1); stem girth in VRO-6 x AOL-05-3 (E_1) and fruit length in Arka Anamika x AOL-03-1 (E_1). Duplicate type of epistasis observed for days to first flowering in crosses, VRO-5 x Red Long (E_2) and GO-2 x AOL-04-3 (E_1); stem girth in VRO-6 x AOL-05-3 (E_1) and fruit length in cross Arka Anamika x AOL-03-1 (E_1). Results revealed additive and additive x additive types of fixable gene effects for days to first flowering and days to first picking as well as fruit yield and its contributing traits in some cross-environment combinations. This suggests simple selection or a single seed descent method could help for improvement of these traits. The results on epistatic gene effects for fruit yield and its contributing component traits in different cross-environment combinations suggests that recurrent selection, bi-parental mating and *inter se* mating between desirable segregants followed by selection or multiple crosses offer good promising methods.

Key words: gene effects, additive x additive [i], dominance x dominance [l] epistasis, recurrent selection, bi-parental mating

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench), a popular vegetable crop is grown in the tropical, sub-tropical low altitude regions of Asia, Africa, America and temperate regions of the Mediterranean basin. In India, okra is commercially grown in the states of Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka, Haryana and Punjab as a *kharif* as well as summer season crop. In India, it is cultivated in the area of 3.76 lakh hectares with the annual production of 36.84 lakh tonnes, which resulted the productivity of 9.80 tonnes per hectare (Anonymous, 2006). In Gujarat, its area, production and productivity is 0.43 lakh hectares,

3.66 lakh tonnes and 8.51 tonnes per hectare, respectively (Anonymous, 2006). Most of breeding works in okra were for yellow vein mosaic virus resistance and very limited breeding efforts have been made for pod yield and its contributing traits. In this crop, various breeding methods were used to develop high yielding hybrids/varieties with early maturity and yellow vein mosaic virus resistance.

In this crop, particularly all plant characters of economic importance are quantitatively inherited. Therefore, the improvement in yield through yield contributing traits depends on the nature, magnitude and heritable variation. Yield is a complex character which is a final product resulting from the interaction of yield attributing characters. Such characters are controlled by polygene and are much influenced by environmental fluctuations. A breeder, therefore,

should have information on the mode of inheritance and genetic architecture for yield and its component characters. This will enable breeder to decide suitable breeding methodology for the crop improvement programme. The partitioning of heritable variation into its components is useful to provide information on the inheritance of quantitative characters. One of the common approaches followed for the purpose is to understand the nature of gene effects by growing different generations and carrying out the generation mean analysis, using first degree statistics. Very little information on these aspects is available in literature on okra crop. The present study revealed nature and magnitude of gene action in inheritance of green fruit yield and its contributing characters under two different environments.

Materials and Methods

Selfed seeds of parental lines used to make six crosses *viz.*; HRB-55 x AOL-05-4, VRO-5 x Red Long, VRO-6 x AOL-05-4, GO-2 x AOL-04-3, Arka Anamika x AOL-03-1 and Parbhani Kranti x AOL-03-6. F₁, F₂ and BC₁ and BC₂ were developed by selfing and backcrossing breeding method. The six generations of each of six crosses were grown in compact family block design with three replications at the Main Vegetable Research Station, Anand Agricultural University, Anand in two environments *kharif* 2005 (E₁) and summer 2006 (E₂). Each plot had one row for parents and F₁s, two rows for each of the BC₁ and BC₂ and four rows for each F₂ population. Each row consisted of 10 plants. The spacing between rows and plants within row followed 60 and 30 cm, respectively. All the recommended package of practices adopted to get complete expression of traits under study.

The observations on ten different characters recorded on five randomly selected plants from each plot of parents and F₁, 10 plants in each plot of BC₁ and BC₂ and 20 plants in each plot of F₂. The characters under study were days to first flowering, days to first picking, plant height, primary branches per plant, stem girth, fruit length, fruit girth, fruit weight, fruits per plant and fruit yield per plant. The additive-dominance model was tested for its adequacy by employing the scaling tests (Mather, 1949 and Hayman & Mather, 1955). The major and interaction gene effects were estimated as advocated by Hayman (1958).

Analysis of variance computed as devised by Panse and Sukhatme (1969). The generation mean analysis analyzed to estimate gene effects of traits as suggested by Hayman (1958). The scaling test as described by Hayman and Mather (1955) was used to check the adequacy of the additive-dominance model for different characters in each cross. The adequacy of scale must satisfy two conditions *viz.*, additivity of gene effects and independence of heritable component from non-heritable ones. The test of first condition provides information regarding the absence or presence of gene interaction. The A, B, C and D tests were made using the following equations for their values and variances. The joint scaling test (additive-dominance model or non-epistatic model) outlined by Cavalli (1952) was also applied to six generations to fit the three-parameter model. It consists of estimation of the parameters, m , $[d]$ and $[h]$ using weighted least square method, followed by a comparison of observed means with expected means. The comparison between observed and expected generation means were made by Chi-square (χ^2) test assuming that the sum of squares minimized in the fitting process distributed as χ^2 . The degree of freedom (d.f.) equals to number of generations minus the number of parameters estimated.

When the three-parameter or non-epistatic model was inadequate, an unweighted six-parameter model was fitted which includes digenic epistatic effects. The goodness of fit of six-parameter model could not be tested by Chi-square test since all the six generations were used for the estimation of various parameters. Various gene effects were estimated using six-parameter model as suggested by Hayman (1958).

Results and Discussion

The mean sum of squares were significant in all the six crosses for both days to first flowering and days to first picking in E₁; plant height and stem girth in E₂ and primary branches per plant, fruits per plant and fruit yield per plant in both E₁ and E₂. The mean values of six generations of all the six crosses reflected early flowering and picking in E₁ than E₂ environment. The fruit traits like fruit length, fruit girth and fruit weight exhibited higher mean values in E₁ than E₂. The similar trend was also observed for fruits per plant and fruit yield per plant. Hence, *kharif* season might be more favourable than summer for expression of these characters under study (Table 1-1 to 1-9).

The individual scaling tests A, B, C and D and joint scaling test revealed that in 56.67 per cent and 43.33 per cent cases 3-parameter and 6-parameter models were fitted well, respectively. However, some of the individual scaling tests were not in agreement with joint scaling tests.

In 3-parameter model, the additive gene effect was significant for plant height (E_1), fruits per plant (E_1) and fruit yield per plant (E_1) in cross HRB-55 x AOL-05-4; fruit weight (E_1) in cross VRO-5 x Red Long; plant height (E_2), primary branches per plant (E_2), fruit length (E_2) and fruit weight (E_1) in cross VRO-6 x AOL-05-3; days to first picking (E_2), plant height (E_1), fruits per plant (E_1 and E_2) and fruit yield per plant (E_2) in cross GO-2 x AOL-04-3; primary branches per plant (E_1) in cross Arka Anamika x AOL-03-1 and primary branches per plant (E_1) and fruit yield per plant (E_2) in cross Parbhani Kranti x AOL-03-6.

Further, the dominance [h] gene effect was observed to be significant for primary branches per plant (E_1 and E_2), fruit length (E_1), fruits per plant (E_2) and fruit yield per plant (E_2) in cross HRB-55 x AOL-05-4; days to first flowering (E_1), days to first picking (E_1) and fruit yield per plant (E_1) in cross VRO-5 x Red Long; plant height (E_1) and fruit length (E_1) in cross VRO-6 x AOL-05-3; fruit yield per plant (E_1) in cross GO-2 x AOL-04-3; fruits per plant (E_2) in cross Arka Anamika x AOL-03-1 and plant height (E_1) and fruit yield per plant (E_1) in cross Parbhani Kranti x AOL-03-6.

Both additive and dominance gene effects were also found significant in eleven cases such as days to first flowering (E_2), days to first picking (E_1 and E_2) and plant height (E_2) in the cross HRB-55 x AOL-05-4; fruit girth (E_2) in cross VRO-5 x Red Long; days to first flowering (E_1) in cross VRO-6 x AOL-05-3; plant height (E_2) in cross GO-2 x AOL-04-3; days to first flowering (E_1) in Arka Anamika x AOL-03-1 and days to first flowering (E_2), fruits per plant (E_2) and fruit yield per plant (E_2) in Parbhani Kranti x AOL-03-6. The adequacy of additive-dominance model was also reported for days to first flowering, plant height, primary branches per plant, fruit length, fruit girth, fruit weight, fruits per plant and fruit yield per plant by Lal *et al.* (1975), Arumugam and Muthukrishnan (1979), Randhwa (1989) and Patel *et al.*, (1991). Aher *et al.* (2003) also cited satisfactory of the additive-dominance model for the traits plant height, fruit length, fruit girth, fruit weight, fruits per

plant and fruit yield per plant. Pulliah *et al.* (1996) reported adequacy of this model for fruits per plant and fruit yield per plant. Korla and Sharma (1987) advocated fitness of additive-dominance model for fruit yield per plant.

Under 6-parameter model, the additive [d] gene effect was significant for 14 cases such as days to first flowering (E_1) and fruit girth (E_2) in cross HRB-55 x AOL-05-4; plant height (E_2), fruit length (E_1) and fruit yield per plant (E_2) in cross VRO-5 x Red Long; days to first picking (E_1) and primary branches per plant (E_1), fruit length (E_2) and fruit weight (E_2) in cross GO-2 x AOL-04-3; days to first picking (E_1) and fruit length (E_2) in cross Arka Anamika x AOL-03-1 and days to first flowering (E_1), days to first picking (E_1) and fruit length (E_1) in cross Parbhani Kranti x AOL-03-6.

The dominance [h] gene effect found significant in eight cases viz., for stem girth (E_1) and fruit yield per plant (E_2) in cross VRO-6 x AOL-05-3; primary branches per plant (E_2) and stem girth (E_2) in cross GO-2 x AOL-04-3; fruit length (E_1) in cross Arka Anamika x AOL-03-1 and fruits per plant (E_1) in cross Parbhani Kranti x AOL-03-6. The positive and significant dominance gene effects suggests to enhance expression of traits like primary branches per plant (E_2) and stem girth (E_2) in cross GO-2 x AOL-04-3 and fruits per plant (E_1) in Parbhani Kranti x AOL-03-6. In desirable direction, dominance gene effect was also identified to govern the inheritance of trait like days to first flowering (E_2) in cross VRO-5 x Red Long. Both additive and dominance gene effects were also found significant for days to first flowering in the crosses VRO-5 x Red Long (E_2) and GO-2 x AOL-04-3 (E_1).

The additive [d] gene effect was reported significant for days to first flowering by Lal *et al.* (1975), Partap *et al.*, (1981 and 1982), Poshiya and Shukla (1986), Randhwa (1989), Patel *et al.* (1990), Chavadhal and Malkhadale (1994), Hoque and Hazarika (1996), Pawar *et al.* (1999), Ahlawat (2004) and Ahmed *et al.* (2004). Both additive and dominance gene effects were also reported significant for the same character by Arumugam and Muthukrishnan (1979), Patel *et al.*, (1990), Liou *et al.* (2002) and Chandra Deo *et al.* (2004).

Further, significant additive gene effect was also quoted for plant height by Randhwa (1989), Sivakumar *et al.* (1995), Pawar *et al.* (1999 b), Nichal

et al. (2000) and Mitra and Das (2003). whereas, dominance gene effect was reported for the control of same trait by Rao and Ramu (1979), Patel *et al.* (1990) and Pullaih *et al.* (1996). In addition to these findings, both additive and dominance kind of gene actions were also cited for the inheritance of this character by Arumugam and Muthurishnan (1979), Partap and Dhankhar (1980), Patel *et al.*, (1990), Liou *et al.* (2002), Aher *et al.* (2003), Singh and Singh (1994) and Chandra Deo *et al.* (2004).

The additive gene effect was cited for primary branches per plant by Randhwa (1989), Patel *et al.*, (1990), Hoque and Hazarika (1996), Pawar *et al.* (1999), Nichal *et al.* (2000) and Mitra and Das (2003). While, Lal *et al.* (1975), Arumugam and Muthukrishnan (1979), Rao and Ramu (1979), Randhwa (1989), Veeraragavathatham and Irulappan (1991), Sivakumar *et al.* (1995), Tripathi *et al.* (2002), Patel *et al.* (1990), Pulliah *et al.* (1996) and Aher *et al.* (2003) quoted dominance gene effects for the control of this character. On the other hand, additive and dominance gene effects were reported by Kulkarni *et al.* (1978), Partap *et al.* (1982), Liou *et al.* (2002) and Chandra Deo *et al.* (2004).

The additive gene effect was quoted for fruit yield per plant by Partap and Dhankhar (1980), Elongovan *et al.* (1981), Singh and Singh (1984), Desai (1990), Veeraraganathatham and Irulappan (1991), Pawar *et al.* (1999), Tripathi *et al.* (2002) and Mitra and Das (2003). On the other hand, the dominance gene effect was reported for fruit yield per plant by Lal *et al.* (1975), Patel *et al.* (1990), Veeraraghavathantham and Irulappan (1990) and Rajani and Manju (1999). Rao and Ramu (1979), Korla and Sharma (1987), Patel *et al.*, (1990), Liou *et al.* (2002), Aher *et al.* (2003) and Chandra Deo *et al.* (2004) investigated both additive and dominance gene effects for fruit yield per plant.

The additive gene effect was reported for fruit length by Partap and Dhankhar (1980), Thaker *et al.* (1981), Veeraragavathatham and Irulappan (1991), Wankhade *et al.* (1991), Shinde *et al.* (1995), Pawar *et al.* (1996), Tripathi *et al.* (2002), Aher *et al.* (2003), Mitra and Das (2003) and Singh and Singh (2003). For the same trait, dominance gene effect was advocated by Arumugam and Muthukrishnan (1979), Patel *et al.* (1990) and Rajani and Manju (1999). Both additive and dominance gene effects were also identified for this trait by Chandra Deo *et al.* (2004).

For fruit girth, the additive gene effect was reported by Lal *et al.* (1975), Arumugam and Muthukrishnan (1979), Partap and Dhankhar (1980), Poshiya and Shukla (1986), Vijay and Manohar (1986), Singh *et al.* (1989), Veeraragavathantham and Irulappan (1990), Ahmed *et al.* (1997), Pawar *et al.* (1999), Aher *et al.* (2003), Mitra and Das (2003) and Singh and Singh (2003). Further, the dominance gene effect for fruit girth was quoted by Patel *et al.* (1990). In addition to these findings, both additive and dominance gene effects were reported for this trait by Rajani and Manju (1999) and Patel (2006). Partap and Dhankhar (1980), Thaker *et al.* (1981), Vijay and Manohar (1986 b), Randhwa (1989), Veeraragavathatham and Irulappam (1991), Shinde *et al.* (1995), Tripathi *et al.* (2002) and Aher *et al.* (2003) reported additive gene effect for fruit weight. Both additive and dominance gene effects were also reported for the control of this character by Randhwa (1989).

The epistatic gene effects such as additive x additive [*i*], additive x dominance [*j*] and dominance x dominance [*l*] were observed to be significant for days to first flowering (E_2) and days to first picking (E_2) in the cross VRO-5 x Red Long. The individual epistatic gene effects like additive x additive [*i*] was significant for one case in cross HRB-55 x AOL-05-4; ten cases in cross VRO-5 x Red Long, two cases in VRO-6 x AOL-05-3, three cases in cross GO-2 x AOL-04-3 and one case in Arka Anamika x AOL-04-1. Whereas, additive x dominance [*j*] digenic non-allelic interaction was also identified significant in 21 cases. Of these, one case was found in cross HRB-55 x AOL-05-4, seven cases in cross VRO-5 x Red Long, three cases in the cross VRO-6 x AOL-05-3, two cases in GO-2 x AOL-04-3, five cases in Arka Anamika x AOL-03-1 and three cases in cross Parbhani Kranti x AOL-03-6. The dominance x dominance [*l*] interaction exhibited significant values in nine cases. It distributed in two cases each of VRO-5 x Red Long and VRO-6 x AOL-05-3 crosses, one each of GO-2 x AOL-04-3 and Arka Anamika x AOL-03-1 crosses and three in Parbhani Kranti x AOL-03-6.

Kulkarni *et al.* (1978), cited dominance x dominance epistatic gene effects for days to first flowering. Patoliya (1994) reported that both additive x dominance and dominance x dominance gene effects were responsible for the control of days to first flowering. In another case, Pullaih *et al.* (1996), quoted dominance x dominance gene effects for plant

height. Both additive x dominance and dominance x dominance gene effects were cited for fruits per plant by Lal *et al.* (1975), Kulkarni *et al.* (1976, 1978), and Pullaih *et al.* (1996). Korla and Sharma (1987) reported additive, dominance and epistatic gene effects responsible for the control of fruit yield per plant. The additive x additive gene effects was cited for fruit yield per plant by Patoliya (1994).

Arumugam and Muthukrishnan (1979) also quoted [i], [j] and [l] digenic non-allelic interactions for fruit length. Lal *et al.* (1975), Arumugam and Muthukrishnan (1979) reported dominance x dominance digenic non-allelic interaction for fruit girth.

The duplicate epistasis was also detected in few cases such as days to first flowering in the crosses VRO-5 x Red Long (E₂) and GO-2 x AOL-04-3 (E₁); stem girth in the cross VRO-6 x AOL-05-3 (E₁) and fruit length in the cross Arka Anamika x AOL-03-1 (E₁). The present findings were found akin with the results obtained by Kulkarni *et al.* (1978) on duplicate kind of epistasis for days to first flowering. Whereas, Arumugam and Muthukrishnan (1979) cited duplicate type of epistasis for fruit length. Under such situations, it would be difficult to get promising segregants through conventional breeding methods. Hence, biparental mating in early segregating generations or recurrent selection may be better breeding approach as compared to the conventional breeding methods for okra crop improvement.

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Table 1-1. Results of scaling tests and estimation of gene effects for nine traits in six crosses of okra grown under two environments -days to first flowering

Scaling tests/Gene effects	HRB-55 x AOL-05-4		VRO-5 x Red Long		VRO-6 x AOL-05-3		GO 2 x AOL-04-3		Arka Anamika x AOL-03-1		Parbhani Kranti x AOL-03-6	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
A	0.73 ± 1.45	0.73 ±2.37	-2.27 ± 1.51	-10.03** ±2.02	2.27 ± 2.09	-	-0.13 ± 1.23	-	1.07 ± 1.51	-	4.80 ** ± 1.58	-0.13 ±1.99
B	-2.13 ± 1.57	-2.07 ±2.09	-0.60 ± 1.13	-3.40* ±1.64	0.07 ± 1.65	-	-0.87 ± 1.74	-	-2.87 ± 1.89	-	-2.53 ± 1.64	-5.47* ±2.74
C	3.13 ± 2.77	-2.33 ±2.58	1.67 ± 2.28	1.40 ±3.04	-0.33 ± 2.85	-	-11.87 ** ±2.47	-	-2.40 ± 2.49	-	2.87 ± 2.48	1.47 ±3.74
D	2.27 * ± 0.99	-0.50 ±1.78	2.27 ± 1.17	7.47** ±1.60	-1.33 ± 1.30	-	-5.43 ** ± 1.16	-	-0.30 ± 1.26	-	0.30 ± 1.18	3.53* ±1.77
3 – Parameter Model												
<i>m</i>	-	59.73 ±0.53	49.03 ±0.33	-	45.85 ±0.53	-	-	-	50.17 ±0.46	-	-	55.64 ±0.78
[<i>d</i>]	-	-2.35** ±0.60	0.35 ±0.32	-	-1.65** ±0.51	-	-	-	3.22 ** ±0.45	-	-	-2.07** ±0.74
[<i>h</i>]	-	-9.39** ±0.63	-2.06** ±0.64	-	-3.26** ±1.02	-	-	-	-2.61 ** ±0.88	-	-	-3.76** ±1.35
χ^2 (3 d.f.)	8.34 *	1.84	4.33	32.66* *	1.75	-	30.56 **	-	4.22	-	13.70 **	5.59
6 – Parameter Model												
<i>m</i>	47.33 ±0.35	-	-	57.52 ±0.59	-	-	45.95 ±0.43	-	-	-	50.90 ±0.42	-
[<i>d</i>]	3.20 ** ±0.70	-	-	2.43* ±1.08	-	-	1.80 * ±0.78	-	-	-	2.17 ** ±0.84	-
[<i>h</i>]	-3.23 ±2.20	-	-	-13.27** ±3.34	-	-	9.03** ±2.49	-	-	-	-3.50 ±2.53	-
[<i>i</i>]	-4.53 * ±1.98	-	-	-14.93** ±3.20	-	-	10.87 ** ±2.32	-	-	-	-0.60 ±2.36	-
[<i>j</i>]	1.43 ±0.91	-	-	-3.37** ±1.15	-	-	0.37 ±0.95	-	-	-	3.67 ** ±1.03	-
[<i>l</i>]	5.93 ±3.70	-	-	28.47** ±5.28	-	-	-9.87* ±3.97	-	-	-	-1.67 ±4.16	-
Type of epistasis	-	-	-	Duplicate	-	-	Duplicate	-	-	-	-	-

*, ** Significant at 5% and 1% levels respectively; E₁ = *kharij* 2005, E₂ = Summer –2006



Table 1-2 Contd.

Days to first picking

Scaling tests/Gene effects	HRB-55 x AOL-05-4		VRO-5 x Red Long		VRO-6 x AOL-05-3		GO 2 x AOL-04-3		Arka Anamika x AOL-03-1		Parbhani Kranti x AOL-03-6	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
A	0.67 ±1.09	-1.27 ±2.89	-0.13 ±1.36	-10.40** ±2.38	4.67** ±1.66	-	0.13 ±1.08	-2.53 ±2.46	0.80 ±1.12	-	3.60 ** ±1.18	-
B	0.47 ±1.52	1.13 ±2.88	-1.20 ±1.12	-3.73 ±2.73	0.73 ±1.41	-	-1.80 ±1.46	-2.33 ±3.17	-3.60 * ±1.48	-	-1.07 ±1.32	-
C	3.47 ± 2.05	7.33 ±3.97	0.33 ±1.70	-1.73 ±3.86	3.13 ±2.72	-	-6.47 ** ±2.14	-7.87 ±4.06	-2.20 ±1.92	-	2.07 ±1.91	-
D	1.17 ±0.76	3.73 ±2.34	0.83 ±1.01	6.20** ±2.26	-1.13 ±1.23	-	-2.40 ** ±0.91	-1.50 ±1.81	0.30 ±0.97	-	-0.23 ±0.92	-
3- Parameter Model												
<i>m</i>	54.07 ±0.39	69.71 ±0.79	56.60 ±0.18	-	-	-	-	61.49 ±0.75	-	-	-	-
[<i>d</i>]	1.65 ** ±0.35	-2.08* ±0.88	-0.17 ±0.18	-	-	-	-	-2.51** ±0.73	-	-	-	-
[<i>h</i>]	1.50 * ±0.76	-11.14** ±0.85	-1.65 ** ±0.45	-	-	-	-	2.26 ±1.50	-	-	-	-
χ^2 (3 d.f.)	4.10	4.69	1.44	20.33 **	7.97*	-	14.00 **	3.86	8.54 *	-	11.28 *	-
6 - Parameter Model												
<i>m</i>	-	-	-	66.93 ±0.80	52.83 ±0.48	-	54.25 ±0.33	-	55.65 ±31.69	-	57.12 ±0.33	-
[<i>d</i>]	-	-	-	1.13 ±1.60	-0.60 ±0.76	-	1.30 * ±0.63	-	3.20 ** ±0.73	-	1.53 * ±0.65	-
[<i>h</i>]	-	-	-	-6.60 ±4.65	0.57 ±2.64	-	1.47 ±2.00	-	-3.40 ±2.07	-	-1.93 ±1.96	-
[<i>i</i>]	-	-	-	-12.40** ±4.52	2.27 ±2.46	-	4.80 ** ±1.82	-	-0.60 ±1.94	-	0.47 ±1.84	-
[<i>j</i>]	-	-	-	-3.33* ±1.68	1.97 * ±0.93	-	0.97 ±0.74	-	2.20 ** ±0.81	-	2.33 ** ±0.81	-
[<i>l</i>]	-	-	-	26.53** ±7.49	-7.67 ±4.09	-	-3.13 ±3.29	-	3.40 ±3.50	-	-3.00 ±3.21	-
Type of epistasis	-	-	-	-	-	-	-	-	-	-	-	-

*, ** Significant at 5% and 1% levels respectively; E₁ = *kharif* 2005, E₂ = Summer -2006



Table 1-3 Contd. Plant height

Scaling tests/Gene effects	HRB-55 x AOL-05-4		VRO-5 x Red Long		VRO-6 x AOL-05-3		GO 2 x AOL-04-3		Arka Anamika x AOL-03-1		Parbhani Kranti x AOL-03-6	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
A	12.00	-0.67	-	7.33	-30.00	-7.33	12.33	0.67	-2.67	-22.33 **	26.33	15.00 **
	±22.03	±6.34		±6.97	±19.50	±5.22	±26.09	±6.79	±20.97	±6.42	±19.66	±5.78
B	-3.67	-2.00	-	21.67 **	3.67	-0.67	12.67	-5.00	-54.33**	0.33	28.33	9.00
	±17.81	±4.57		±7.59	±20.26	±4.93	±22.36	±4.65	±19.23	±7.28	±16.09	±6.07
C	23.00	-10.00	-	32.80 *	2.67	-8.67	21.67	-11.67	-85.33**	-21.00 *	57.33	12.67
	±33.41	±8.98		±13.55	±29.83	±7.10	±38.64	±8.15	±32.38	±10.63	±29.33	±8.54
D	7.33	-3.67	-	1.90	14.50	-0.33	-1.67	-3.67	-14.17	0.50	1.33	-5.67
	±14.28	±4.21		±5.06	±12.38	±3.36	±18.81	±4.41	±16.39	±4.44	±12.15	±4.85
3 – Parameter Model												
<i>m</i>	120.85	34.48	-	-	94.35	38.13	122.48	39.46	-	-	141.86	-
	±6.08	±0.98			±4.66	±1.54	±7.07	±1.38			±4.01	
[<i>d</i>]	-11.37 *	5.88 **	-	-	4.95	3.03 *	14.97 *	10.12 **	-	-	-1.93	-
	±5.52	±0.97			±4.47	±1.52	±6.83	±1.37			±3.77	
[<i>h</i>]	6.40	6.35 **	-	-	21.95 *	1.71	16.10	5.82 *	-	-	39.47 **	-
	±11.89	±2.31			±9.94	±2.85	±13.27	±2.69			±8.92	
χ^2 (3 d.f.)	1.04	1.42	-	9.64 *	3.72	2.71	0.51	2.75	11.86**	13.93 **	4.38	8.29 *
6 - Parameter Model												
<i>m</i>	-	-	-	49.28	-	-	-	-	121.58	-48.42	-	48.25
				±1.99					±6.10	±1.44		±1.65
[<i>d</i>]	-	-	-	-12.67 **	-	-	-	-	15.67	-3.67	-	3.83
				±3.13					±10.94	±3.38		±3.55
[<i>h</i>]	-	-	-	4.70	-	-	-	-	19.17	-0.33	-	13.83
				±11.51					±34.46	±9.94		±10.08
[<i>i</i>]	-	-	-	-3.80	-	-	-	-	28.33	-1.00	-	11.33
				±10.11					±32.78	±8.88		±9.71
[<i>j</i>]	-	-	-	-7.17 *	-	-	-	-	25.83 *	-11.33 **	-	3.00
				±3.63					±13.11	±3.97		±3.89
[<i>l</i>]	-	-	-	-25.20	-	-	-	-	28.67	23.00	-	-35.33 *
				±18.44					54.44	±17.19		±16.58
Type of epistasis	-	-	-	-	-	-	-	-	-	-	-	-

* , ** Significant at 5% and 1% levels respectively ; E₁ = *khariif* 2005, E₂ = Summer -2006



Table 1-4 Contd.

Primary branches per plant

Scaling tests/Gene effects	HRB-55 x AOL-05-4		VRO-5 x Red Long		VRO-6 x AOL-05-3		GO 2 x AOL-04-3		Arka Anamika x AOL-03-1		Parbhani Kranti x AOL-03-6	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
A	-0.27	1.00	0.13	-0.33	-0.07	-1.73 *	0.00	-1.87	-0.20	-1.73	0.87	1.40
	±0.90	±1.06	±0.88	±0.99	±0.72	±0.87	±1.22	±1.06	±0.94	±1.09	±1.27	±1.23
B	0.27	-0.33	-0.27	2.73 **	2.20 **	-0.33	-2.20*	-0.33	-2.53 **	-0.07	-0.53	1.07
	±0.89	±0.87	±0.89	±0.98	±0.82	±0.73	±0.98	±0.96	±0.96	±1.22	±0.87	±0.86
C	1.87 *	1.73	3.00*	2.27	2.33	-3.40 *	-4.93 **	-4.20 **	-1.80	-1.87	-1.80	1.67
	±1.39	±1.50	±1.50	±1.29	±1.32	±1.35	±1.50	±1.54	±1.45	±1.99	±1.47	±1.43
D	0.93	0.53	1.30*	-0.07	0.10	-0.67	-1.37	-1.00	0.47	-0.03	-1.07	-0.40
	±0.60	0.59	±0.66	±0.68	±0.72	±0.47	±0.73	±0.63	±0.69	±0.74	±0.73	±0.77
3 – Parameter Model												
<i>m</i>	6.05	3.15	6.12	-	-	3.36	-	-	5.63	5.11	6.63	4.60
	±0.30	±0.29	±0.30			±0.24			±0.29	±0.32	±0.33	±0.28
[<i>d</i>]	0.29	0.34	0.36	-	-	-1.60 **	-	-	0.88 **	-0.31	0.79 *	0.05
	±0.28	±0.25	±0.28			±0.22			±0.29	±0.28	±0.33	±0.28
[<i>h</i>]	-1.13 *	1.14 *	-1.11	-	-	0.72	-	-	-0.11	-0.83	-0.46	0.56
	±0.54	±0.57	±0.54			±0.49			±0.53	±0.66	±0.58	±0.51
χ^2 (3 d.f.)	3.04	3.84	5.13	9.77 *	8.87*	7.57	15.12**	9.45 *	7.02	3.11	3.26	2.62
6 - Parameter Model												
<i>m</i>	-	-	-	4.72	4.35	-	5.47	3.83	-	-	-	-
				±0.20	±0.28		±0.23	±0.20				
[<i>d</i>]	-	-	-	-0.77	-0.47	-	2.70 **	0.47	-	-	-	-
				±0.55	±0.45		±0.57	±0.50				
[<i>h</i>]	-	-	-	0.23	-1.73	-	2.27	3.17 *	-	-	-	-
				±1.46	±1.48		±1.58	±1.43				
[<i>i</i>]	-	-	-	0.13	-0.20	-	2.73	2.00	-	-	-	-
				±1.37	±1.44		±1.46	±1.27				
[<i>j</i>]	-	-	-	-1.53 *	-1.13 *	-	1.10	-0.77	-	-	-	-
				±0.64	±0.52		±0.74	±0.58				
[<i>l</i>]	-	-	-	-2.53	-1.93	-	-0.53	0.20	-	-	-	-
				±2.55	±2.25		±2.72	±2.53				
Type of epistasis	-	-	-	-	-	-	-	-	-	-	-	-

*, ** Significant at 5% and 1% levels respectively ; E₁ = *khariif* 2005, E₂ = Summer -2006



Table 1-5 Contd.

Stem girth

Scaling tests/Gene effects	HRB-55 x AOL-05-4		VRO-5 x Red Long		VRO-6 x AOL-05-3		GO 2 x AOL-04-3		Arka Anamika x AOL-03-1		Parbhani Kranti x AOL-03-6	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
A	-	-0.13 ±0.94	-	-0.67 ±0.72	-1.57 ** ±0.55	-2.07 * ±0.85	-	-2.17 ±1.12	-	-0.67 ±0.99	-0.27 ±0.62	1.00 ±1.10
B	-	0.07 ±0.82	-	2.30 ** ±0.63	-0.40 ±0.49	0.50 ±0.83	-	-1.07 ±0.95	-	0.37 ±1.03	-0.10 ±0.54	1.27 ±0.98
C	-	1.30 ±1.35	-	1.67 ±1.05	1.23 ±0.68	-3.30 ** ±1.28	-	-4.43 ** ±1.69	-	-1.87 ±1.62	-0.60 ±0.81	1.03 ±1.46
D	-	0.68 ±0.61	-	0.02 ±0.45	1.60 ** ±0.38	-0.87 ±0.51	-	-0.60 ±0.53	-	-0.78 ±0.63	-0.12 ±0.41	-0.62 ±0.77
3 – Parameter Model												
<i>m</i>	-	5.24 ±0.29	-	-	-	-	-	-	-	6.44 ±0.26	7.76 ±0.17	6.90 ±0.28
[<i>d</i>]	-	0.38 ±0.28	-	-	-	-	-	-	-	0.21 ±0.24	0.02 ±0.17	-0.41 ±0.28
[<i>h</i>]	-	0.75 ±0.51	-	-	-	-	-	-	-	0.62 ±0.55	0.02 ±0.31	0.60 ±0.52
χ^2 (3 d.f.)	-	1.59	-	18.40 **	19.45 **	11.71 **	-	8.46 *	-	2.91	0.63	2.15
6 - Parameter Model												
<i>m</i>	-	-	-	6.80 ±0.15	7.51 ±0.12	5.79 ±0.16	-	5.42 ±0.15	-	-	-	-
[<i>d</i>]	-	-	-	-0.48 ±0.33	0.12 ±0.30	-0.62 ±0.39	-	0.77 ±0.43	-	-	-	-
[<i>h</i>]	-	-	-	0.40 ±0.99	-3.20 ** ±0.80	1.97 ±1.15	-	2.62 * ±1.31	-	-	-	-
[<i>i</i>]	-	-	-	-3.33 ** ±0.90	-3.20 ** ±0.76	1.73 ±1.01	-	1.20 ±1.05	-	-	-	-
[<i>j</i>]	-	-	-	-1.48 ** ±0.41	-0.58 ±0.35	-1.28 * ±0.50	-	-0.55 ±0.52	-	-	-	-
[<i>l</i>]	-	-	-	-1.60 ±1.69	5.17 ** ±1.38	-0.17 ±2.01	-	2.03 ±2.42	-	-	-	-
Type of epistasis	-	-	-	-	Duplicate			-	-	-	-	-

*, ** Significant at 5% and 1% levels respectively ; E₁ = *kharif* 2005, E₂ = Summer -2006



Table 1-6 Contd.

Fruit length

Scaling tests/Gene effects	HRB-55 x AOL-05-4		VRO-5 x Red Long		VRO-6 x AOL-05-3		GO 2 x AOL-04-3		Arka Anamika x AOL-03-1		Parbhani Kranti x AOL-03-6	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
A	-0.84 ±1.68	-	2.49 ±1.42	-3.31 ±1.77	-1.70 ±1.40	1.13 ±1.22	-	1.05 ±1.82	-4.21 ** ±1.57	-4.84 ** ±1.20	-4.21 ** ±1.34	-3.68 * ±1.65
B	0.45 ±1.46	-	-0.85 ±1.57	-2.32 ±1.65	-0.18 ±1.29	0.42 ±1.16	-	-4.71 ** ±1.51	-2.59 * ±1.27	4.95 ** ±1.29	0.77 ±1.37	-0.43 ±1.88
C	1.63 ±2.58	-	7.42 ** ±2.41	-6.67 ** ±2.54	-2.50 ±2.24	-0.50 ±1.83	-	-5.01 ±2.84	-0.76 ±2.14	0.88 ±2.03	1.13 ±2.14	-6.14 * ±2.72
D	1.01 ±1.00	-	2.04 ±1.17	-0.52 ±1.39	-0.31 ±0.88	-1.02 ±0.80	-	-0.67 ±0.94	3.02 ** ±1.00	0.39 ±1.06	2.29 ±1.00	-1.02 ±1.32
3 – Parameter Model												
<i>m</i>	12.40 ±0.49	-	-	-	12.57 ±0.33	12.83 ±0.29	-	-	-	-	-	-
[<i>d</i>]	-0.31 ±0.43	-	-	-	0.45 ±0.31	1.05 ** ±0.28	-	-	-	-	-	-
[<i>h</i>]	2.45 * ±0.97	-	-	-	1.58 * ±0.71	1.17 ±0.61	-	-	-	-	-	-
χ^2 (3 d.f.)	1.43		10.55*	8.50 *	2.15	1.96	-	15.66 **	12.57 **	39.76 **	14.02 **	8.24 *
6 - Parameter Model												
<i>m</i>	-	-	16.32 ±0.43	15.72 ±0.49	-	-	-	13.90 ±0.33	14.16 ±0.34	15.81 ±0.39	14.42 ±0.36	14.91 ±0.46
[<i>d</i>]	-	-	2.44 ** ± 0.80	0.52 ±0.99	-	-	-	4.28 ** ±0.68	-0.88 ±0.73	-1.84 ** ±0.71	-2.17 ** ±0.69	-1.24 ±0.94
[<i>h</i>]	-	-	-3.23 ± 2.49	3.05 ±2.90	-	-	-	2.97 ±2.27	-4.83 * ±2.16	-2.33 ±2.21	-3.67 ±2.16	0.53 ±2.83
[<i>i</i>]	-	-	-4.08 ± 2.34	1.04 ±2.78	-	-	-	1.35 ±1.88	-6.04 ** ±2.00	-0.77 ±2.11	-4.57 ±2.00	2.03 ±2.65
[<i>j</i>]	-	-	0.82 ± 0.93	-0.49 ±1.12	-	-	-	2.88 ** ±0.85	-0.81 ±0.91	-4.89 ** ±0.79	-2.49 ** ±0.86	-1.63 ±1.12
[<i>l</i>]	-	-	0.74 ± 4.01	4.59 ±4.72	-	-	-	2.31 ±3.94	12.84 ** ±3.62	0.67 ±3.49	8.01* ±3.51	2.07 ±4.65
Type of epistasis	-	-	-	-	-	-	-	-	Duplicate	-	-	-

* , ** Significant at 5% and 1% levels respectively ; E₁ = kharif 2005, E₂ = Summer –2006



Table 1-7 Contd.

Fruit weight

Scaling tests/Gene effects	HRB-55 x AOL-05-4		VRO-5 x Red Long		VRO-6 x AOL-05-3		GO 2 x AOL-04-3		Arka Anamika x AOL-03-1		Parbhani Kranti x AOL-03-6	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
A	-	1.10 ±2.28	6.60* ±2.81	-	-5.95* ±2.41	-	-	3.60 ±3.68	-	-	-	-
B	-	4.90* ±2.36	5.30 ±3.16	-	-1.02 ±2.12	-	-	-5.60 ±2.92	-	-	-	-
C	-	10.70** ±4.13	5.80 ±5.37	-	-1.94 ±3.14	-	-	7.30 ±5.87	-	-	-	-
D	-	2.35 ±1.96	-3.05 ±2.54	-	2.52 ±1.67	-	-	4.65* ±2.36	-	-	-	-
3 – Parameter Model												
<i>m</i>	-	-	26.81 ±0.87	-	20.30 ±0.56	-	-	-	-	-	-	-
[<i>d</i>]	-	-	2.02* ±0.82	-	2.52** ±0.56	-	-	-	-	-	-	-
[<i>h</i>]	-	-	2.10 ±1.68	-	-0.69 ±1.10	-	-	-	-	-	-	-
χ^2 (3 d.f.)	-	8.98*	6.84	-	6.13	-	-	14.03**	-	-	-	-
6 - Parameter Model												
<i>m</i>	-	17.46 ±0.77	-	-	-	-	-	19.72 ±0.91	-	-	-	-
[<i>d</i>]	-	-1.37 ±1.20	-	-	-	-	-	5.52** ±1.50	-	-	-	-
[<i>h</i>]	-	-5.06 ±4.14	-	-	-	-	-	-8.28 ±5.25	-	-	-	-
[<i>i</i>]	-	-4.70 ±3.91	-	-	-	-	-	-9.30* ±4.72	-	-	-	-
[<i>j</i>]	-	-1.90 ±1.44	-	-	-	-	-	4.60* ±1.88	-	-	-	-
[<i>l</i>]	-	-1.30 ±6.33	-	-	-	-	-	11.30 ±8.38	-	-	-	-
Type of epistasis	-	-	-	-	-	-	-	-	-	-	-	-

*, ** Significant at 5% and 1% levels respectively; E₁ = kharif 2005, E₂ = Summer –2006



Table 1-8 Contd.

Fruits per plant

Scaling tests/Gene effects	HRB-55 x AOL-05-4		VRO-5 x Red Long		VRO-6 x AOL-05-3		GO 2 x AOL-04-3		Arka Anamika x AOL-03-1		Parbhani Kranti x AOL-03-6	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
A	3.07	1.27	-1.53	-0.13	-10.13 **	-1.53	4.00	2.67	3.67	-5.27 *	-4.80	2.87
	±2.82	±2.39	±3.83	±2.23	±2.99	±2.39	±3.47	±2.68	±3.23	±2.62	±3.27	±2.12
B	4.60	-3.07	-10.93	3.87 *	-3.60	2.53	3.33	2.80	-2.67	3.87	1.20	2.40
	±2.75	±1.89	** ±3.38	±1.69	±3.45	±2.25	±3.09	±1.72	±3.17	±3.16	±2.82	±2.23
C	14.07 *	-2.60	-9.20	4.73	-9.00	-5.73	12.07 *	1.87	4.60	0.40	-11.87 **	-1.60
	±5.35	±3.25	±5.85	±3.29	±4.80	±3.55	±5.29	±3.06	±5.46	±4.35	±4.23	±4.17
D	3.20	-0.40	1.63	0.50	2.37	-3.37 *	2.37	-1.80	1.80	0.90	-4.13	-3.43
	±2.23	±1.44	±2.79	±1.82	±2.13	±1.70	±2.67	±1.60	±2.36	±2.07	±2.39	±1.86
3 – Parameter Model												
<i>M</i>	15.53	5.92	-	10.09	-	8.21	15.70	9.30	16.87	9.74	-	7.83
	±0.70	±0.40		±0.56		±0.75	±1.01	±0.63	±1.06	±0.84		±0.61
[<i>d</i>]	-2.47 **	0.43	-	-0.73	-	0.61	2.68 **	3.85 **	-1.04	-0.58	-	1.54 **
	±0.65	±0.39		±0.57		±0.74	±1.00	±0.64	±0.96	±0.81		±0.56
[<i>h</i>]	2.45	3.93 **	-	0.02	-	0.17	2.93	0.11	0.98	3.38 *	-	2.57 *
	±1.54	±0.93		±0.85		±1.28	±1.75	±1.10	±1.99	±1.60		±1.25
χ^2 (3 d.f.)	7.04	4.19	10.65 *	6.54	11.54 **	6.22	5.42	3.29	3.85	7.51	9.50 *	4.36
6 - Parameter Model												
<i>M</i>	-	-	22.63	-	18.35	-	-	-	-	-	15.65	-
			±1.01		±0.69						±0.80	
[<i>d</i>]	-	-	2.70	-	-0.53	-	-	-	-	-	0.77	-
			±1.93		±1.63						±1.77	
[<i>h</i>]	-	-	-0.33	-	-1.80	-	-	-	-	-	9.83 *	-
			±5.97		±4.70						±5.00	
[<i>i</i>]	-	-	-3.27	-	-4.73	-	-	-	-	-	8.27	-
			±5.58		±4.27						±4.77	
[<i>j</i>]	-	-	4.70 *	-	-3.27	-	-	-	-	-	-3.00	-
			±2.21		±1.97						±2.06	
[<i>l</i>]	-	-	15.73	-	18.47 *	-	-	-	-	-	-4.67	-
			±9.68		±8.09						±8.25	
Type of epistasis	-	-	-	-	-	-	-	-	-	-	-	-

*, ** Significant at 5% and 1% levels respectively ; E₁ = *kharif* 2005, E₂ = Summer -2006



Table 1-9 Contd.

Scaling tests/Gene effects	Fruit yield per plant											
	HRB-55 x AOL-05-4		VRO-5 x Red Long		VRO-6 x AOL-05-3		GO 2 x AOL-04-3		Arka Anamika x AOL-03-1		Parbhani Kranti x AOL-03-6	
	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂	E ₁	E ₂
A	90.00	26.33	-71.67	-44.73	-191.67 **	-56.67	105.00	35.33	85.33	-91.00 *	-37.00	99.33 *
	±63.74	±44.31	±94.44	±53.53	±73.66	±45.37	±74.76	±65.83	±53.85	±46.10	±72.20	±45.31
B	110.00	-38.67	-156.33	154.33 **	-59.00	11.00	46.00	12.33	35.67	188.00 **	61.67	53.00
	±62.19	±36.11	±89.33	±46.25	±77.26	±32.68	±68.31	±34.11	±67.75	±68.99	±57.24	±46.80
C	204.33*	-39.00	-139.27	211.27 *	-233.67 *	-162.67 *	288.33 *	-33.00	202.67	44.67	-102.33	55.67
	±103.01	±59.00	±135.68	±88.48	±102.64	±63.93	±113.21	±66.52	±109.47	±76.95	±100.05	±79.15
D	2.17	-13.33	44.37	50.83	8.50	-58.50 *	68.67	-40.33	40.83	-26.17	-63.50	-48.33
	±42.96	±26.56	±64.95	±47.85	±47.22	±27.55	±57.11	±34.36	±55.79	±42.89	±51.53	±39.70
3 – Parameter Model												
<i>M</i>	264.66	81.29	475.88	-	-	-	245.36	154.95	279.66	-	295.14	136.96
	±15.60	±7.74	±26.64				±19.58	±13.86	±15.72		±19.13	±108.97
[<i>d</i>]	-75.88	12.74	42.71	-	-	-	34.02	83.82 **	-57.46 **	-	31.64	30.55 **
	**	±7.56	±25.95				±19.20	±13.60	±15.48		±19.03	±10.66
	±15.04											
[<i>h</i>]	66.05	69.79 **	125.20 *	-	-	-	106.64	-6.42	36.22	-	78.15 *	46.67 *
	±34.25	±17.51	±50.63				**	±24.86	±30.10		±33.50	±22.74
							±37.22					
χ^2 (3 d.f.)	4.66	2.48	3.23	17.76 **	7.98 *	9.18 *	6.97	1.45	4.67	14.73 **	3.46	5.30
6 - Parameter Model												
<i>m</i>	-	-	-	242.17	299.25	115.17	-	-	-	198.17	-	-
				±18.97	±12.58	±10.42				±12.98		
[<i>d</i>]	-	-	-	-58.17 *	6.67	-1.50	-	-	-	-105.17 **	-	-
				±29.17	±39.97	±18.01				±34.13		
[<i>h</i>]	-	-	-	-96.37	51.00	147.33 *	-	-	-	104.33	-	-
				±98.37	±104.50	±60.19				±90.35		
[<i>i</i>]	-	-	-	-101.67	-17.00	117.00 *	-	-	-	52.33	-	-
				±95.70	±94.44	±55.09				±85.78		
[<i>j</i>]	-	-	-	-99.53 **	-66.33	-33.83	-	-	-	-139.50 **	-	-
				±33.66	±45.81	±25.53				±38.36		
[<i>l</i>]	-	-	-	-7.93	267.67	-71.33	-	-	-	-149.33	-	-
				±146.43	±189.98	±96.31				±156.72		
Type of epistasis	-	-	-	-	-	-	-	-	-	-	-	-

*, ** Significant at 5% and 1% levels respectively; E₁ = *kharif* 2005, E₂ = Summer -2006