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Studies on heterosis for qualitative traits in okra

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ABSTRACT

Eight okra parental lines, *viz.*, Pusa A4, DOV-1-2, DOV-2, DOV-12, WB selection, IC-090491, DOV-62 and C-10 were crossed in diallel mating design without reciprocals to produce 28 hybrids. All these hybrid combinations without reciprocals along with their parents were evaluated to study heterosis with respect to protein, total dietary fibre and mineral content. *Per se* performance showed considerable differences among the eight parents. The hybrid Pusa A4 × IC-090491 showed highly significant positive heterosis over standard parent for protein (69.61%), total dietary fibre (50.81%), phosphorus (13.19%), potassium (16.15%), calcium (34.81%), magnesium (8.47%), iron (100.65%) and copper (6.28%) content. The hybrid effects and heterosis for various minerals showed that none of the parent and hybrid excelled for all the minerals, pointing to the need of utilising multiple crossing methods for pyramiding these qualitative traits without comprising on yield and other horticultural traits.

Key words: Okra, heterosis, minerals, protein, total dietary fibre.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench.), the only vegetable crop of significance in the family Malvaceae is widely cultivated in the tropical and subtropical parts of the world. To some extent it is also grown in the warmer areas of temperate regions. India ranks first in the world with 6.35 million tonnes (75% of the total world production) of okra produced from over 0.53 million ha land (FAOSTAT, 4; NHB, 9). Nutritionally, okra fruits are a good source of protein, dietary fibre and minerals like calcium, phosphorus, potassium, iron and copper (Gemede *et al.*, 6).

Development of quality F_1 hybrids with better productivity and adaptability is the main focus of okra breeding throughout the world. At present, more emphasis is being given for improving yield than quality; however the exploitation of hybrid vigour for protein, total dietary fibre and minerals will expand the scope of okra breeding. Quantitative research has been done in the field of heterosis for vegetative traits, earliness, yield and its related traits in okra, but very little effort have been done on improvement of fruit quality. Hence, this study was undertaken with an objective to develop and assess hybrids rich in protein, total dietary fibre, phosphorus, potassium, calcium, magnesium, iron, zinc and copper contents.

MATERIALS AND METHODS

The experiment was conducted at the Research Farm of Division of Vegetable Science, ICAR-IARI, Pusa, New Delhi. Eight genetically divergent parental lines, *viz.*, Pusa A4, DOV-1-2, DOV-2, DOV-12, WB selection, IC-090491, DOV-62 and C-10 were selected and crossed in Diallel fashion without reciprocals to obtain 28 F_1 hybrids (Simmonds, 11; Fehr *et al.*, 5). These 28 hybrids were sown along with their parents at a spacing of 60 cm × 30 cm in Randomised Block Design with three replications and recommended cultivation practices were followed to raise the crop (Mishra and Hedau, 8). Observations were recorded on ten randomly tagged plants in each entry in all the three replications.

For nutrient analysis, fresh fruits were collected from each replication and were processed according to the standard protocol to be followed for nutrient analysis. The methods used for estimation of nutrients were done by following methods given by Prasad *et al.* (10). Protein was estimated by multiplying total nitrogen content obtained through micro Kjeldhal method with conversion factor. Total dietary fibre (TDF) content was evaluated using the Megazyme-K-TDFR diagnostic kit (Bray, Co.Wicklow, Ireland) based on AOAC enzymatic gravimetric method 985.29 and AACC method 32-05.01 (AOAC, 1). Phosphorus was determined by vando-molybdate method (UV-VIS spectrophotometer DR 5000 Model, Hach Co., USA) and potassium by using a microprocessor based flame photometer (Systronic Type 128, Systronics India Ltd.) using specific filter for potassium and LPG flame from diacid digested sample. Determination of calcium, magnesium, iron, manganese and copper was done by using atomic absorption spectrophotometer (GBC Avanta PM

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904 AA model, GBC, Australia) directly from the diacid digest using a nitrous oxide-acetylene flame at specific wavelength and current strength required for each mineral. The data generated were used to compute heterotic effects which is expressed as the percentage increase (+) or decrease (-) of F_1 mean values over better parent and standard check variety for the qualitative traits and crosses, following the standard formula (Jinks and Jones, 7).

RESULTS AND DISCUSSION

Per se performance data (Table 1) recorded that there was considerable difference among the parents for all the traits studied. Among parents (Table 1) DOV-1-2 recorded maximum mean value for phosphorus, calcium and iron content and the parent DOV-62 recorded maximum value for protein and total dietary fibre content. While the parent C-10 recorded the maximum value for potassium and zinc content, the parent DOV-2 for copper content and IC-090491 for magnesium content. Thus, among parents, comparatively higher performance for quality traits was displayed in DOV-1-2.

The aim of heterosis study was to identify the best heterotic combinations and its exploitation for commercial purpose. In order to find out suitable parents and cross combinations for protein, total dietary fibre and minerals in okra fruits, range and mean of parents and hybrids, percentage of heterosis over better parent and heterosis over standard parent (Pusa Sawani) were calculated. None of the hybrids in this study had recorded the maximum heterosis for all the traits studied, but significant and desirable level of heterosis over standard parent and better parent was obtained in several hybrids for the different qualitative traits.

For nutrients like protein, total dietary fibre, phosphorus and zinc, mean of hybrids was found higher than parental means; also the variation was more in hybrids than parents. The parental mean value was found to be higher than the hybrid mean for potassium, calcium, magnesium, iron and copper even though the range of variation was more in hybrids (Table 2). For all the 9 traits studied, high and significant heterosis was obtained in both directions in heterosis over better and standard parents.

The heterosis over better parent and standard parent is given in Tables 3 & 4. The hybrid Pusa A4 × IC-090491 showed significant positive heterosis over standard parent for all studied traits except zinc content, while Pusa A4 × DOV-62 showed heterosis over standard parent for protein, total dietary fibre, phosphorus, potassium, calcium, magnesium and copper content. In the cross IC-090491 × DOV-62, significant positive heterosis over standard parent was recorded for protein, total dietary fibre, phosphorus and copper content, while over better parent for potassium and calcium content. The cross Pusa A4 × DOV-12 showed significant positive heterosis over standard parent for protein, total dietary fibre, phosphorus, potassium and magnesium content while, DOV-1-2 × WB selection revealed significant heterosis over better parent for potassium, iron and zinc; also over standard parent for total dietary fibre and over both parents for copper content. The significant positive

Table 1. Performance of eight parental okra lines for the various nutritional traits.

Parent	Protein (g)	TDF (mg/ g)	P content (ppm)	K content (ppm)	Ca content (ppm)	Mg content (ppm)	Fe content (ppm)	Zn content (ppm)	Cu content (ppm)
Pusa A4	1.02	62.33	24.80	227.00	42.49	23.49	10.34	3.93	3.66
DOV-1-2	2.17	62.00	28.67	190.67	65.20	23.22	22.30	3.02	3.34
DOV-2	1.52	70.67	26.77	250.33	43.71	23.61	14.81	3.11	4.79
DOV-12	2.08	55.67	26.40	205.33	38.64	23.86	10.23	3.93	4.63
WB selection	1.96	80.67	23.50	196.33	35.85	22.28	7.27	3.33	3.18
IC-090491	1.85	70.67	23.27	212.00	25.08	27.18	8.43	2.99	3.98
DOV-62	2.33	97.33	23.30	205.33	36.73	22.34	15.59	3.12	4.31
C-10	1.46	70.67	27.33	306.00	33.23	25.72	15.73	3.93	3.50
Mean	1.80	71.25	25.51	224.12	40.12	23.96	13.09	3.42	3.92
Range	1.0-2.3	55.7-97.33	23.3-28.67	190.7-306.0	25.1-65.2	22.3-27.18	7.3-22.3	2.99- 3.93	3.2- 4.79
CD at 5%	0.23	9.78	2.02	4.25	6.48	0.34	0.97	0.22	0.31

*,**Significant at 5 and 1% probability levels, respectively.
TDF = Total Dietary fibre

Table 2. Range of mean values of parents, F_1 hybrids and heterosis (over better and standard parents) for various qualitative traits.

Particulars	Protein (g)	TDF (mg/ g)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Fe (ppm)	Zn (ppm)	Cu (ppm)
Range of mean values									
Parents	1.71 - 1.88	66.61 - 75.89	25.10 - 25.91	215.15 - 233.09	44.86 - 35.37	23.60 - 24.33	12.77 - 13.41	3.41 - 3.43	3.18 - 4.7
F_1	1.04 - 2.19	50.6 - 97.33	22.43 -29.38	128.33 - 290.67	25.69 - 57.28	17.89 - 25.54	5.14 - 20.75	2.99 - 4.15	3.3 - 4.6
Mean values									
Parents	1.80	71.25	25.51	224.12	40.12	23.96	13.09	3.42	3.92
F_1	1.84	81.25	25.53	217.69	36.43	23.62	8.19	3.49	3.82
Top three hybrids with hybrid effects	$P_2 \times P_7$ (2.19)	$P_6 \times P_7$ (97.33)	$P_1 \times P_4$ (29.38)	$P_1 \times P_4$ (290.67)	$P_1 \times P_6$ (57.28)	$P_4 \times P_6$ (25.54)	$P_1 \times P_6$ (20.75)	$P_3 \times P_6$ (4.15)	$P_1 \times P_3$ (4.62)
	$P_1 \times P_8$ (2.17)	$P_6 \times P_8$ (97.00)	$P_2 \times P_7$ (29.33)	$P_1 \times P_6$ (263.67)	$P_1 \times P_7$ (50.31)	$P_1 \times P_6$ (25.48)	$P_3 \times P_4$ (14.51)	$P_4 \times P_6$ (4.15)	$P_2 \times P_5$ (4.22)
	$P_3 \times P_5$ (2.17)	$P_1 \times P_5$ (96.33)	$P_2 \times P_3$ (29.03)	$P_1 \times P_5$ (255.67)	$P_1 \times P_8$ (49.36)	$P_1 \times P_7$ (25.35)	$P_2 \times P_8$ (11.64)	$P_1 \times P_6$ (4.07)	$P_1 \times P_7$ (4.14)
Top three F_1 hybrids with heterosis % over BP	$P_1 \times P_8$ (48.63)	$P_2 \times P_4$ (46.24)	$P_6 \times P_7$ (21.89)	$P_1 \times P_4$ (28.05)	$P_1 \times P_6$ (34.81)	$P_1 \times P_7$ (7.92)	$P_1 \times P_6$ (146.14)	$P_3 \times P_6$ (32.44)	$P_2 \times P_5$ (29.45)
	-	$P_1 \times P_3$ (45.47)	$P_1 \times P_7$ (13.83)	$P_2 \times P_7$ (24.35)	$P_1 \times P_7$ (18.40)	$P_1 \times P_2$ (7.07)	$P_2 \times P_5$ (9.90)	$P_2 \times P_5$ (21.92)	$P_5 \times P_8$ (16.77)
	-	$P_6 \times P_8$ (37.26)	$P_1 \times P_6$ (13.19)	$P_4 \times P_6$ (20.44)	$P_1 \times P_8$ (16.17)	$P_5 \times P_7$ (7.03)	-	$P_2 \times P_7$ (16.99)	-
Top three F_1 hybrids with heterosis % over SP	$P_2 \times P_7$ (114.71)	$P_2 \times P_7$ (54.55)	$P_1 \times P_4$ (18.47)	$P_1 \times P_4$ (28.05)	$P_1 \times P_6$ (34.81)	$P_4 \times P_6$ (8.73)	$P_1 \times P_6$ (100.68)	$P_3 \times P_6$ (5.60)	$P_1 \times P_3$ (26.23)
	$P_1 \times P_8$ (112.75)	$P_6 \times P_7$ (56.15)	$P_2 \times P_7$ (18.27)	$P_1 \times P_6$ (16.15)	$P_1 \times P_7$ (18.40)	$P_1 \times P_6$ (8.47)	$P_3 \times P_4$ (40.33)	$P_4 \times P_6$ (5.60)	$P_2 \times P_5$ (15.30)
	$P_3 \times P_5$ (112.75)	$P_7 \times P_8$ (55.62)	$P_2 \times P_3$ (17.06)	$P_1 \times P_5$ (12.63)	$P_1 \times P_8$ (16.17)	$P_1 \times P_7$ (7.92)	$P_2 \times P_8$ (12.57)	-	$P_1 \times P_7$ (13.11)

TDF = Total dietary fibre, P = Phosphorus, K = Potassium, Ca = Calcium, Mg = Magnesium, Fe = Iron, Zn = Zinc, Cu = Copper

heterosis over standard parent was observed in the cross DOV-1-2 × IC-09491 for protein, total dietary fibre, magnesium and copper content, while over better parent for zinc content. While in cross DOV-1-2 × DOV-62 significant positive heterosis over standard parent was recorded for protein, total dietary fibre, phosphorus and calcium content, while over better parent for zinc content and over both in potassium content. DOV-2 × IC-09491 showed significant heterosis over standard parent for protein, magnesium and copper content, while over standard and better parent for total dietary fibre and zinc content. In the cross DOV-12 × IC-09491, significant positive heterosis over standard parent was recorded for phosphorus, magnesium and copper content, while heterosis over both standard and better parent was recorded for potassium and zinc content. Not a single hybrid showed significant heterosis in positive direction for all the qualitative traits under this study. Similar results were obtained in common bean for protein, calcium, magnesium, zinc and iron by Ceyhan *et al*. (2), on cabbage for potassium, calcium, iron, zinc and manganese by Singh *et al*. (12), on cauliflower for ascorbic acid, anthocyanin and lycopene concentration by Dey *et al*. (3) in okra for yield and its contributing by Verma and Sood (13). The hybrid effects and heterosis for various minerals showed that none of the parents and hybrids excelled for all the minerals and yield, further suggests the necessity of using multiple crossing breeding approaches, *i.e.* population improvement methods like heterosis breeding, recurrent selection, synthetics, composites for increasing the mineral concentration in okra, without losing the vigour advantage for yield and other economic traits.

Table 3. Percentage of heterosis over better parent (BP) and standard parent (SP) in crosses for various qualitative traits in okra.

Cross	Protein (g/ 100)		TDF (mg/g)		P (ppm)		K (ppm)		Ca (ppm)	
	BP	SP	BP	SP	BP	SP	BP	SP	BP	SP
Pusa A4 × DOV-1-2	-10.60	90.20**	-10.69	-10.69	-11.30**	2.54	9.11**	9.11**	-25.34**	14.57*
Pusa A4 × DOV-2	11.18	65.69**	14.15**	29.42**	-14.90**	-8.15**	-27.83**	-20.41**	-4.71	-1.98
Pusa A4 × DOV-12	-15.87**	71.57**	45.47**	45.47**	11.29**	18.47**	28.05**	28.05**	-7.51	-7.51
Pusa A4 × WB selection	6.12	103.92**	19.41**	54.55**	-2.82	-2.82	12.63**	12.63**	-30.10**	-30.10**
Pusa A4 × IC-090491	-6.49	69.61**	33.01**	50.81**	13.19**	13.19**	16.15**	16.15**	34.81**	34.81**
Pusa A4 × DOV-62	-18.45**	86.27**	-6.84	45.47**	13.83**	13.83**	11.16**	11.16**	18.40**	18.40**
Pusa A4 × C-10	48.63**	112.75**	14.15**	29.42**	-5.49	4.15	-27.78**	-2.64**	16.17**	16.17**
DOV-1-2 × DOV-2	-7.83	96.08**	28.30**	45.47**	1.26	17.06**	-17.98**	-9.55**	-51.55**	-25.65**
DOV-1-2 × DOV-12	-8.76	94.12**	46.24**	45.47**	-17.34**	-4.44	-14.12**	-22.32**	-56.70**	-33.56**
DOV-1-2 × WB selection	-52.07**	1.96	18.17**	52.94**	-20.47**	-8.06*	10.36**	-4.55**	-48.22**	-20.55**
DOV-1-2 × IC-090491	-9.68	92.16**	30.18**	47.60**	-17.23**	-4.31	-12.74**	-18.50**	-49.65**	-22.73**
DOV-1-2 × DOV-62	-6.01	114.71**	-1.37	54.02**	2.30	18.27**	24.35**	12.48**	-47.79**	-19.89**
DOV-1-2 × C-10	-19.35**	71.57**	28.30**	45.47**	-4.67	10.20**	-30.28**	-6.02**	-27.30**	11.56*
DOV-2 × DOV-12	-8.65	86.27**	-18.88**	-8.02	-7.47*	-0.12	-29.43**	-22.17**	-5.97	-3.27
DOV-2 × WB selection	10.71	112.75**	0.00	29.42**	-8.37**	-1.09	-11.98**	-2.94**	-33.10**	-31.18**
DOV-2 × IC-090491	-2.16	77.45**	28.30**	45.47**	-2.39	5.36	-14.78**	-6.02**	-24.34**	-22.17**
DOV-2 × DOV-62	-27.47**	65.69**	-6.84	45.47**	-8.85**	-1.61	-48.74**	-43.47**	-38.11**	-36.34**
DOV-2 × C-10	13.82	69.61**	-14.15**	-2.66	-2.93	6.98*	-19.93**	7.93**	-41.23**	-39.54**
DOV-12 × WB selection	-2.88	98.04**	-37.19**	-18.71**	-13.64**	-8.06*	-7.63**	-16.44**	-31.13**	-37.37**
DOV-12 × IC-090491	-15.87**	71.57**	-21.71**	-11.23	4.92	11.69**	20.44**	12.48**	0.65	-8.47
DOV-12 × DOC-62	-38.20**	41.18**	-27.39**	13.38*	-4.55	1.61	3.25**	-6.61**	-30.80**	-37.07**
DOV-12 × C-10	-14.90**	73.53**	0.00	13.38*	-7.17*	2.30	-26.47**	-0.88	-13.77*	-21.58**
WB selection × IC-090491	-2.04	88.24**	0.00	29.42**	-4.55	-9.56**	-3.15**	-9.55**	-19.61**	-32.17**
WB selection × DOV-62	-29.18**	61.76**	-17.12**	29.42**	-0.55	-5.77	1.63*	-8.07**	12.22	-2.99
WB selection × C-10	3.06	98.04**	-12.40**	13.38*	-6.07*	3.51	-17.97**	10.57**	-19.00**	-31.65**
IC-090491 × DOV-62	-14.16**	96.08**	0.00	56.15**	21.89**	14.52**	3.15**	-3.67**	14.92*	-0.66
IC-090491 × C-10	1.62	84.31**	37.26**	55.62**	-7.72**	1.69	-33.99**	-11.01**	-12.70	-31.73**
DOV-62 × C-10	-26.61**	67.65**	-3.42	50.81**	-17.31**	-8.87**	-41.07**	-20.56**	19.14**	2.99

*,**Significant at 5 and 1% probability levels, respectively.
TDF = Total Dietary fibre

From the study, it was revealed that not a single parent recorded highest mean value for all the qualitative traits studied. Among the eight parents, DOV-1-2 recorded highest mean performance for three qualitative traits, *i.e.*, phosphorus, calcium and iron content. The hybrid Pusa A4 × IC-090491 showed highly significant positive heterosis for all studied traits except zinc content, while the hybrid Pusa A4 × DOV-62 showed significant positive heterosis for protein, total dietary fibre, phosphorus, potassium, calcium, magnesium and copper contents.

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Table 4. Percentage of heterosis over Better Parent (BP) and Standard Parent (SP) of crosses for various qualitative traits in okra.

Cross	Mg (ppm)		Fe (ppm)		Zn (ppm)		Cu (ppm)	
	BP	SP	BP	SP	BP	SP	BP	SP
Pusa A4 × DOV-1-2	7.07**	7.07**	-63.45**	-21.18**	3.56	3.56	0.00	0.00
Pusa A4 × DOV-2	4.70**	5.24**	-25.59**	6.58	3.31	3.31	-3.55	26.23**
Pusa A4 × DOV-12	0.46	2.04**	-7.06*	-7.06*	-11.70**	-11.70**	-20.95**	0.00
Pusa A4 × WB selection	-23.84**	-23.84**	-28.47**	-49.71**	-22.90**	-22.90**	2.19	2.19
Pusa A4 × IC-090491	-6.25**	8.47**	146.14**	100.68**	3.56	3.56	2.01	10.93**
Pusa A4 × DOV-62	7.92**	7.92**	-50.42**	-25.24**	2.80	2.80	-3.94	13.11**
Pusa A4 × C-10	-6.30**	2.60**	-48.06**	-20.99**	3.05	3.05	0.00	0.00
DOV-1-2 × DOV-2	-2.03**	-1.53*	-69.69**	-34.62**	8.68**	-13.99**	-20.25**	4.37
DOV-1-2 × DOV-12	-6.37**	-4.90**	-61.79**	-17.60**	-20.61**	-20.61**	-19.22**	2.19
DOV-1-2 × WB selection	-5.99**	-7.07**	9.90*	-22.73**	21.92**	3.31	26.35**	15.30**
DOV-1-2 × IC-090491	-12.44**	1.32*	-8.78*	-25.63**	17.88**	-9.41**	0.00	8.74**
DOV-1-2 × DOV-62	-4.69**	-5.79**	-71.79**	-39.17**	16.99**	-7.12**	-13.23**	2.19
DOV-1-2 × C-10	-4.74**	4.30**	-47.80**	12.57**	-10.94**	-10.94**	-4.57	-8.74**
DOV-2 × DOV-12	3.65**	5.28**	-2.03	40.33**	-19.85**	-19.85**	-21.92**	2.19
DOV-2 × WB selection	2.58**	3.11**	-13.89**	-39.46**	-5.11*	-19.59**	-20.25**	4.37
DOV-2 × IC-090491	-8.35**	6.05**	-14.83**	-30.56**	33.44**	5.60**	-18.58**	6.56*
DOV-2 × DOV-62	-2.80**	-2.30**	-65.17**	-47.49**	3.21	-18.07**	-25.26**	-2.19
DOV-2 × C-10	-7.12**	1.70**	-54.67**	-31.04**	-16.79**	-16.79**	-20.25**	4.37
DOV-12 × WB selection	-1.30*	0.26	-10.04*	-36.75**	-18.32**	-18.32**	-17.49**	4.37
DOV-12 × IC-090491	-6.03**	8.73**	-4.86	-22.44**	5.60**	5.60**	-14.04**	8.74**
DOV-12 × DOC-62	-0.21	1.36*	-50.03**	-24.66**	-3.82	-3.82	-22.68**	-2.19
DOV-12 × C-10	-5.37**	3.62**	-58.61**	-37.04**	-16.79**	-16.79**	-15.77**	6.56*
WB selection × IC-090491	-14.05**	-0.55	-19.34**	-34.24**	-8.11**	-22.14**	-2.01	6.56*
WB selection × DOV-62	7.03**	1.79**	-1.51	-30.75**	-7.81**	-21.88**	-9.51**	6.56*
WB selection × C-10	-12.87**	-4.60**	-17.06**	-41.68**	-21.12**	-21.12**	11.43**	6.56*
IC-090491 × DOV-62	-13.47**	0.13	-39.03**	-50.29**	-4.17	-23.92**	-5.80*	10.93**
IC-090491 × C-10	-17.40**	-4.43**	-4.86	-22.44**	-22.65**	-22.65**	-2.01	6.56*
DOV-62 × C-10	-9.41**	-0.81	-53.72**	-29.59**	-23.16**	-23.16**	-5.80*	10.93**

*,**Significant at 5 and 1% probability levels, respectively
Mg = Magnesium, Fe = iron, Zn = Zinc, Cu = Copper

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