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HETEROSIS AND INBREEDING DEPRESSION STUDIES IN OKRA [*ABELMOSCHUS ESCULENTUS* (L.) *MOENCH*]

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ABSTRACT
The present investigation, the heterosis percentage for better parent found to be more or less similar in magnitude. The F_1 of cross GDO-6 x Julie (11.98%) and their F_2's (2.42%) recorded high heterosis over better parent for significant and maximum standard heterosis for yield per plant. Inbreeding depression study showed the reduction in vigour in F_2's of crosses over F_1's. The reduction in performance found to be non-significant for all the characters under study. The maximum inbreeding depression for yield was observed in the cross GDO-6 x Julie (8.53%) and for no. of branches per plant in the cross GDO-6 x Julie (20.69%).The high estimates with significant heterosis and the inbreeding depression for the characters in the cross GDO-6 x Julie and IC-90222 x GDO-1 indicating the utilization additive genetic component under selection.

INTRODUCTION

Okra being an often cross pollinated crop exists greater variability in this crop (Swarup, 1977). India is center of diversity for okra provides a range of variation for its genetic improvement in yield. However, there are different kind of stresses which limits the desirable yield and quality. Improvement in yield can be achieved either by evolving high yielding varieties or hybrids. The genetic enhancement is one of the important tools to improve productivity of any crop. The heterotic breeding, a modern approach to enhance the genetic potential has been widely achieved and established in various crop species. Therefore, the development of high yielding hybrids may be useful to get higher yield programme is very crucile factor. Selection of individuals is made on the basis of their phenotype to bring about improvement in the characters in desirable direction. Thus, the exploitation of hybrid vigour in okra has been recognized as important tool by the breeder for increasing the yield. The aim of present investigation is to spot out the best heterotic combinations giving high degree of useful heterosis with low inbreeding depression in further generations. Aware *et al*. (2014) and Neetu *et al*. (2015) reported the heterosis and inbreeding depression in okra. Therefore, the study was undertaken to find out the estimate the extent of heterosis in F_1 crosses for yield and yield contributing characters and the estimate the extent of inbreeding depression in respective crosses for yield and yield contributing characters in okra.

MATERIALS AND METHODS

The present investigation "Heterosis and inbreeding depression studies in okra (*Abelmoschus esculentus* (L.) Moench)" was conducted during kharif season 2015 in Main Garden, Department of Horticulture, Dr. PDKV, Akola (M.S.) using Randomized Block Design with three replications. The experimental material comprised The nineteen treatments of okra comprised of six parents viz. GDO-4, Julie, GDO-6, GDO-1, Arka Anamika and IC-90222, six crosses of F_1's generations, six crosses of F_2's generations and one check were evaluated for heterosis and inbreeding depression studies. The experiment was conducted in randomized block design with three replications at Main garden, Department of Horticulture, Dr. PDKV., Akola (M.S.) during Kharif 2015. The observations were recorded on seventeen characters viz. plant height (cm), internodal length (cm), number of branches per plant, days to flower initiation, days required for 50% flowering, days required for first harvest, length of fruit (cm), diameter of fruit (cm), weight of fruit, number of fruits per plant, yield per plant (g), chlorophyll content in leaves (mg/g), protein content in fruit (mg/g), crude fiber content in fruit (%), incidence of Y.V.M.V (%), yield per plot (kg), yield per hectare (q). The data obtained on the characters were analyzed to estimate mean sum of squares, heterosis and inbreeding depression as per the standard procedure suggested by Panse Sukhatme (1967) and Singh and Narayanan (1993).

Estimation of heterosis

The magnitude of heterosis was estimated in relation to better parent values.

It was estimated in percent over better parent as follows.

$$\% \text{ heterosis is over better parent (BPH)} = \frac{\overline{F_1} - \overline{BP}}{(\text{Heterobeltiosis})_{BP}} \times 100$$

Where,

$\overline{F1}$ = Mean performance of cross

$\overline{B1}$ = Mean performance of better parent

Estimation of Inbreding Depression

Inbreeding depression was carried out with the help of following formulae

Inbreeding depression = $(F_1-F_2) / F_1] \times 100$

Where,

F_1 and F_2 = mean values over for F_1 and F_2 population of same cross.

RESULTS AND DISCUSSION

The analysis of variance (Table 1) revealed the significant differences among

the treatments for the seventeen characters studied. It indicated the presence of genetic variations amongst the treatments. The degree of heterosis and inbreeding depression is presented in (Table 1 and 2).

Mean performance of parents and F_1's crosses and their F_2's showed (Table 1 and 2) the presence of high mean performance of crosses for all the characters except days to 50 % flowering over the parents. It is expected also because in crosses desirable genes are combining together from two different parents resulting into hybrid vigour.

Similar results have been obtained by some workers Vijay and Manohar (1986), More and Patil (1997) and Reddy *et al.* (2012).The reduction in mean performance value or F_1's of crosses and their F_2's for all the characters over the F_1's indicating the loss of vigour due to segregation of genotypic constitution. Similar results were also reported by Joshi *et al.* (1958).

Estimation of heterosis and inbreeding depression

Heterosis is the superiority or inferiority of F_1's over the parents. Whereas, inbreeding depression is called as a loss in fitness or vigour due to inbreeding. Mainly the magnitude of heterosis is measured as deviation from mid parent (average heterosis), better parent (heterobeltiosis) and commercial check (standard heterosis) are presented in Table 1.

Considerable amount of average heterosis in desirable direction was observed in all the characters studied. In F_1 crosses and their F_2's the highest positive significant average heterosis among the characters was observed for plant height (19.79% and -6.53%) followed by number of branches per plant (30.34% and 27.47%), internodal length (12.50% and -0.45%), days to flower initiation (3.84% and 5.26%), days to 50% flowering (3.33% and 5.50%), days to first harvest (2.57% and 3.45%), number of fruits per plant (36.99% and 24.81%), weight of fruit (19.44% and 9.25%), length of fruit (7.25% and 11.14%), diameter of fruit (10.34 % 12.22%), chlorophyll content (3.99% and 1.10%), fiber content (7.90 and 11.04), protein content (2.15% and 0.88%), yield per plant(g) (19.44% and 9.25%), yield per plot (19.46% and 9.27%), yield per hectare (19.46% and 9.27%).

Amongst the F_1 crosses studied the cross GDO-6 x Julie has recorded highest and significant average heterosis for number of branches per plant (30.34%), followed by fourth heighest significant average heterosis for number of fruits per plant (17.49%), weight of fruit(19.44%), yield per plant (g) (19.44 %), yield per plot (19.46%), yield per hectare (19.46%) and their F_2's for days to flower initiation (5.26%) followed by days

Table 1: Estimates of average heterosis (H_1), heterobelteosis (H_2) and standard heterosis (H_3) for various characters

Crosses	Plant height (cm)						Number of branches per plant					
	H_1		H_2		H_3		H_1		H_2		H_3	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
GDO-4 x GDO-1	14.12*	-7.38	14.06*	-7.44	14.01*	-7.48	18.28*	3.23	14.58	0.00	-1.79	-14.29*
GDO-6 x Julie	0.43	-18.29**	-5.21	-22.21**	-0.81	-18.60**	30.34**	3.37	26.09**	0.00	3.57	-17.86*
Arka Anamika x Julie	5.38	-27.51**	2.17	-29.71**	13.84*	-21.69**	20.42**	-3.66	9.52	12.38	2.68	-17.86*
GDO-6 x GDO-4	4.87	-6.95	2.07	-9.44	2.02	-9.48	16.48*	27.47**	15.22	26.09**	-5.36	3.57
IC-90222 x GDO-1	19.79**	-6.53	9.03	-14.93*	8.86	-15.06*	4.26	4.26	2.08	2.08	-12.50	-12.50
GDO-6 x GDO-1	3.40	-14.54*	0.68	-16.79*	0.53	-16.92*	12.77	8.51	10.42	6.25	-5.36	-8.93
SE (diff) +	6.64		7.67		7.67		0.22		0.25		0.25	
CD at 5%	13.47		15.55		15.55		0.44		0.51		0.51	
CD at 1%	18.06		20.85		20.85		0.59		0.68		0.68	

Crosses	Internodal length (cm)						Days to flower initiation					
	H_1		H_2		H_3		H_1		H_2		H_3	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
GDO-4 x GDO-1	-19.85**	-12.99*	-24.78**	-18.33**	-15.57*	-8.34	-0.72	1.16	-1.29	0.58	2.54	4.48*
GDO-6 x Julie	-1.25	-0.45	-2.13	-1.35	-3.00	-2.22	-0.83	5.26**	-5.46**	0.35	-2.69	3.29
Arka Anamika x Julie	5.33	-1.52	5.27	-1.57	4.34	-2.45	-1.13	-2.73	-1.30	-2.89	1.94	0.30
GDO-6 x GDO-4	12.50*	-8.30	11.86	-8.81	10.12	-10.23	1.73	3.41*	-2.91	-1.31	-0.30	1.35
IC-90222 x GDO-1	-14.34**	-14.34**	-18.52**	-18.52**	1.33	1.33	-0.30	5.07**	-3.74*	-8.35**	0.00	-4.78*
GDO-6 x GDO-1	-3.61	-2.65	-10.01	-9.12	1.00	2.00	3.84*	1.57	-1.44	-3.60	2.39	0.15
SE (diff) +	0.34		0.39		0.39		0.72		0.83		0.83	
CD at 5%	0.69		0.80		0.80		1.46		1.68		1.68	
CD at 1%	0.92		1.07		1.07		1.95		2.26		2.26	

Table 1: Cont....

Crosses	Days to 50% flowering						Days to first harvest					
	H_1		H_2		H_3		H_1		H_2		H_3	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
GDO-4 x GDO-1	0.26	0.09	-0.26	0.38	2.77	3.43*	-0.79	0.92	-0.92	0.78	1.88	3.63*
GDO-6 x Julie	-0.27	5.50**	-3.63*	1.95	-1.98	3.69*	-1.69	3.45*	-4.97**	0.00	-2.42	2.69
Arka Anamika x Julie	-1.09	-2.25	-2.16	-3.30	1.72	0.53	-1.86	-2.51	-2.27	-2.92	1.21	0.54
GDO-6 x GDO-4	1.07	2.14	-2.46	-1.42	-0.53	0.53	0.00	2.03	-3.40*	-1.44	-0.67	1.34
IC-90222 x GDO-1	-0.92	-5.04**	-3.14	-7.17**	-0.20	-4.35*	-0.47	-4.15**	-2.56	-6.16**	-0.07	-3.76*
GDO-6 x GDO-1	3.33*	0.40	-0.77	3.59*	2.24	-0.66	2.57	1.36	0.79	-1.97	1.75	0.54
SE (diff) +	0.73		0.84		0.84		0.67		0.77		0.77	
CD at 5%	1.48		1.70		1.70		1.36		1.57		1.57	
CD at 1%	1.98		2.28		2.28		1.82		2.10		2.10	

Crosses	Number of fruits/plant						Weight of fruit (g)					
	H_1		H_2		H_3		H_1		H_2		H_3	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
GDO-4 x GDO-1	25.91**	24.66**	17.36*	16.19*	9.63	8.55	-0.83	-0.33	-2.90	-2.41	13.53**	14.11**
GDO-6 x Julie	17.49**	16.95**	14.17*	13.65*	18.05*	17.50*	19.44**	9.25*	11.98**	2.42	28.06**	17.14**
Arka Anamika x Julie	13.20*	11.42*	9.58	7.86	21.03**	19.13**	3.98	0.38	-4.75	-8.05*	14.57**	10.60*
GDO-6 x GDO-4	23.62**	16.09*	21.00**	13.63	18.05**	10.85	-6.11	-7.42*	-7.06	-8.36*	6.29	4.80
IC-90222 x GDO-1	27.76**	20.69**	11.87	5.68	20.22**	13.57	-8.52*	-6.86	-8.60*	-6.94	6.87	8.82
GDO-6 x GDO-1	36.99**	24.81**	25.17**	14.05	22.12**	11.26	-3.87	0.79	-4.92	-0.32	11.18*	16.56**
SE (diff) +	1.45		1.67		1.67		0.33		0.38		0.38	
CD at 5%	2.94		3.39		3.39		0.66		0.76		0.76	
CD at 1%	3.94		4.55		4.55		0.89		1.02		1.02	

Table 1: Cont....

Crosses	Fruit length (cm)						Fruit diameter (cm)					
	H_1		H_2		H_3		H_1		H_2		H_3	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
GDO-4 x GDO-1	-4.17	-6.36	-4.89	-7.06	6.68	4.24	2.54	0.20	-0.38	-2.66	37.89**	34.74**
GDO-6 x Julie	4.03	8.46*	1.27	5.58	14.64**	19.52**	-12.27**	-7.58*	-14.44**	-9.86*	27.89**	34.74**
Arka Anamika x Julie	7.25	0.46	3.62	-2.93	25.80**	17.84**	-3.46	10.96**	-7.04	6.85	32.11**	51.84**
GDO-6 x GDO-4	1.42	-2.74	-0.82	-4.89	11.24*	6.68	10.34*	12.22**	3.35	5.11	54.47**	57.11**
IC-90222 x GDO-1	3.91	-7.56	-1.77	-12.61**	21.84**	8.40	-0.47	-1.97	-1.67	-3.15	39.47**	37.37**
GDO-6 x GDO-1	6.65	11.14**	5.07	9.49*	16.08**	20.96**	-5.30	-10.79**	-8.80*	-14.08**	36.32**	28.42**
SE (diff) +	0.36		0.42		0.42		0.07		0.08		0.8	
CD at 5%	0.74		0.85		0.85		0.14		0.14		0.16	
CD at 1%	0.99		1.15		1.15		0.19		0.19		0.21	

Crosses	Leaf chlorophyll content						Crude fiber content in fruit %					
	H_1		H_2		H_3		H_1		H_2		H_3	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
GDO-4 x GDO-1	1.13	-0.31	0.00	-1.42	-2.96**	-4.34**	7.90	4.29	7.69	4.09	-11.09*	-14.06*
GDO-6 x Julie	3.99**	0.88	3.49**	0.39	5.33**	2.17*	-6.57	-8.15	-13.09**	-14.57*	-18.01**	-19.40**
Arka Anamika x Julie	1.18	0.00	0.98	-0.20	1.78	0.59	-1.32	0.52	-10.86**	-9.20	-10.30	-8.63
GDO-6 x GDO-4	1.50	1.10	-1.94	-2.33*	-0.20	-0.59	-6.07	11.04*	-12.09*	3.92	-17.06**	-1.96
IC-90222 x GDO-1	-6.35**	-6.75**	-7.78**	-7.58**	-8.88**	-8.68**	-7.06	-4.97	-19.03**	-17.22**	-9.95	-7.93
GDO-6 x GDO-1	1.19	0.60	-1.16	-1.74	0.59	0.00	3.13	3.91	-3.32	-2.58	-8.78	-8.09
SE (diff) +	0.01		0.02		0.02		0.48		0.55		0.55	
CD at 5%	0.03		0.03		0.03		0.97		1.12		1.12	
CD at 1%	0.04		0.05		0.05		1.30		1.50		1.50	

to 50% flowering (5.50%),days to first harvesting (3.45%),third highest average heterosis number of fruits per plant (16.95%), weight of fruit(9.25%), yield per plant (g) (9.25%), yield per plot (9.27%), yield per hectare (9.27%) and second highest in fruit length (8.46%). Significant average heterosis for yield per plant (g), yield per plot (kg) and yield per hectare(q) in the F_1 and their F_2 of cross GDO-6 x Julie is expected because of significant average heterosis for number of branches per plant and these characters have direct influence on yield. Average heterosis for earliness was found non significant in all the crosses studied. Indicating the none of the cross combination could be prove useful for development of early genotypes.

Table 1: Cont.....

Crosses	Protein Content in Fruit %						Yield/ plant (g)					
	H_1		H_2		H_3		H_1		H_2		H_3	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
GDO-4 x GDO-1	-1.35	-2.47	-4.75**	-5.65**	-4.57**	-5.65**	-0.83	0.83	-2.90	-1.27	13.53**	15.44**
GDO-6 x Julie	-0.44	-0.22	-3.59*	-3.38**	-0.65	-0.43	19.44**	9.25*	11.98**	2.42	28.06**	17.14**
Arka Anamika x Julie	2.15	-0.22	-2.26	-4.53**	3.26	0.87	3.98	0.38	-4.75	-8.05*	14.57**	10.60*
GDO-6 x GDO-4	-6.64**	-6.21**	-8.02**	-7.59**	-5.22**	-4.78**	-6.11	-7.42*	-7.06	-12.87**	6.29	4.80
IC-90222 x GDO-1	-9.13**	-9.13**	-15.57**	-15.57**	-8.04**	-8.04**	-8.52*	-6.86	-8.60*	-9.53*	6.87	8.82
GDO-6 x GDO-1	-0.44	0.88	-5.06**	-3.80*	-2.17	-0.87	-3.87	0.79	-4.92	-3.10	11.18*	16.56**
SE (diff) +	0.02		0.02		0.02		4.59		5.30		5.30	
CD at 5%	0.04		0.04		0.04		9.31		10.75		10.75	
CD at 1%	0.05		0.06		0.06		12.48		14.41		14.41	

Significant at 5% level. ,** - Significant at 1% level; N ote - Significance for Heterosis (H_1) was tested over F_1-MP.; Significance for Heterobeltiosis (H_2) was tested over F_1-BP ; Significance for Standard Heterosis (H_3) was tested over F_1-Check

Table 1: Cont....

Crosses							Yield/ hectare (q)					
	H_1		H_2		H_3		H_1		H_2		H_3	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
GDO-4 x GDO-1	-0.82	0.82	-5.6	-4.04	13.56**	15.44**	-0.82	0.82	-2.89	-1.28	13.63**	15.52**
GDO-6 x Julie	19.46**	9.27	6.48	-2.6	28.10**	17.18**	19.46**	9.27*	12.01**	2.46	28.18**	17.24**
Arka Anamika x Julie	4.01	0.38	-4.72	-8.04*	14.62**	10.63*	4.01	0.38	-4.72	-8.04*	14.69**	10.70*
GDO-6 x GDO-4	-6.09	-7.40*	-11.63**	-12.86**	6.32	4.84	-6.09	-7.40*	-7.03	-8.33	6.38	4.9
IC-90222 x GDO-1	-8.53*	-6.86	-11.15**	-9.54*	6.89	8.83	-8.52*	-6.86	-8.60*	-6.93	6.96	8.9
GDO-6 x GDO-1	-3.85	0.8	-7.57	-3.09	11.20*	16.59**	-3.85	0.81	-4.91	-0.3	11.27*	16.66**
SE (diff) +	0.06		0.07		0.07		3.57		4.13		4.13	
CD at 5%	0.13		0.15		0.15		7.25		8.37		8.37	
CD at 1%	0.17		0.2		0.2		9.72		11.22		11.22	

Crosses	Y.M.V.M. Incidence %					
	H_1		H_2		H_3	
	F1	F2	F1	F2	F1	F2
GDO-4 x GDO-1	21.74	-4.35	16.67	-8.33	-40.61**	-53.33**
GDO-6 x Julie	45.45	172.73**	0	87.50*	-66.06**	-36.36**
Arka Anamika x Julie	-12.5	-37.5	-46.15*	-61.54**	-70.30**	-78.79**
GDO-6 x GDO-4	15.79	47.37	0	27.27	-53.33**	-40.61**
IC-90222 x GDO-1	12	-4	7.69	-7.69	-40.61**	-49.09**
GDO-6 x GDO-1	-20	-50.00*	-33.33	-58.33*	-66.06**	-78.79**
SE (diff) +	0.11		0.13		0.13	
CD at 5%	0.22		0.26		0.26	
CD at 1%	0.3		0.34		0.34	

The significant average heterosis for yield and yield contributing characters were reported by More and Patil (1997), Reddy *et al*. (2012), Dubey *et al*. (2014) Neetu *et al*., (2015) and Spaldon *et al*. (2015).

Amongst the characters in F_1 and their F_2's studied the highest positive as well as negative significant heterobeltiosis noticed for plant height (14.06% and -7.44%) followed by number of branches per plant (26.09% and 26.09%), internodal length (11.86% and -1.35%), days to 50% flowering (-0.26% and 3.59%), number of fruits per plant (25.17% and 16.19%), weight of fruit (11.98% and 2.42%), fruit length (5.07% and 9.49%), diameter of fruit (3.35% and 6.85%), chlorophyll content (3.49% and 0.39%), fiber content (7.69% and 4.09%), protein content (-2.26% and -3.38%), yield per plant (11.98% and 2.42%), yield per plot (6.48% and -2.60%) and yield per hectare (12.01% and 2.46%).

The F_1 cross GDO-6 x Julie had recorded highest and significant heterobeltiosis for number of branches per plant (26.09%) followed by weight of fruit (11.98%), chlorophyll content (3.49%) yield per plant (11.98%), yield per plot (6.48%), yield per hectare (12.01%) and their F_2's for internodal length (-1.35%) followed by second highest for days to flower initiation (0.35%), days to 50% flowering (1.95%), third highest for number of fruits per plant (13.65%), weight of fruit (2.42%), chlorophyll content (0.39%), protein content (-3.38%), yield per plant (2.42%), yield per plot (-2.60%), yield per hectare (2.46%).On the basis of above heterobeltiosis percentage the above said promise for further exploitation as the best parent used or the cross found to be high yielding among parent. High heterobeltiosis in F_1 and their F_2 of cross GDO-6 x Julie for yield per plant, yield per plot and yield per hectare was also expected because of significant heterobeltiosis for yield contributing characters.

The significant heterobeltiosis for yield per plant and other yield contributing characters was reported by Vijay and Manohar (1986), Mamimdwar *et al*. (2006), Senthil Kumar

Table 2: Estimates of Inbreeding Depression for various characters

Hybrid	Plant Height (cm)	C.D. 5%	Number of Branches / Plant	C.D.5%	Internodal Length (cm)	C.D. 5%	Days to Flower Initiation	C.D. 5%	Days to 50% Flowering	C.D. 5%	Days to First Harvest	C.D. 5%
GDO-4 x GDO-1	18.84	8.351**	12.727	0.628	-8.564	0.766	-1.895	2.944	-0.642	2.476	-1.715	2.159
GDO-6 x Julie	17.93	26.026	20.690	0.693*	-0.803	0.814	-6.144	1.736*	-5.787	1.410**	-5.234	1.614*
Arka Anamika x Julie	31.20	29.29*	20.000	0.498*	6.503	1.431	1.613	2.213	1.167	2.127	0.664	2.428
GDO-6 x GDO-4	11.27	11.23*	-9.434	0.888	18.485	1.286	-1.649	2.036	-1.061	2.385	-2.030	2.143
IC-90222 x GDO-1	21.97	24.88*	0.000	0.634	0.000	1.045	4.783	2.110*	4.158	2.646	3.699	1.921
GDO-6 x GDO-1	17.35	20.29*	3.774	0.791	-0.991	0.684	2.190	1.656	2.839	1.255*	1.189	1.457
Average	19.99	7.052**	8.449	0.243*	3.031	0.376	-0.149	0.937	0.141	0.955	-0.547	0.844

Hybrid	Number Fruits/ Plant	C.D. 5%	Weight of Fruit (g)	C.D. 5%	Fruit Length (cm)	C.D. 5%	Fruit Diameter (cm)	C.D. 5%	Leaf Chlorophyll Content	C.D. 5%	Crude Fiber Content in Fruit %	C.D. 5%
GDO-4 x GDO-1	0.990	3.580	-0.510	0.740	2.287	0.744	2.290	0.277	1.423	0.040	3.340	1.185
GDO-6 x Julie	0.460	4.097	8.533	1.728	-4.257	0.497	-5.350	0.315	2.996	0.052*	1.696	0.999
Arka Anamika x Julie	1.570	4.038	3.468	0.675	6.328	1.388	-14.940	0.337	1.163	0.045	-1.867	1.449
GDO-6 x GDO-4	6.092	2.412	1.402	0.915	4.099	0.879	-1.704	0.207	0.395	0.049	-18.210	1.495*
IC-90222 x GDO-1	5.530	3.862	-1.820	0.927	11.031	1.234	1.509	0.135	-0.216	0.046	-2.246	1.606
GDO-6 x GDO-1	8.889	3.970	-4.840	0.626	-4.204	0.912	5.792	0.167	0.588	0.045	-0.762	1.269
Average	3.980	1.148*	1.247	0.420	2.677	0.452	-1.938	0.104	1.093	0.049	-2.884	0.480

Hybrid	Protein Content in Fruit %	C.D. 5%	Yield/ plant (g)	C.D. 5%	Yield/ plot (kg)	C.D. 5%	Yield/ hectare (q)	C.D. 5%	Y.M.V.M. Incidence %	C.D. 5%
GDO-4 x GDO-1	1.139	0.073	-1.677	11.236	-1.656	0.157	-1.657	8.741	21.429	0.290
GDO-6 x Julie	-0.219	0.047	8.533	24.198	8.527	0.339	8.531	18.816	-87.500	0.343
Arka Anamika x Julie	2.316	0.041	3.468	9.443	3.484	0.132	3.483	7.310	28.571	0.366
GDO-6 x GDO-4	-0.459	0.046	1.402	12.813	1.391	0.179	1.390	9.947	-27.273	0.366
IC-90222 x GDO-1	0.000	0.072	-1.820	12.975	-1.819	0.182	-1.819	10.134	14.286	0.410
GDO-6 x GDO-1	-1.333	0.086	-4.840	8.757	-4.845	0.123	-4.847	6.848	37.500	0.290
Average	0.261	0.040	1.052	5.934	1.055	0.083	1.055	4.615	0.000	0.143

*Significant at 5% level of significance; ** Significant at 1% level of significance; Note -Significance for Inbreeding Depression was tested over F1- F2

and Sreeparvathy (2010), Lyngdoh *et al*. (2013).

In F_1 and their F_2's of crosses the highest positive significant useful heterosis for plant height (14.01% and -7.48%), followed by number of branches per plant (3.57% and 3.57%), internodal length (10.12% and 2.00%), days to flower initiation (2.54% and 4.48%), days to 50% flowering (2.77% and 3.69%), days to first harvest (1.88% and 3.63%), number of fruits per plant (22.12% and 19.13%), weight of fruit (28.06% and 17.14%), length of fruit (25.80% and 20.96%), diameter of fruit (54.47 % and 57.11%), chlorophyll content (5.33% and 2.17%), protein content (3.26% and 0.87%), yield per plant (28.06 % and 17.14%), yield per plot (28.10% and 17.18%) and yield per hectare (28.18% and 17.24%).

The F_1 cross GDO-6 x Julie recorded highest significant useful heterosis for number of branches per plant (3.57%) followed by weight of fruit (28.06%), chlorophyll content (5.33%), yield per plant (28.06%), yield per plot (28.10%), yield per hectare (28.18%) and their F_2's for days to 50% flowering (3.69%) followed by second highest in days to first harvest (2.69%), second highest useful heterosis for number of fruits per plant (17.50%), weight of fruit (17.14%), second highest useful heterosis in fruit length (19.52%), chlorophyll content (2.17%), yield per plant (17.14%), yield per plot (17.18%), yield per hectare (17.24%).Thus, the above said could be useful for commercial exploitation affects testing on large scale. High useful heterosis for yield was also expected in this crosses because of there crosses had also recorded high mean performance there heterosis for other yield contributing characters. This cross recorded positive and significant useful heterosis for days to 50% flowering indicate later on in cross with increasing vegetative phase reflecting into increase in height of plant.

Significant useful heterosis for yield per plant and other yield contributing character was reported by several research workers like Amutha *et al*. (2007), Senthil Kumar and Sreeparvathy (2010), Lyngdoh *et al*. (2013) and Dubey *et al*., (2014).

Overall the study revealed that magnitude of percentage over mid parent(H_1),better parent (H_2) and useful heterosis (H_3) were found more or less similar among the all the characters. It may be due to fact that newly developed lines and used which shown good mean performance for all the character under study. The F_1 and their F_2 of cross GDO-6 x Julie found to be promising on the basis of standard heterosis (H_1), heterobeltiosis (H_2) and useful heterosis (H_3) for plant height, days to 50% flowering, number of branches per plant, number of fruits per plant, weight of fruit, chlorophyll content, yield per plant, yield per plot and yield per hectare.

Inbreeding depression

Estimates of inbreeding depression presented in Table 2, revealed that maximum inbreeding depression for all the characters under study were found non significant except some characters such as for plant height in the cross Arka Anamika x Julie (31.21%), cross IC-90222 x GDO-1(21.98%), cross GDO-4 x GDO-1(18.85%), cross GDO-6 x GDO-1(17.35%) and cross GDO-6 x GDO-4 (11.28%), for branches per plant in the cross GDO-6 x Julie (20.69%) and cross Arka Anamika x Julie (20.00%) ,for days to initiation of flowering in the cross IC-90222 x GDO-1 (4.78%), for days to 50% flowering in the cross GDO-6 x GDO-1 (2.84%), for chlorophyll content cross GDO-6 x Julie (3.00%) all these crosses indicating that the lower performance of F_2's than F_1's for all the characters due to lack of segregation of desirable gene responsible for dominance effect or it may be due to tight linkage of desirable genes or due to phenomenon of fixing of heterozygosity. Such crosses could prove useful in diallel selective mating system. Similar kind of results for inbreeding depression for yield and it's contributing character was also reported by More and Patil (1997), Amutha *et al*. (2007), Aware *et al*. (2014) and Neetu *et al*. (2015).

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