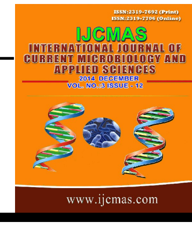

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Original Research Article

Heteosis and inbreeding depression studies in Okra (*Abelmoschus esculentus (L.) Moench*)

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A B S T R A C T

The present investigation "Heterosis and Inbreeding Depression studies in okra (*Abelmoschus esculentus (L.) Moench*)" was conducted with a view to estimate the extent of heterosis and inbreeding depression along with the maternal effects on yield and it's contributing characters. The experiment was conducted during kharif season 2008 at the field of Chilli and vegetable research unit, Dr. PDKV, Akola (M.S.) using Randomized Block Design with three replications. The experimental material comprised 17 treatments viz., Parents, F_1's and F_2's including their reciprocal crosses. Observations were recorded in each replication for each treatment on seven characters namely, days to 50% flowering, plant height, number of branches per plant, length of fruit (cm), girth of fruit (cm), number of fruits per plant and yield per plant (kg). Analysis of variance for experimental design revealed the significant differences for the character under study. The mean performance of the parents, crosses, reciprocal crosses and F_2's indicated high mean performance of crosses over parental lines used mean performance of F_2's of crosses and reciprocal crosses showed decrease in mean values over respective F_1's .Heterosis percentage for mid parent (H_1), heterabetiosis (H_2) and standard heterosis (H_3) found to be more or less similar in magnitude. The cross AKO-107 X AKO-94-04-06, reciprocal cross AKO-94-04-06 x AKO-107 and AKO-111 x AKO- 102 recorded high heterosis over check is Parbhani kranti for yield per plant (39.75 %,31.62% and 21.63% respectively). The former two crosses also showed high useful heterosis for girth of fruit (62.61% and 44.77%), length of fruit (11.53 and 9.53 %) and for plant height (27.70% and 28.46 %) indicating importance for its exploitation after testing its performance in large scale. Inbreeding depression study revealed that the reduction on vigour in F_2's of crosses over F_1's reduction in performance found to be non-significant for all the characters under study except for plant height in the cross PK x AKO107 (13.16 %) and cross AKO-94-04-06 x AKO-107 (11.19 %). The significant useful heterosis and the inbreeding depression for the characters yield per plant(g), number of fruit for plant, girth of fruit in the cross (AKO-107 X AKO-94-04-06) indicating the utilization additive genetic component under selection. The direct crosses and their respective reciprocal crosses showed non significant difference in heterosis percentage for mid parent (H_1), heterbeltiosis (H_2) and useful heterosis (H_3) for all the character except days to 50 % flowering. Overall the study indicated that the cross AKO-107 x AKO-94-04-06 showed high mean performance and high useful heterosis but low inbreeding depression and yield per plant & number of branches per plant indicating the preponderance of additive gene action and under such situation the breeding procedure like Pure line selection could be prove useful for obtaining the better segregants from the cross.

Keywords

Abelmoschus esculentus (L.) Moench, Heteosis, inbreeding depression, and Okra

Introduction

Okra is one of the most important vegetable crops grown throughout the India. The number of improved varieties/hybrids is being cultivated on farmers field. However there is a need and scope to breed for new genotypes better than widely adopted variety i.e. Parbhani Kranti.

The ultimate aim of plant breeder is to improve the yield of economic produce. 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. Heterosis and inbreeding depression study is also important in deciding breeding methodology to be employed for improvement of crop. The heterotic cross combination for yield and other important character over standard check can be exploitation. However, cross combination with high heterosis with low inbreeding depression in conjunction with high heritability and genetic advance could be prove useful for development of better segergants.

Materials and Methods

The Seventeen treatments of okra comprised of five parents viz. Parbhani Kranti, AKO-107, AKO-102, AKO-111 and AKO-94-04-06, six crosses and six $F_{2's}$ of crosses were evaluated for heterosis and inbreeding depression studies The experimental materials were grown in randomized block design with three replications at Chilli and Vegetable Research Unit, Dr. PDKV., Akola during Kharif 2008-09.The observations were recorded on seven characters viz. days to 50 percent flowering (days), plant height (cm), number of branches per plant, length of fruit (cm), girth of fruit (cm), number of fruits per plant and yield per plant (kg). 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 and Sukhatme (1967) and Singh and Narayanan (1993).

Result and Discussion

The analysis of variance (Table 1) revealed the significant differences among the treatments for the seven characters studied. It indicated the presence of genetic variations amongst the treatments. The dregree of heterosis and inbreeding depression is presented in (Table 1 & 2)

Mean performance of parents, direct crosses and reciprocal crosses indicated (Table 1 & 2) the presence of high mean performance of direct cross and reciprocal 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 Pratap and Dhankar (1980), Vijay and Manohar (1986) and Sonia Sood *et al.* (1993). The reduction in mean performance value or F_1's of direct crosses and reciprocal crosses 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. The highest positive significant relative heterosis among the characters was observed for number of fruits per plant (50.12 %) followed by girth of fruit (42.66 %), number of branches per plant (35.74 %), yield per plant(g) (32.24 %), yield per plot (32.28 %), plant height (24.13 %), days to 50 % flowering (24.13 %) and length of fruit(cm) (12.83 %).

Amongst the crosses studied the cross AKO-111 x AKO-102 has recorded highest and significant relative heterosis for number of branches per plant (35.74%) yield per plant (kg) (32.24 %) and second highest for number of fruits per plant (48.79%). Significant relative heterosis for yield per plant in the cross AKO-111 x AKO-102 is expected because of significant relative heterosis for number of branches per plant and these characters have direct influence on yield. Relative 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. The significant average heterosis for yield and yield contributing characters were reported by Singh and Mandal (1993), Poshiya and Vashi (1995),More and Patil (1997), Sivakumar *et al.* (1997) and Mamidwar and Mehta (2006).

Amongst the characters studied the highest and significant heterobeltiosis noticed for number of fruits per plant (47.48 %), for girth of fruit (37.72 %), number of branches per plant (34.52 %), yield per plant (31.55 %), plant height (18.07 %).

The crosses AKO-107 x AKO-94-04-06 had recorded highest and significant heterobeltiosis for yield per plant (31.55%) ,third highest for number of fruits per plant (26.58%),girth of fruit (37.72%),second highest for length of fruit (8.60%) and plant height (17.36%). 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 parents.High heterobeltiosis in cross AKO-107 x AKO-94-04-06 for yield per plant and yield per plot was also expected because of significant heterobeltiosis for yield contributing characters.None of the cross combination found to be useful for earliness. However, significant positive heterosis for days to 50% flowering was recorded by cross AKO-94-04-06 x AKO-107.

The significant heterobeltiosis for yield per plant and other yield contributing characters was reported by Pratap and Dhankar (1980), Elangovan *et al*. (1981), Vijay and Manohar (1986), Shukla and Gautam (1990), Singh and Sood (1999), Kulkarni and Viruprakashappa (1977), Sheela *et al.* (1988), Dayasagar, Rewale *et al.* (2003) Mamimdwar *et al*. (2006) Shobha *et al.* (2008).

The highest and positive significant useful heterosis for girth of fruit (62.60 %) followed by yield per plant (39.74%), for number of branches per plant (36.40 %), for plant height (28.46 %), for days to 50 % flowering (24.112 %), for number of fruits per plant (23.58 %) and length of fruit(11.53 %).

The direct cross AKO-107 x AKO-94-04-06 recorded highest useful heterosis for yield per plant (31.82 and 39.59%),length of fruit (11.53% and 9.53 %), girth of fruit

(62.61 % and 44.77%), plant height (27.70 % and 28.46 %) and second and third respectively for number of fruits per plant. 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 Elangovan *et al.* (1981), Sheel *et al*. (1988) Shukla And Gautam (1990), Wankhade *et al.* (1997), Singh and Sood (1999), Desai *et al.* (2007), Amutha *et al*. (2007) and Shobha *et al.* (2008).

Overall the study revealed that magnitude of percentage over mid parent(H1),better parent (H2) and useful heterosis (H3) 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 cross AKO-107 x AKO-94-04-06 and reciprocal cross AK0-94-04-06 x AKO-107 and cross AKO-102 x AKO-111 found to be promising on the basis of standard heterosis (H1),heterobeltiosis (H2) and useful heterosis (H3) for yield per plant and number of fruits per plant.

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 for plant height in the cross P.K x AKO-107 (13.16 %) AKO-94-04-06 x AKO-107 (11.19%) indicating that the performance of F_1 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 be prove useful in diallel selective mating system. Inbreeding depression for yield and it's contributing character was also reported by Kulkarni and Viruprakashappa (1977), More and Patil (1997), Sonia and Sood (1999), Shukla and Gautam (1990), Changani and Shukla (1980) and Amutha *et al.* (2007).

Estimates of differences in direct crosses and reciprocal crosses for average heterosis (%), heterobeltiosis (%) and useful heterosis

Difference observed in mid parent heterosis (%), heterobeltiosis (%) and useful heterosis (%) were presented in Table 3. It revealed that direct crosses and reciprocal crosses do not Show much variation in magnitude of heterosis percentage for all the characters studied except for days to 50% flowering in the direct cross AK0-102 x AKO-111 for mid parent heterosis (13.80) and better parent(12.48).

It indicates that for earliness in cross the female parent must be AKO-111with the male parent AKO-102 and for other characters studied. Once the heterotic cross combination get identified any one of the parental line could be used as pollen source.

Table no.1 Estimates of Average Heterosis (H1), Heterobelteosis (H2) and Standard Heterosis (H3) for various characters

Crosses	Days to 50% flowering			Plant height (cm)			No. of branches per plant			Length of fruit (cm)		
	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3
PK x AKO- 107	-4.39	-8.43	--	11.58*	9.59*	9.59**	23.76*	20	27.18	12.19**	9.41*	9.41*
AKO-107 X PK	15.25*	10.38	20.56**	8.8	6.86	6.86	28.25*	24.34	31.79*	10.09**	7.37	7.37
AKO-111 x AKO-102	-5.73	-11.91	4.95	13.80**	8.08	8.11	35.74**	34.52*	38.24**	9.43**	5.89	5.64
AKO-102 x AKO-111	7.64	0.58	19.85**	14.45**	8.69*	8.72*	33.93**	32.73*	36.40**	9.89**	6.26	6.005
AKO- 107x AKO- 94-04-06	17.74**	7.79	17.72**	24.44**	17.36**	27.70**	13.77	11.3	17.97	12.83**	8.60*	11.53**
AKO- 94-04- 6 x AKO- 107	24.13**	13.63**	24.10**	25.19**	18.07**	28.46**	20	17.39	24.42	10.81**	6.66	9.53*
SE (diff) ±	3.1	3.58	3.58	4.6	5.3	5.3	0.264	0.3	0.3	0.27	0.31	0.31
CD at 5%	6.11	7.05	7.05	9.06	10.47	10.47	0.521	0.6	0.6	0.53	0.62	0.62
CD at 1%	8.12	9.3	9.3	12.02	13.92	13.92	0.691	0.8	0.8	0.71	0.82	0.82

* - Significant at 5% level; ** - Significant at 1% level.

N Note - 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

Contd…

Table.1 Average Heterosis (H_1), Heterobelteosis (H_2) and Standard Heterosis (H_3) for various characters

Crosses	Girth of fruit (cm)			Number of fruits per plant			Yield per plant (g)		
	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3
PK x AKO- 107	9.24	3.78	14.13	36.93**	23.58**	23.58**	21.82*	18.25	25.62*
AKO-107 x PK	11.75	6.64	17.28	22.80**	10.83	10.83	21.47*	17.91	25.26*
AKO-111 x AKO-102	6.94	1.98	20.97	48.79**	46.08**	13.58*	32.24**	30.65**	29.64**
AKO-102 x AKO-111	6.94	1.98	20.97	50.12**	47.48**	14.66**	22.63*	21.15*	20.21
AKO- 107 x AKO-94-04-06	42.66**	37.72**	62.61**	38.46**	26.58**	23.00**	31.80**	31.54**	39.74**
AKO- 94-04- 6 x AKO- 107	27.01**	22.62	44.77**	33.77**	22.29**	18.83**	23.58**	23.33*	31.02**
SE (diff) ±	0.15	0.18	0.18	0.72	0.83	0.83	15.69	12.81	12.81
CD at 5%	0.31	0.35	0.35	1.41	1.63	1.63	30.91	25.23	25.23
CD at 1%	0.41	0.47	0.47	1.88	2.17	2.17	41.1	35.56	35.56

* - Significant at 5% level. ,** - Significant at 1% level.

Note - 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.2 Estimates of Inbreeding Depression for various characters

Crosses	Days to 50% flowering	Plant height (cm)	No. of branches per plant	Length of fruit (cm)	Girth of fruit (cm)	No. of fruit per plant	Yield per plant (g)
PK x AKO- 107	-5.67	13.16 *	22.82	5.345	1.37	13.96	12.34
AKO-107 x PK	8.22	10.26	28.92	3.76	6.89	-2.25	10.54
AKO-111 x AKO-102	-11.48	1.88	18.9	8.18	6.75	2.71	18.37
AKO-102 x AKO-111	3.55	2.45	17.9	4.48	6.95	2.18	8.29
AKO- 107 x AKO- 94-04-06	-2.4	9.37	8.98	5.55	31.88	7.45	19.32
AKO- 94-04-06 x AKO- 107	10.28	11.19 *	1.48	5.3	24.25	1.12	15.64
SE (diff.) ±	5.93	8.81	0.5	0.52	0.3	1.37	21.24
CD at 5%	11.7	17.36	0.99	1.03	0.59	2.71	41.85
CD at 1%	15.56	23.09	1.32	1.37	0.79	3.61	55.66

* Significant at 5% level of significance

** Significant at 1% level of significance

N Note - Significance for Inbreeding Depression was tested over F1- F2

Table.3 Estimates of differences in direct crosses and reciprocal crosses for average heterosis(%), heterobeltiosis (%) and useful heterosis (%) for various characters

Sr no.	Parents, direct crosses and	Mean	Heterosis % over MP	Heterosis % over BP	Heterosis % over Check	Differences in heterosis (%) in direct crosses and MP	BP	Check	Mean	Heterosis % over MP	Heterosis % over BP	Heterosis % over Check	Differences in heterosis (%) in direct crosses and MP	BP	Check
	Days to 50% flowering								Plant height (cm)						
1	PK	47	-4.39	-8.43	--	+19.65**	+18.81**	+20.56**	126.1	+11.58**	+9.59*	+9.59*	-2.78	-2.73	-2.73
	PK x AKO-107	47							138.2						
	AKO-107 x PK	56.66	+15.25*	10.38	+20.56**				134.76	+8.80*	+6.86*	+6.86*			
	AKO-107	51.33							121.6						
2	AKO-111	48.66	-5.73	-11.91	4.95	13.80**	+12.48 *	14.89	113.46	+13.80**	8.08	8.11	0.65	0.61	0.61
	AKO-111 x AKO-102	49.33							136.33						
	AKO-102 x AKO-111	56.33	7.64	0.58	19.85				137.1	+14.45**	+8.69*	+8.72*			
	AKO-102	56							126.13						
	PK	47							126.1						
3	AKO-107	51.33	+17.74**	7.79	+17.72**	6.4	5.84	6.38	121.6	+24.44**	+17.36**	+27.70**	0.75	0.71	0.69
	AKO-107 x AKO-94 04-06	55.33							161.03						
	AKO-94-04-06 x AKO-107	58.33	+24.13**	+13.63**	+24.10**				162	+25.19**	+18.07**	+28.46**			
	AKO-94-04-06	42.66							137.2						
	PK	47							126.1						
	Numberof branches per plant								Girth of fruit (cm)						
1	PK	2.17	+ 23.76*	20	27.18	4.49	4.34	4.61	1.273	9.24	3.78	14.13	2.51	2.86	3.15
	PK x AKO-107	2.76							1.453						
	AKO-107 x PK	2.86	+ 28.25*	24.34	+ 31.79*				1.493	11.75	6.64	17.28			
	AKO-107	2.3							1.4						
2	AKO-111	2.23	+ 35.74**	+ 34.52*	+ 38.24**	-1.81	-1.79	-1.84	1.38	6.94	1.98	20.97	--	--	--
	AKO-111 x AKO-102	3							1.54						
	AKO-102 x AKO-111	2.96	+ 33.93**	+ 32.73*	+36.41*				1.54	6.94	1.98	20.97			
	AKO-102	2.2							1.51						
	PK	2.17							1.273						
3	AKO-107	2.3	13.77	11.3	17.97	6.23	6.09	6.45	1.4	+42.66**	+37.72**	+62.60**	15.65	-15.1	-17.84
	AKO-107 x AKO-94-04-06	2.56							2.07						
	AKO-94-04-06 x AKO-107	2.7	20	17.39	24.42				1.843	+27.01**	+22.62**	+44.77**			
	AKO-94-04-06	2.2							1.5033						
	PK	2.17							1.273						

Table.3 Estimates of differences in direct crosses and reciprocal crosses for average heterosis(%), heterobeltiosis (%) and useful heterosis (%) for various characters

Sr no.	Parents, direct crosses and .	Mean	Heterosis % over MP	Heterosis % over BP	Heterosis % over Check	Differences in heterosis (%) in direct crosses and			Mean	Heterosis % over MP	Heterosis % over BP	Heterosis % over Check	Differences in heterosis (%) in direct crosses and		
						MP	BP	Check					MP	BP	Check
Length of fruit (cm)									Number of fruits per plant						
1	PK	8.326	+12.10**	+9.41*	+9.41*	-2.14	-2.04	-2.04	12	+36.93**	+23.58**	+23.58**	-14.13	-12.75	-12.75
	PK x AKO-107	9.11							14.83						
	AKO-107 x PK	8.94	+10.09**	7.37	7.37				13.3	+22.80**	10.83	10.83			
	AKO-107	7.92							9.66						
2	AKO-111	8.306	+9.43**	5.89	5.64	0.37	0.37	0.36	9.33	+48.79**	+46.08**	+13.58*	1.33	1.4	1.08
	AKO-111 x AKO-102	8.796							13.63						
	AKO-102 x AKO-111	8.826	+9.8**	6.26	6.005				13.76	+50.12**	+47.48**	+14.66*			
	AKO-102	7.77							9						
	PK	8.3226							12						
3	AKO-107	7.92	+12.83**	+8.60*	+11.53**	-2.16	-1.94	-2	9.66	+38.46**	+26.58**	23.00**	-4.69	-4.29	-4.17
	AKO-107 x AKO-94-04-06	9.286							14.76						
	AKO-94-04-06 x AKO-107	9.12	+10.81**	6.66	+9.53*				14.26	+33.77**	+22.29**	18.83**			
	AKO-94-04-06	8.55							11.66						
	PK	8.326							12						

Table.3 Estimates of differences in direct crosses and reciprocal crosses for average heterosis(%), heterobeltiosis (%) and useful heterosis (%) for various characters

Sr no.	Parents, direct crosses and .	Mean	Heterosis % over MP	Heterosis % over BP	Heterosis % over Check	Differences in heterosis (%) in direct crosses and		
						MP	BP	Check
	Yield per plant (gm)							
1	PK	4.61	+ 21.82*	18.25	+25.62*	-0.35	-0.34	-0.36
	PK x AKO-107	4.535						
	AKO-107 x PK	4.522	+ 21.47*	17.91	+25.26*			
	AKO-107	3.835						
2	AKO-111	3.496	+32.24**	+30.65**	+29.64**	-9.61	-9.5	-9.53
	AKO-111 x AKO-102	4.68						
	AKO-102 x AKO-111	4.34	+ 22.63*	+21.15*	20.21			
	AKO-102	3.582						
	PK	3.61						
3	AKO-107	3.835	+ 31.81**	+31.55**	+39.74**	-8.23	-8.21	-8.72
	AKO-107 x AKO-94-04-06	5.045						
	AKO-94-04-06 x AKO-107	4.73	+ 23.58**	+23.33*	+31.02**			
	AKO-94-04-06	3.82						
	PK	3.61						

Table.4 Estimates of differences in direct crosses and reciprocal crosses for inbreeding depression

Sr no.	Parents, direct crosses and reciprocal crosses	Mean	Inbreeding depression observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses	Mean	Inbreeding depression observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses	Mean	Inbreeding depression observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses
	Days to 50% flowering				Plant height (cm)			Number of branches per plant		
1	PK x AKO-107	14.83	-5.67	13.89	138.2	+13.16 *	-2.9	2.76	22.82	6.1
	AKO-107 x PK	13.3	8.22		134.76	10.26		2.86	28.92	
2	AKO-111 x AKO-102	13.63	-11.48	15.03	136.33	1.88	0.57	3	18.9	-1
	AKO-102 x AKO-111	13.76	3.55		137.1	2.45		2.96	17.9	
3	AKO-107 x AKO-94-04-06	14.76	-2.4	12.68	161.03	9.37	20.56	2.56	8.98	-7.5
	AKO-94-04-06 x AKO-107	14.26	10.28		162	+11.19 *		2.7	1.48	

Table.4 Estimates of differences in direct crosses and reciprocal crosses for inbreeding depression

Sr no.	Parents, direct crosses and reciprocal crosses	Mean	Inbreeding depression on observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses	Mean	Inbreeding depression on observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses	Mean	Inbreeding depression on observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses	Mean	Inbreeding depression on observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses
Length of fruits per plant				Girth of fruit(cm)				Number of fruits per plant			Yield per plant (kg)		
1	PK x AKO-107	9.11	5.34	-1.58	1.45	1.37	5.52	14.83	13.96	11.71	4.53	12.34	-1.8
	AKO-107 x PK	8.94	3.76		1.49	6.89		13.3	-2.25		4.52	10.54	
2	AKO-111 x AKO-102	8.796	8.18	-3.7	1.54	6.75	0.2	13.63	2.71	-0.53	4.68	18.37	-10.08
	AKO-102 x AKO-111	8.826	4.48		1.54	6.95		13.76	2.18		4.34	8.29	
3	AKO-107 x AKO-94-04-06	9.286	5.55	-0.25	2.07	31.88	-7.63	14.76	7.45	-6.33	5.045	19.32	-3.68
	AKO-94-04-06 x AKO-107	9.12	5.3		1.84	24.25		14.26	1.12		4.73	15.64	

Table.4 Estimates of differences in direct crosses and reciprocal crosses for inbreeding depression

Sr no.	Parents, direct crosses and reciprocal crosses	Mean	Inbreeding depression observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses	Mean	Inbreeding depression observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses	Mean	Inbreeding depression observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses	Mean	Inbreeding depression observed (%)	Difference in Inbreeding depression (%) in direct crosses and reciprocal crosses
Length of fruits per plant				Girth of fruit(cm)				Number of fruits per plant			Yield per plant (kg)		
1	PK x AKO-107	9.11	5.34	-1.58	1.45	1.37	5.52	14.83	13.96	11.71	4.53	12.34	-1.8
	AKO-107 x PK	8.94	3.76		1.49	6.89		13.3	-2.25		4.52	10.54	
2	AKO-111 x AKO-102	8.796	8.18	-3.7	1.54	6.75	0.2	13.63	2.71	-0.53	4.68	18.37	-10.08
	AKO-102 x AKO-111	8.826	4.48		1.54	6.95		13.76	2.18		4.34	8.29	
3	AKO-107 x AKO-94-04-06	9.286	5.55	-0.25	2.07	31.88	-7.63	14.76	7.45	-6.33	5.045	19.32	-3.68
	AKO-94-04-06 x AKO-107	9.12	5.3		1.84	24.25		14.26	1.12		4.73	15.64	

Estimates of differences in direct crosses and reciprocal crosses for Inbreeding depression

Differences in the inbreeding depression percentage was observed in direct crosses and reciprocal crosses in Table 4. Inbreeding depression value varies in direct crosses and reciprocal crosses. A maximum difference in respect of inbreeding depression was observed in cross AKO-107 x AKO-94 -04-06 and reciprocal cross AK0-94 -04-06 x AKO-107 for plant height. It was followed cross AKO-111x AKO-102 and reciprocal cross AK0-102 x AKO-111 for days to 50 % flowering. Minimum difference in respect of inbreeding depression was observed in cross AKO-111x AKO-102 and reciprocal cross AK0-102 x AKO-111 for yield per plant.

The heterosis study under present investigation revealed that magnitude of heterosis percentage for average heterosis (H_1), heterobeltiosis (H_2) and standard heterosis (H_3) were more or less similar. Moreover the former two crosses also showed significant standard heterosis for length of fruit (11.53% and 7.53%), girth of fruit (62.09% and 44.77%) and plant height (27.70 and 28.40%). And the cross AKO-111 x AKO-102 also showed significant standard heterosis for number of branches per plant (38.24%). Thus, it is concluded that these three crosses could be utilized for the exploitation of heterotic effects for yield and other yield contributing characters after its testing on large area.

Inbreeding depression studied in the crosses revealed that the non significant inbreeding depression (%) for all the characters studied except plant height in the cross P.K x AKO-107 (13.16%) and cross AKO-94-04-06 x AKO-107 (11.19%).

Among the six crosses studied the cross AKO-107 x AKO-94-04-06 exhibited highest standard heterosis with non significant inbreeding depression for yield and other yield contributing characters. It indicated that the presence of heterosis due to additive gene action, which could be capitalized in subsequent generation for development of better segregants. Thus, the simple breeding procedure like pure line selection would be prove useful for obtaining better derivatives from the cross AKO-107 x AKO-94-04-06.

The crosses and reciprocal crosses studied for magnitude of heterosis and inbreeding depression revealed the non significant differences among them. It indicate that inbreeding programme or for exploitation of heterosis for yield and yield contributing characters any one of the parent in selected cross under present material could be used as pollen source except for the character day's to 50% flowering.

Overall conclusion of the study is, in the light of present investigation it is concluded that the characters under study were mostly governed by additive genetic variance and more particularly the cross AKO-107 x AKO-94-04-06 could be prove useful for obtaining the better sergeants using breeding procedure like Pure line selection.

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