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Genetic Causes of Heterosis for Fruit Yield in Okra (*Abelmoschus esculentus* (L) Moench)

K Ramya and N Senthil Kumar
Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalainagar 608 002, Cuddalore Dist, Tamilnadu

ABSTRACT

In the present investigation the genetic causes of heterosis in okra was elucidated by using (7 x 7) diallele analysis. It as found out that combining ability is important for the observed heterosis and not the gene distribution. The direct and reciprocal cross combinations of Pusa A4 x Punjab Padmini, Varsha Uphar x Punjab Padmini, Pusa A4 x EMS 8 and the cross Parbhani Kranti x Punjab Padmini and Pusa A4 x Parbhani Kranti which portrayed high mean and commercial heterosis were endowed with significant *sca* effects and had both or atleast one of the parents with significant *gca* effects.

Key words : *Gca* and *sca* effects, Gene Distribution, Genetic Diversity, Heterosis.

Okra (*Abelmoschus esculentus* (L.) Moench) is an annual vegetable crop grown through out the tropics and warmer parts of temperate regions. It is an important vegetable crop for nutritional as well as economic point of view. Okra is special valued for its tender and delicious fruits all over the country. Combining ability analysis is being extensively used to study the nature and magnitude of genotypic variability and to facilitate the selection of parents in hybrid breeding programme. Knowledge of genetics and heterosis is important in deciding the breeding strategies for yield improvement in any crop, especially okra.

MATERIAL AND METHODS

Seven genetically diverse genotypes of okra namely Varsha Uphar (VU/ P1), Pusa A4 (P2), Parbhani Kranti (PK/ P3), PB 266 (P4), Punjab Padmini (PP/P5), Gujarat Bhindi (GB/P6) and EMS 8 (P7) were crossed in full diallel fashion at Plant Breeding Farm, Faculty of Agriculture, Annamalai University, Tamilnadu during 2008. The resulting 42 hybrids (21 direct and 21 reciprocals) were sown in the field during January, 2009, following randomized block design with three replications. All the parents and hybrids were selfed. All the entries were sown in a single row plot size of 3m. A row to row spacing of 45 cm and plant to plant spacing of 30 cm was adopted. Recommended agronomic practices and need based plant protection measures were taken for raising a good crop. Data were recorded on five randomly selected plants for the characters *viz.,* days to first fruit harvest, number of fruits per plant, fruit weight (g), fruit length (mm) and fruit yield per plant (g). The data were analyzed for combining ability and heterosis using standard procedures as outlined by Griffing (1956), mode I, (fixed) and method 1; Wynnee *et al.,* (1970). The combining ability of parents and hybrids were scored as per the method outlined below. The parents / cross combinations which showed favourable significant *gca /sca* effects were given the score +1. The parents / cross combinations which showed unfavourable significant *gca / sca* effects were given the score -1. Non significant *gca/sca* effects were given the score 0. Total scores more than +1 was considered as good combiner.

RESULTS AND DISCUSSION

The analysis of variance revealed that the parents and hybrids differed among themselves for all the characters stud yied. This indicates the presence of high genetic variability in the reference population. Therefore, further analysis of combining ability and gene action is appropriate (Table1). The contribution of individual lines to hybrid performance was accomplished by general combining ability effects. When the parents were assessed for their over all combining ability, the parents namely PP (+8) was found to be good general combiner followed by EMS 8 (+4), Pusa A4 (+3) and PK (+3) (Table 4). The parents PP (370.14g), Pusa A4 (410.55g), and PK (386.63g) showed high per se performance for fruit yield per plant, number of fruits per plant and fruit weight (Table 2). This may indicate that these genotypes have enormous amount of additive genetic

Table 1. ANOVA for fruit yield and its component characters in okra

S. No.	Characters	df	MSS	'F' value
1.	Days to first fruit harvest	48	41.43**	592.25
2.	Number of fruits per plant	48	45.88**	481.98
3.	Fruit weight (g)	48	4.05**	84.31
4.	Fruit length (cm)	48	10.80**	78.07
5.	Fruit yield per plant (g)	48	18534.23**	560.60

** - Significant at 1 per cent level

Table 2. Relationship between *per se* performance and *gca* effects in okra.

S. No.	Characters	Parents with high *per se*	Parents with favourable *gca* effects	Common parent
1.	Days to first fruit harvest	PK (46.40)	EMS 8	PK
		Pusa A4 (48.80)	Pusa A4	Pusa A4
		EMS 8 (50.13)	PK	EMS 8
2.	Number of fruits per plant	VU(26.13)	Pusa A4	VU
		Pusa A4(25.53)	EMS 8	PUSA A4
		PK(24.07)	PP	PK
		PP(21.20)	VU	PP
		EMS 8(21.00)	PK	EMS 8
3.	Fruit weight (g)	PP(17.48)	PP	PP
		Pusa A4(16.08)	Pusa A4	Pusa A4
		PK(16.07)	PK	PK
4.	Fruit length (cm)	PP(18.23)	PP	PP
		VU(16.60)	VU	VU
		GB(15.35)	PK	PK
		PK(15.28)		
5.	Fruit yield per plant (g)	Pusa A4(410.55)	Pusa A4	Pusa A4
		PK(386.63)	PP	PK
		PP(370.14)	EMS 8	PP
		VU(362.62)	PK	

*, ** = Significant at 5 per cent & 1 per cent level

Table 3. Relationship between standard heterosis (d_{iii}), *per se* performance, *gca* effects and *sca* effects in okra.

Characters	Best eight crosses with high d_{iii} and high *per se*	Mean	d_{iii}	*sca* effects	*gca* effects
Days to first fruit harvest	Pusa A4 x PK	43.73	-9.41**	-1.73**	-1.93** x -1.64**
	PK x Pusa A4	44.00	-8.85**	-1.73**	-1.64** x -1.93**
	PK x PP	44.07	-8.70**	-2.47**	-1.64** x -0.96**
	EMS 8 x PK	44.07	-8.70**	-1.07**	-2.29** x -1.64**
	PP x PK	44.13	-8.57**	-2.47**	-0.96** x -1.64**
	PK x EMS 8	44.27	-8.27**	-1.07**	-1.64** x -2.29**
	EMS 8 x Pusa A4	44.27	-8.29**	-0.55**	-2.29** x -1.93**
	Pusa A4 x EMS 8	44.53	-7.75**	-0.55**	-1.93** x -2.29**
Number of fruits per plant	EMS 8 x PUSA A4	32.13	38.08**	2.28**	1.63** x 2.75**
	Pusa A4 x PK	32.00	37.52**	0.53**	2.75** x 0.16**
	Pusa A4 x EMS 8	31.73	36.36**	2.28**	2.75** x 1.63**
	PK x PUSA A4	30.93	32.92**	0.53**	0.16** x 2.75**
	Pusa A4 x VU	30.73	32.06**	1.15**	2.75** x 0.76**
	Pusa A4 x PP	30.20	29.78**	0.92**	2.75** x 1.23**
	PP x PUSA A4	30.13	29.48**	0.92**	1.23** x 2.73**
	VU x PP	29.73	27.76**	2.44**	0.76** x 1.23**
Fruit weight (g)	PP x PK	18.43	22.46**	1.17**	1.19** x 0.37**
	PK x PP	18.39	22.20**	1.17**	0.37** x 1.19**
	Pusa A4 x PP	18.09	20.20**	0.70**	0.41** x 1.19**
	PP x VU	17.87	18.74**	1.09**	1.19** x -0.55**
	PP x Pusa A4	17.85	18.61**	0.70**	1.19** x 0.41**
	PB 266 x PK	17.05	13.29**	0.46**	-0.42** x 0.37**
	VU x PP	16.93	12.49**	1.09**	-0.55** x 1.19**
	VU x Pusa A4	16.73	11.16**	0.96**	-0.55** x 0.41**
Fruit length (cm)	Pusa A4 x PP	18.78	28.02**	1.95**	-0.35** x 1.91**
	PK x PP	18.13	23.59**	0.53**	0.11** x 1.91**
	PP x Pusa A4	18.01	22.77**	1.95**	1.91** x -0.35**
	PP x GB	17.93	22.22**	0.46**	1.91** x -0.11**
	VU x Pusa A4	17.40	18.61**	0.60**	0.90** x -0.35**
	VU x PP	17.05	16.22**	-0.70**	0.90** x 1.91**
	PP x VU	16.93	15.41**	-0.70**	1.91** x 0.90**
	VU x EMS 8	16.85	14.86**	0.78**	0.90** x -0.60**
Fruit yield per plant (g)	Pusa A4 x PP	546.20	55.96**	40.32**	54.25** x 49.50**
	PP x Pusa A4	537.87	53.59**	40.32**	49.50** x 54.25**
	PP x VU	530.16	51.38**	70.28**	49.50** x -0.92
	PK x PP	514.78	46.99**	44.16**	10.89** x 49.50**
	Pusa A4 x EMS 8	506.87	44.73**	39.76**	54.25** x 13.17**
	VU x PP	503.50	43.77**	70.28**	-0.92 x 49.50**
	EMS 8 x Pusa A4	503.41	43.75**	39.76**	13.17** x 54.25**
	Pusa A4 x PK	499.53	42.64**	35.98**	54.25** x 10.89**

***, ** =** Significant at 5 per cent & 1 per cent level, d_{iii} – Standard Heterosis

Table 4. Scoring based on *gca* and *sca* effects for all the traits studied in okra.

Parents	Total score (*gca* effects)
VU	-1
Pusa A4	+3
PK	+3
PB 266	-8
PP	+8
GB	-7
EMS 8	+4
Hybrids	**Total score (*sca* effects)**
VU x Pusa A4	+5
VU x PK	-3
VU x PB266	-6
VU x PP	+6
VU x GB	-8
VU x EMS8	+3
Pusa A4 x PK	+4
Pusa A4x PB266	-1
Pusa A4 x PP	+7
Pusa A4 x GB	-7
Pusa A4 x EMS8	+8
PK x PB266	-1
PK x PP	+6
PK x GB	-4
PK x EMS8	+6
PB266 x PP	+6
PB266 x GB	0
PB266 x EMS8	+5
PP x GB	+4
PP x EMS8	-7
GB x EMS8	+8

variability for the traits of interest (Table 2). Hence, the above parents are suggested for varietal breeding programme.

When the cross combinations were assessed for their over all specific combining ability effects, the cross combinations *viz.,* Pusa A4 x EMS 8 (+8) and GB x EMS 8 (+8) were found to be high specific combiners followed by Pusa A4 x PP (+7), VU x PP (+6), PK x PP (+6), PK x EMS 8 (+6), PB 266 x GB (+6), VU x Pusa A4(+5), PB 266 x EMS 8 (+5) and Pusa A4 x PK (+4) (Table 4). The direct and reciprocal cross combinations of Pusa A4 x PP (546.20g), VU x PP (503.50g), Pusa A4 x EMS 8 (506.87g), PK x PP(514.78g) and the cross Pusa A4 x PK(499.53g) registered the maximum significant mean performance for fruit yield per plant among 21 direct and 21 reciprocal cross combinations.The above eight cross combinations also recorded maximum standard heterosis for fruit yield per plant. Standard heterosis upto the tune of 55.96 was recorded by Pusa A4 x PP followed by PP x Pusa A4 (53.59), PP x VU (51.38), PK x PP (46.99), Pusa A4 x EMS 8 (43.77) and VU x PP (43.77) for fruit yield per plant. These cross combination also exhibited high standard heterosis for all other traits studied. Hence, the above cross combinations which exhibited high *per se* performance, maximum standard heterosis, significant *sca* effects and total score are suggested as the best hybrids of okra. Thus, there was a good agreement between mean performance, *sca* effects and standard heterosis (Table 4).The cross combinations which showed high significant *sca* effects had both the parents with highly significant *gca* effects or atleast one of the parents with significant *gca* effects for all the traits studied. (Adeniji and Kehinde 2003, Bendale *et al.,* 2004 and Pankajet *et al.,*2004). High specific combining ability may be due to epistasis. Hence, the observed heterosis may be due to epistasis (Senthil Kumar and Anandan.2006).

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