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RESEARCH PAPER

Studies on heterosis for fruit yield and quality attributing characters in in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract : The present investigation was conducted on heterosis for fruit yield quality attributing characters in okra. Fifteen F_1 hybrids were generated by half diallel (excluding reciprocals) mating design. These F_1 hybrids along with six parents were evaluated in Randomized Block Design with three replications during late *Rabi* season of 2018 at three locations HRS, Lam; KVK, V.R.Gudem and KVK, Vonipenta, Andhra Pradesh. Observations were recorded for five randomly selected and tagged plants from each treatment for fruit yield and quality attributing characters *viz.,* number of fruits per plant, fruit length (cm), fruit girth (cm), fruit weight (g), number of seeds per fruit, test weight (g/100), fruit yield per plant (g), fruit yield per hectare (t), fibre content (%), ascorbic acid content (mg/100g) and shelf life (days). The values of F_1 hybrids averaged over three replications were used for estimating heterosis and pooled data was obtained. The top five heterotic cross combinations *viz.,* 440-10-1 x HRB-9-2, VRO-6 x HRB-9-2, TCR-1674 x HRB-9-2, VRO-6 x JPM-20-16-39 and VRO-3 x HRB-9-2 were identified as stable with desirable heterosis for fruit yield and other important traits.

Key Words : Okra, Heterosis, Half diallel, Yield, Quality

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INTRODUCTION

Okra [*Abelomoschus esculentus* (L.) Moench] commonly known as lady's finger belongs to the family Malvaceae. It is native to Tropical Asia. Okra is an allopolyploid with the most observed chromosome number of 2n=8x=130. It is an often crosspollinated crop. Okra fruit contains 90% water, 3% dietary fibre, 7% carbohydrates, 2% protein, good quantities of minerals, vitamin C and A and moderate contents of thiamin, folate and magnesium (Chopra *et al*., 1956).

During recent years, the commercial exploitation of hybrid vigour and selection of parents on the basis of combining ability have expanded a new alley in crop improvement. The term heterosis refers to a phenomenon in which F_1 shows increase or decrease in vigour over the parents. Shull (1908) referred to this phenomenon as the stimulus of heterozygosity and hybrid vigour in okra

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has been first reported by Vijayaraghavan and Warier (1946). The ease in emasculation, very high percentage of fruit setting and higher seed yield per cross indicate the possibilities of exploitation of its hybrid vigour. Exploitation of heterosis in okra has been recognized as a practical tool in providing the breeders a means of improving yield and other important traits. For developing promising varieties through hybridization, the choice of parents is a matter of great concern to the plant breeder. A high yielding genotype may or may not transmit its superiority to its progenies. Therefore, the success of a breeding programme is determined by useful gene combinations in the form of high combining inbred.

MATERIAL AND METHODS

The present investigation was carried out at three locations HRS, Lam; KVK, V.R.Gudem and KVK, Vonipenta, Andhra Pradesh, India during *Rabi* and *Summer*, 2018-19. The experimental material consisted of six parental lines *viz.,* VRO-3, VRO-6, 440-10-1, TCR-1674, JPM-20-16-39 and HRB-9-2 of these were crossed in diallel fashion excluding reciprocals during *Rabi*, 2018. The resultant 15 F_1 hybrids along with six parents and one check were evaluated in Randomized Block Design with three replications with spacing of 60 x 30 cm during *Summer*, 2019. Observations were recorded on five randomly selected plants from each plot for yield and quality parameters *viz.,* number of fruits per plant, fruit length (cm), fruit girth (cm), fruit weight (g), number of seeds per fruit, test weight (g/100), fruit yield per plant (g), fruit yield per hectare (t), fibre content (%), ascorbic acid content (mg/100g) and shelf life (days). The values of F_1 averaged over three replications were used for estimating heterosis. The magnitude of heterosis was calculated as percentage increase or decrease of F_1 mean over the mean of better parent (BP) (Turner, 1953 and Hays *et al.,* 1955) and per cent superiority over standard check were calculated. The analysis of variance, for all the characters under study, was carried out by the method suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The analysis of variance carried out for different traits of okra are presented in Table 1. The analysis of variance revealed significant differences among treatments for all the yield and quality traits indicating the presence of appreciable genetic diversity among the parents and cross combinations. This indicates the existence of wide variability in the material studied and there is a good scope for identifying promising parents and hybrid combinations, and improving the yield through its components. These results are in conformity with the findings of Artiverma and Soniasood (2015); Tiwari *et al.* (2016) and Shwetha *et al.* (2018) in okra.

Per cent arelative heterosis over relative parent, heterobeltiosis over better parent and standard heterosis in Tables 2, 3, 4, 5, 6, 7, 8 ,9 10, 11 and 12. In pooled analysis, the range of relative heterosis varied from -12.55 to 15.14 per cent. The range of heterosis over better parent varied from -21.11 to 5.7 per cent. Standard heterosis over the check Samrat ranged from -11.85 to 22.16. The cross 440-10-1 x HRB-9-2 exhibited significant positive heterosis of 22.16 per cent over check Samrat for number of fruits per plant (Table 2). Similar results are reported by Bhatt *et al.* (2016), Satish *et al.* (2017) and Makdoomi *et al.* (2018). For fruit length in pooled analysis, the range of relative heterosis varied from 0.98 to 10.34 per cent. The range of heterosis over better parent varied from -0.94 to 9.71 per cent. Seven hybrids over mid parent and three over better parent

Table 1. : Pooled analysis of variance for combining ability (Half-diallel) for yield and quality attributes for stability in okra

Source	Df	Number of fruits per plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Number of seeds per fruit	Test weight of seeds (g)	Yield per plant (g)	Yield (t/ha)	Fibre content (%)	Asorbic acid content (mg/100mg)	Shelf life (days)
Replicates	2	0.052	2.192**	0.044	0.486	1.658	0.475*	41.321	0.082	0.022	0.156	0.022
Treatments	20	7.508**	0.814**	0.189*	9.642**	113.109**	0.359**	6301.180**	16.946*	0.454**	29.829**	1.026*
Parents	5	14.480**	0.285	0.189	1.174	137.777**	0.667**	5812.716*	17.958	0.707**	33.940**	0.703**
Hybrids	14	5.533*	0.599*	0.122	4.771*	97.250**	0.216	4664.188*	11.954	0.389**	29.260**	1.164**
Parent Vs.Hybrids	1	0.299	6.479**	1.110**	120.171**	211.804**	0.823*	31661.390**	81.792**	0.085	17.244**	0.700**
Error	40	2.193	0.250	0.086	1.987	12.678	0.143	2351.297	7.35	0.125	1.201	0.045
Total	62	3.838	0.494	0.118	4.408	44.72	0.223	3550.938	10.211	0.228	10.402	0.361

* and ** indicate significance of values at P=0.05 and 0.01, respectively

were found superior by exhibiting significant positive heterosis. Standard heterosis over Samrat ranged from -2.23 to 9.22. One hybrid 440-10-1 x HRB-9-2 exhibited significant positive heterosis of 9.22 per cent over check Samrat (Table 3). Similar results are reported by Satish *et al*. (2017) and Makdoomi *et al*. (2018). In pooled analysis, the hybrids were in the range of -4.24 to 15.23 per cent for relative heterosis and from -5.88 to 13.38 per cent of heterobeltiosis. Four crosses over mid parent and three over better parent have recorded significant positive effects. The standard heterosis over the check Samrat varied from 0.53 to 10.96 per cent. Two hybrids showed significant positive standard heterosis over Samrat for fruit girth (Table 4). Similar results are

Table 2 : Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for number of fruits per plant in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	
VRO-3 X VRO-6	-11.59	-12.71	-6.36	4.29	-3.41	-33.33 **	5.70	2.55	7.11	-1.13	-4.64	-11.85
VRO-3 X 440-10-1	-4.17	-8.00	4.55	15.41	13.55	-30.98 **	1.29	-3.67	4.89	2.63	-1.25	-8.27
VRO-3 X TCR-1674	5.38	4.26	11.36	2.78	-11.9	-27.45 **	10.63	6.25	13.33	6.51	-0.02	-2.14
VRO-3 X JPM-20-16-39	-16.00	-27.81 **	5.00	-1.30	-19.15	-25.49 **	-6.31	-14.81	2.22	-8.72	-21.11 **	-7.01
VRO-3 X HRB-9-2	12.38	0.00	34.09 **	5.64	-14.17	-19.22	-7.87	-20.00	6.67	3.22	-11.24	5.89
VRO-6 X 440-10-1	19.34 *	16.00	31.82 **	-2.72	-8.52	-36.86 **	-1.67	-3.67	4.89	5.96	5.70	-1.82
VRO-6 X TCR-1674	10.40	10.17	18.18	1.04	-7.14	-23.53 *	-1.05	-2.08	4.44	3.60	0.72	-1.41
VRO-6 X JPM-20-16-39	-8.27	-20.31 *	15.91	16.79	2.13	-5.88	-2.57	-8.89	9.33	0.68	-10.18	5.87
VRO-6 X HRB-9-2	2.07	-8.14	23.18	0.96	-12.50	-17.65	2.8	-8.33	22.22	2.04	-9.45	8.04
440-10-1 X TCR-1674	3.51	0.40	14.09	-6.85	-19.05	-33.33 **	5.15	4.08	13.33	1.27	-1.31	-3.41
440-10-1 X JPM-20-16-39	-15.79	-25.00 **	9.09	8.21	-10.21	-17.25	-2.52	-7.04	11.56	-4.84	-14.93 *	0.28
440-10-1 X HRB-9-2	10.09	1.69	36.36 **	24.05 *	2.08	-3.92	13.76	3.33	37.78 **	15.14 *	2.39	22.16 **
TCR-1674 x JPM-20-16-39	-4.50	-17.19 *	20.45	14.61	8.51	0.00	-5.49	-10.74	7.11	0.78	-7.76	8.72
TCR-1674 X HRB-9-2	0.00	-10.17	20.45	0.00	-6.25	-11.76	7.78	-3.00	29.33 *	2.76	-6.47	11.59
JPM-20-16-39 x HRB-9-2	-15.12	-18.44 *	18.64	-11.58	-12.50	-17.65	-10.53	-15.00	13.33	-12.55*	-13.08	3.71

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for fruit length in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
VRO-3 X VRO-6	0.87	0.03	2.11	-1.79	-3.24	-16.92 *	7.69	5.93	7.61	2.75	2.26	-2.23
VRO-3 X 440-10-1	3.25	2.65	3.04	-4.65	-6.03	-16.92 *	4.69	0.58	7.27	1.43	-0.46	-2.08
VRO-3 X TCR-1674	0.83	0.66	1.39	3.42	-1.18	-15.15 *	6.41	4.33	6.70	3.81	3.30	-2.18
VRO-3 X JPM-20-16-39	4.97	3.14	3.53	7.45	5.85	-9.12	15.29 **	12.76**	15.91 **	9.79**	9.71 **	3.88
VRO-3 X HRB-9-2	0.76	0.75	1.13	14.48	12.82	-0.25	5.22	0.00	9.09	6.68*	4.05	3.63
VRO-6 X 440-10-1	16.57 **	14.94**	17.33 **	-8.25	-10.88	-21.21 **	-3.96	-6.24	0.00	0.98	-0.44	-2.06
VRO-6 X TCR-1674	-1.38	-2.04	0.00	16.29 *	12.73	-6.06	2.56	2.22	4.55	5.27	4.25	-0.33
VRO-6 X JPM-20-16-39	2.01	-0.60	1.48	8.80	8.79	-9.34	8.64	8.00	11.02 *	6.65*	6.05	1.40
VRO-6 X HRB-9-2	10.38 *	9.44	11.72 *	10.87	7.68	-4.80	3.56	0.00	9.09	7.76**	5.61	5.18
440-10-1 X TCR-1674	11.00 *	10.17	10.97 *	-2.11	-7.74	-18.43 *	5.73	3.56	10.45 *	5.05	2.58	0.91
440-10-1 X JPM-20-16-39	11.41 *	10.09	9.23	5.00	1.97	-9.85	2.00	0.15	6.82	5.70	3.64	1.95
440-10-1 X HRB-9-2	19.10 **	18.43**	18.84 **	11.37	11.37	-1.54	3.23	2.08	11.36 *	10.34 **	9.66 **	9.22 **
TCR-1674 x JPM-20-16-39	5.46	3.45	4.20	15.05	11.55	-7.07	4.18	3.91	6.82	7.67*	7.22 *	1.37
TCR-1674 X HRB-9-2	0.07	-0.11	0.61	3.96	-2.03	-13.38	2.15	-1.04	7.95	2.05	-0.94	-1.35
JPM-20-16-39 x HRB-9-2	15.40 **	13.41**	13.80 **	17.62 *	14.22	0.98	-3.46	-6.25	2.27	8.38**	5.63	5.20

* and ** indicate significance of values at P=0.05 and 0.01, respectively

reported by More *et al*. (2015b) and Makdoomi *et al*. (2018) in okra.

For fruit weight in pooled analysis, relative heterosis ranged from 7.30 to 29.62 per cent. The heterobeltiosis ranged from 3.53) to 27.77 per cent. Twelve and seven hybrids exhibited significant positive relative heterosis and heterobeltiosis, respectively. The standard heterosis over Samrat ranged from 2.68 to 25.46 per cent. Seven hybrids registered significant positive standard heterosis over Samrat (Table 5). Similar results are reported by More *et al*. (2015b) and Makdoomi *et al*. (2018) in okra. In pooled analysis, the range of relative heterosis varied from –8.8 to 17.43 per cent. The range of heterosis over better parent varied from -14.62 to 13.08 per cent. Seven hybrids showed significant positive average heterosis over mid parent and one hybrid over heterobeltiosis. Standard

Table 4: Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for fruit girth in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
VRO-3 X VRO-6	12.85 *	9.61	10.39	-1.23	-4.32	-7.27	5.24	2.61	6.15	5.71	2.71	3.14
VRO-3 X 440-10-1	0.38	-5.50	1.61	-4.29	-11.41	-5.45	2.81	-1.08	5.17	-0.24	-5.88	0.53
VRO-3 X TCR-1674	8.72	5.05	6.93	-4.29	-10.92	-6.06	1.69	-1.64	3.45	2.11	-2.50	1.54
VRO-3 X JPM-20-16-39	20.23 **	20.19**	14.16 *	9.44	5.17	3.64	15.94 **	14.94**	14.94 **	15.23 **	13.38**	10.96 *
VRO-3 X HRB-9-2	16.96 **	16.13*	11.83	18.24 **	15.89*	9.64	1.14	-1.12	1.72	11.71 **	9.85 *	7.64
VRO-6 X 440-10-1	2.07	-1.17	6.27	-10.18	-14.31 *	-8.55	0.27	-1.08	5.17	-2.46	-5.38	1.07
VRO-6 X TCR-1674	14.16 *	13.56*	15.59 *	1.17	-2.93	2.36	3.31	2.46	7.76	6.17	4.27	8.59
VRO-6 X JPM-20-16-39	17.22 **	13.88*	14.70 *	6.05	5.17	3.64	11.86 **	10	13.79 **	11.80 **	10.38*	10.84 *
VRO-6 X HRB-9-2	16.43 **	13.88*	14.70 *	10.7	9.38	6.00	3.06	2.78	6.32	9.88*	8.55	9.00
440-10-1 X TCR-1674	2.74	0.00	7.53	-17.74**	-18.23 **	-12.73	1.90	1.35	7.76	-4.24	-5.44	1.01
440-10-1 X JPM-20-16-39	10.62	4.17	12.01	-6.11	-9.71	-3.64	0.28	-2.70	3.45	1.65	-2.61	4.03
440-10-1 X HRB-9-2	9.03	3.33	11.11	6.56	0.51	7.27	1.65	0.00	6.32	5.64	1.28	8.18
TCR-1674 x JPM-20-16-39	9.84	6.16	8.06	1.60	-1.72	3.64	4.2	1.64	6.90	5.16	1.99	6.22
TCR-1674 X HRB-9-2	13.99 *	10.92	12.90	-1.85	-6.90	-1.82	1.10	0.00	5.17	4.34	1.25	5.45
JPM-20-16-39 x HRB-9-2	18.99 **	18.18**	13.80 *	2.98	0.92	-0.55	0.28	-1.12	1.72	7.26	7.19	5.04

* and ** indicate significane of values at P=0.05 and 0.01, respectively

Table 5 : Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for fruit weight in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
VRO-3 X VRO-6	28.43 **	26.10**	30.02 **	0.25	0.00	-22.69 **	14.09	11.26	17.07	15.07 *	13.17	7.93
VRO-3 X 440-10-1	18.43 *	13.43	16.96	3.27	1.99	-21.15 *	17.91	15.56	21.6	14.11 *	11.23	6.09
VRO-3 X TCR-1674	7.79	2.35	17.39	16.86	11.82	-5.38	23.68 *	20.20	26.48 *	16.37 **	14.14	13.20
VRO-3 X JPM-20-16-39	27.99 **	22.36*	38.32 **	31.07 **	27.96**	3.85	30.07 **	27.48*	34.15 **	29.62 **	27.77**	25.46 **
VRO-3 X HRB-9-2	26.25 **	26.00**	30.43 **	31.46 **	24.44*	7.69	9.63	9.27	14.98	21.16 **	19.35**	17.33 *
VRO-6 X 440-10-1	41.03 **	37.50**	36.65 **	3.54	2.50	-21.15 *	-3.29	-3.79	-2.79	12.96	11.95	3.23
VRO-6 X TCR-1674	8.92	1.64	16.58	11.9	6.82	-9.62	2.45	2.09	2.09	7.30	3.53	2.68
VRO-6 X JPM-20-16-39	14.62	7.69	21.74 *	22.14 *	18.96	-3.46	35.18 **	34.48**	35.89 **	24.56 **	20.77**	18.59 **
VRO-6 X HRB-9-2	29.18 **	26.60**	31.06 **	24.71 **	17.78	1.92	31.18 **	28.33*	34.15 **	28.68 **	24.70**	22.58 **
440-10-1 X TCR-1674	6.93	-2.53	11.8	-5.77	-10.91	-24.62 **	35.65 **	34.48**	35.89 **	14.43 *	9.46	8.56
440-10-1 X JPM-20-16-39	21.56 **	11.54	26.09 **	5.65	1.90	-17.31 *	19.66	19.66	20.91	16.46 **	11.94	9.91
440-10-1 X HRB-9-2	28.66 **	23.00*	27.33 **	25.89 **	17.78	1.92	31.53 **	29.33*	35.19 **	29.00 **	23.92**	21.82 **
TCR-1674 x JPM-20-16-39	1.84	1.10	15.96	21.11 *	18.64	0.38	31.13 **	30.00*	31.36 *	17.99 **	17.40*	16.44 *
TCR-1674 X HRB-9-2	23.95 **	17.91*	35.24 **	3.37	2.22	-11.54	19.66	16.67	21.95	16.47 **	15.96*	15.01 *
JPM-20-16-39 x HRB-9-2	4.23	-0.16	12.86	16.97	13.33	-1.92	8.47	6.67	11.50	9.41	9.35	7.50

heterosis over Samrat ranged from -18.95 to 16.37. Two hybrids exhibited significant positive heterosis over Samrat for number of seeds per fruit (Table 6). These results are conformity with the findings of Sujith Kumar *et al*. (2017) and Makdoomi *et al*. (2018). For test weight of seeds pooled analysis of average heterosis for 15 hybrids studied indicated a range of -5.19 to 11.97 per cent. Heterobeltiosis ranged from -9.42 to 10.22 per cent. One hybrid exhibited significant positive relative heterosis. The standard heterosis over Samrat ranged from -14.11 to 1.30 per cent (Table 7). These results are conformity with the findings Patel and Patel (2016) and Makdoomi *et al*. (2018) in okra.

In pooled analysis, average heterosis ranged from -5.77 to 50.49 per cent. Two hybrids exhibited significant positive relative heterosis. Heterobeltiosis ranged from

Table.6: Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for number of seeds per fruit in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
VRO-3 X VRO-6	21.59 *	12.27	14.95	-4.15	-14.77	-30.98 **	7.67	4.82	-7.67	8.85	8.73	-8.95
VRO-3 X 440-10-1	1.55	-4.73	11.31	-9.57	-17.59	-36.85 **	0.11	-2.13	-9.74	-1.97	-7.40	-12.79 *
VRO-3 X TCR-1674	21.25 *	19.02	21.86 *	-7.82	-16.32	-35.33 **	17.38 *	13.81	6.74	11.71 *	8.08	-3.21
VRO-3 X JPM-20-16-39	-20.94**	-35.97 **	5.78	12.37	0.82	-20.00 **	10.62	2.09	6.32	-1.64	-14.62 **	-2.87
VRO-3 X HRB-9-2	20.10 *	19.14	21.98 *	19.22 *	9.35	-17.39 **	2.90	2.35	-9.84	13.50 **	11.25	-2.98
VRO-6 X 440-10-1	-5.43	-17.63	-3.77	-10.90	-13.29	-29.78 **	-10.21	-14.49	-21.14 **	-8.80	-13.94 *	-18.95 **
VRO-6 X TCR-1674	26.78 **	19.11	17.46	18.13 *	15.44	-6.52	-2.34	-7.73	-13.47	13.34 **	9.54	-1.90
VRO-6 X JPM-20-16-39	30.67 **	-0.38	64.57 **	6.58	5.50	-14.57 *	11.60	0.50	4.66	17.43 **	1.84	15.86 **
VRO-6 X HRB-9-2	16.62	8.48	9.30	1.53	-1.88	-20.54 **	14.34	11.89	-2.49	11.06 *	8.73	-5.18
440-10-1 X TCR-1674	14.64	5.70	23.49 *	-8.19	-8.58	-29.35 **	-1.39	-2.21	-8.29	2.24	-0.27	-6.08
440-10-1 X JPM-20-16-39	12.25	-4.18	58.29 **	-20.42**	-21.78 **	-37.93 **	0.79	-4.98	-1.04	-0.05	-8.65	3.92
440-10-1 X HRB-9-2	1.04	-5.91	9.92	17.86 *	17.02	-10.33	12.07	8.99	0.52	9.81	5.74	-0.41
TCR-1674 x JPM-20-16-39	7.71	-13.99 *	42.09 **	1.46	0.14	-20.54 **	8.48	3.08	7.36	6.33	-4.98	8.10
TCR-1674 X HRB-9-2	13.42	12.22	13.07	28.02 **	26.58**	-2.17	4.81	1.10	-5.18	14.58 **	13.08*	1.26
JPM-20-16-39 x HRB-9-2	29.90 **	4.56	72.74 **	17.89 *	15.07	-8.70	-1.95	-9.95	-6.22	15.81 **	2.29	16.37 **

Table 7 : Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for test weight of seeds in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
VRO-3 X VRO-6	13.57	10.37	5.32	3.13	2.02	-11.03	4.14	1.25	-0.82	7.30	5.35	-1.45
VRO-3 X 440-10-1	11.41	8.86	-1.96	6.30	4.31	-9.03	7.62	7.35	-0.68	8.67	7.16	-3.40
VRO-3 X TCR-1674	15.41	5.24	-5.23	-0.39	-1.95	-14.48 *	3.54	1.85	-2.59	6.49	3.39	-6.80
VRO-3 X JPM-20-16-39	-12.11	-21.31 *	-10.36	-3.06	-6.96	-11.76	4.81	2.38	-0.68	-3.64	-9.42	-7.20
VRO-3 X HRB-9-2	-1.51	-9.86	-2.24	6.47	1.84	-2.73	0.50	-1.82	-4.76	1.36	-3.93	-3.30
VRO-6 X 440-10-1	-19.23	-23.24	-26.75 *	11.71	10.8	-5.45	-3.63	-6.53	-8.44	-5.19	-8.18	-14.11 **
VRO-6 X TCR-1674	27.83 *	13.60	8.40	4.00	3.48	-11.7	-6.11	-7.22	-9.12	8.05	3.05	-3.60
VRO-6 X JPM-20-16-39	-1.43	-9.43	3.17	7.90	2.49	-2.79	-0.95	-1.44	-3.45	1.12	-3.27	-0.90
VRO-6 X HRB-9-2	9.46	2.88	11.58	1.54	-3.87	-8.18	-2.02	-2.50	-4.49	3.25	-0.40	0.25
440-10-1 X TCR-1674	30.15 *	21.24	4.20	1.69	1.36	-14.36 *	3.65	1.71	-2.72	11.97 *	10.22	-3.40
440-10-1 X JPM-20-16-39	10.25	-3.28	10.18	2.71	-3.19	-8.18	1.18	-1.4	-4.35	5.00	-2.59	-0.20
440-10-1 X HRB-9-2	19.40	7.02	16.06	-1.52	-7.49	-11.64	1.32	-1.26	-4.22	7.28	0.35	1.00
TCR-1674 x JPM-20-16-39	10.7	-8.61	4.11	0.57	-4.92	-9.82	-1.69	-2.38	-5.31	3.34	-5.52	-3.20
TCR-1674 X HRB-9-2	24.49 *	4.82	13.68	-7.07	-12.44	-16.36 **	3.53	2.81	-0.27	8.12	-0.35	0.30
JPM-20-16-39 x HRB-9-2	3.67	1.19	15.27	-2.26	-2.60	-6.97	-3.23	-3.23	-6.12	-0.25	-1.12	1.30

* and ** indicate significance of values at P=0.05 and 0.01, respectively

-7.43 to 28.67 per cent. The standard heterosis over Samrat ranged from -2.18 to 61.83 per cent. Three hybrids registered significant positive standard heterosis over Samrat for fruit yield per plant (Table 8). Similar results are reported by Makdoomi *et al*. (2018). For fruit yield per hectare in pooled analysis, average heterosis ranged from -6.59 to 54.86 per cent. Two hybrids exhibited significant positive relative heterosis. Heterobeltiosis ranged from -12.18 to 29.25 per cent. The standard heterosis over Samrat ranged from -2.58 to 68.67 per cent. Two hybrids registered significant positive standard heterosis over Samrat (Table 9). In pooled analysis, the hybrids were in the range of -17.14 to 8.79 per cent for relative heterosis and of -29. to -

Table 8 : Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for yield per plant in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
VRO-3 X VRO-6	15.78	14.73	32.59	3.16	-2.43	-50.04 **	25.25	17.54	23.30	16.98	12.82	-2.18
VRO-3 X 440-10-1	21.46	19.08	37.63	9.48	6.41	-48.53 **	18.81	6.14	24.10	17.77	11.99	0.00
VRO-3 X TCR-1674	19.79	13.23	46.96	18.44	-2.19	-31.47 *	56.11	46.47	53.72	33.76	21.74	19.53
VRO-3 X JPM-20-16-39	7.42	-12.05	59.44 *	22.28	-4.45	-22.50	25.03	10.04	33.15	17.59	-2.27	18.85
VRO-3 X HRB-9-2	40.61 **	19.84	96.60 **	34.26	3.20	-12.32	6.82	-11.78	24.53	25.43	2.88	29.39
VRO-6 X 440-10-1	76.44 **	74.56**	98.08 **	-5.23	-7.86	-52.81 **	-14.49	-18.89	-5.16	17.89	16.18	3.75
VRO-6 X TCR-1674	70.78 **	60.04**	107.72 **	14.68	-0.76	-30.46 *	-2.81	-2.84	1.97	26.92	19.50	17.33
VRO-6 X JPM-20-16-39	3.66	-15.73	52.78 *	43.23 *	16.83	-5.25	35.39	26.38	52.91	25.52	7.51	30.74
VRO-6 X HRB-9-2	34.11 *	13.43	86.09 **	26.23	1.16	-14.06	39.23	21.34	71.29 *	34.31 *	13.45	42.68 *
440-10-1 X TCR-1674	14.13	5.89	37.44	-16.78	-29.67	-50.72 **	43.52	36.17	59.22	19.13	13.74	11.67
440-10-1 X JPM-20-16-39	2.19	-17.61	49.38 *	11.27	-11.19	-27.97	8.25	6.43	28.77	6.75	-7.43	12.58
440-10-1 X HRB-9-2	50.08 **	25.84	106.44 **	47.71 *	15.9	-1.53	52.35 *	39.27	96.60 **	50.49 **	28.67	61.83 **
TCR-1674 x JPM-20-16-39	-1.21	-15.24	53.66 *	35.70 *	26.47	2.57	17.84	10.03	33.13	15.45	4.33	26.88
TCR-1674 X HRB-9-2	24.38	11.39	82.74 **	2.39	-6.58	-20.64	33.58	16.45	64.38	22.20	8.80	36.83 *
JPM-20-16-39 x HRB-9-2	-14.49	-18.55	47.66 *	-1.41	-3.64	-18.14	-0.29	-7.41	30.70	-5.77	-7.33	16.55

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table.9: Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for yield per hectare in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
VRO-3 X VRO-6	19.07	17.74	40.62	4.5	-3.26	-57.90 **	29.59	20.38	27.22	20.88	15.65	-2.58
VRO-3 X 440-10-1	25.97	23.01	46.90	13.41	8.94	-56.17 **	21.8	7.00	28.15	21.74	14.50	0.00
VRO-3 X TCR-1674	23.59	15.60	58.56	24.12	-2.73	-36.46 *	65.97	54.31	62.76	40.96	25.97	23.11
VRO-3 X JPM-20-16-39	4.70	-16.60	67.93 *	21.71	-10.28	-29.90	24.99	7.98	34.5	16.28	-6.25	17.78
VRO-3 X HRB-9-2	39.10 *	15.73	108.13 **	38.93	0.64	-16.88	0.70	-18.83	20.21	23.10	-2.16	27.68
VRO-6 X 440-10-1	104.70 **	102.11**	135.98 **	-7.3	-10.8	-61.18 **	-16.59	-21.50	-5.99	25.75	23.52	7.88
VRO-6 X TCR-1674	84.57 **	70.84**	134.33 **	18.93	-0.92	-35.28	-3.12	-3.21	2.29	32.45	23.31	20.51
VRO-6 X JPM-20-16-39	0.39	-20.70	59.67	47.96	15.18	-10.00	36.95	26.56	57.65	25.62	4.93	31.82
VRO-6 X HRB-9-2	35.67 *	11.87	101.19 **	26.53	-3.4	-20.21	41.17	20.95	79.14 *	35.93 *	11.84	45.95 *
440-10-1 X TCR-1674	16.90	6.95	46.69	-21.78	-36.8	-58.71 **	50.26	41.30	69.23	23.01	16.47	13.83
440-10-1 X JPM-20-16-39	-1.36	-22.80	55.44	7.58	-18.51	-36.33 *	5.92	3.88	29.39	3.61	-12.18	10.33
440-10-1 X HRB-9-2	54.32 **	25.99	126.57 **	53.50 *	14.14	-5.72	55.92 *	41.00	108.84 **	54.86 **	29.25	68.67 **
TCR-1674 x JPM-20-16-39	-5.03	-20.17	60.74 *	43.51 *	31.74	2.94	20.62	11.38	38.74	16.66	3.71	30.29
TCR-1674 X HRB-9-2	24.32	9.57	97.04 **	-2.41	-12.62	-27.82	34.89	15.48	71.03	21.83	6.53	39.03
JPM-20-16-39 x HRB-9-2	-16.35	-20.82	59.43	-1.70	-4.35	-21.00	-0.35	-8.27	35.86	-6.59	-8.34	19.62

* and ** indicate significance of values at P=0.05 and 0.01, respectively

1.81 per cent for heterobeltiosis. Three hybrids recorded significant negative heterobeltiosis. The standard heterosis over the check Samrat varied from -16.12 to 27.69 per cent and one hybrid had significant positive heterosis over Samrat for fibre content (Table 10). Similar results are reported by Sankeet *et al*. (2017). In pooled analysis, the range of relative heterosis varied from -12.37 to 47.82 per cent. The range of heterosis over better parent varied from -30.47 to 44.52 per cent. Five and three hybrids showed significant positive average heterosis and heterobelteosis, respectively. Standard heterosis over Samrat ranged from -46.12 to 1.05. Thirteen hybrids showed significant negative heterosis over Samrat for ascorbic acid content (Table 11).

Table 10 : Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for fibre content in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
VRO-3 X VRO-6	-9.37	-20.55	-3.33	-0.97	-12.33	0.00	-7.09	-18.62	2.61	-5.86	-17.18	-0.41
VRO-3 X 440-10-1	-2.91	-9.09	-16.67	-2.92	-4.00	-15.62	4.35	-0.92	-6.09	-0.47	-4.52	-12.81
VRO-3 X TCR-1674	4.00	-7.14	8.33	4.45	-7.53	5.47	0.79	-11.72	11.3	3.15	-8.71	8.26
VRO-3 X JPM-20-16-39	-0.50	-15.61	11.11	1.16	-13.85	7.68	-3.47	-18.85	12.9	-0.86	-16.09	10.61
VRO-3 X HRB-9-2	0.00	-1.82	-10.00	-2.44	-2.65	-14.06	0.47	-1.38	-6.52	-0.69	-1.81	-10.33
VRO-6 X 440-10-1	-6.61	-22.60 *	-5.83	-5.47	-17.12	-5.47	-9.47	-24.14 *	-4.35	-7.29	-21.31 *	-5.37
VRO-6 X TCR-1674	-5.59	-7.53	12.5	-0.68	-0.68	13.28	-4.14	-4.14	20.87	-3.46	-4.12	15.29
VRO-6 X JPM-20-16-39	-5.26	-8.86	20.00	3.27	-1.25	23.44	0.33	-4.38	33.04 *	-0.66	-5.02	25.21
VRO-6 X HRB-9-2	-4.76	-17.81	0.00	-8.88	-19.18	-7.81	-13.6	-25.52 *	-6.09	-8.88	-20.62	-4.55
440-10-1 X TCR-1674	-16.1	-29.29 **	-17.5	-17.97	-28.08 **	-17.97	-17.7	-31.03 **	-13.04	-17.14	-29.27 **	-16.12
440-10-1 X JPM-20-16-39	-11.02	-28.48 **	-5.83	-11.11	-25.00 **	-6.25	-14.73	-31.25 **	-4.35	-12.26	-28.21 **	-5.37
440-10-1 X HRB-9-2	-2.97	-7.55	-18.33	-12.11	-13.27	-23.44	-1.48	-4.76	-13.04	-5.97	-8.80	-18.60
TCR-1674 x JPM-20-16-39	2.68	-3.16	27.50 *	3.27	-1.25	23.44	0.33	-4.38	33.04 *	1.98	-3.13	27.69 *
TCR-1674 X HRB-9-2	-2.44	-14.29	0.00	1.16	-10.27	2.34	0.00	-13.79	8.70	-0.20	-12.54	3.72
JPM-20-16-39 x HRB-9-2	6.82	-10.76	17.5	10.62	-5.63	17.97	9.43	-9.37	26.09	8.79	-8.78	20.25

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 11 : Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for ascorbic acid content in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
VRO-3 X VRO-6	0.55	0.40	-42.06 **	3.68	1.64	-48.78 **	4.3	-1.82	-46.92 **	2.83	0.03	-46.12 **
VRO-3 X 440-10-1	19.43 **	1.82	-16.67 **	29.59 **	7.07	-17.30 **	20.38 **	1.33	-19.86 **	23.26 **	3.52	-17.97 **
VRO-3 X TCR-1674	21.79 **	15.38*	-25.60 **	20.60 **	11.27	-33.67 **	14.23 *	7.45	-34.09 **	18.79 **	11.27	-31.38 **
VRO-3 X JPM-20-16-39	10.39	-9.64	-18.15 **	3.60	-17.77 **	-29.47 **	-4.77	-21.88 **	-34.09 **	2.93	-16.58 **	-27.63 **
VRO-3 X HRB-9-2	2.83	1.68	-39.98 **	-0.35	-1.69	-50.46 **	1.71	0.46	-45.69 **	1.38	0.86	-45.67 **
VRO-6 X 440-10-1	3.91	-11.52 *	-27.58 **	4.38	-15.11 **	-34.42 **	10.88	-11.11 *	-29.70 **	6.40	-12.61 *	-30.75 **
VRO-6 X TCR-1674	-1.14	-6.46	-39.68 **	-15.01*	-23.00 **	-54.10 **	4.75	-6.88	-42.88 **	-3.93	-12.29	-45.91 **
VRO-6 X JPM-20-16-39	-10.25	-26.62 **	-33.53 **	-14.27**	-32.94 **	-42.49 **	-12.44*	-31.46 **	-42.18 **	-12.37*	-30.47 **	-39.68 **
VRO-6 X HRB-9-2	32.94 **	31.26**	-22.52 **	60.28 **	59.25**	-21.91 **	50.48 **	43.33**	-24.43 **	47.82 **	44.52**	-22.95 **
440-10-1 X TCR-1674	26.10 **	12.73*	-7.74	31.29 **	16.30**	-10.16 *	35.17 **	20.00**	-5.1	30.97 **	16.45**	-7.72
440-10-1 X JPM-20-16-39	26.58 **	20.48**	9.13	14.34 **	8.66	-6.80	24.95 **	21.04**	2.11	21.74 **	16.48**	1.05
440-10-1 X HRB-9-2	9.86	-5.45	-22.62 **	11.04	-9.24	-29.89 **	0.67	-16.11 **	-33.66 **	7.18	-10.36	-28.96 **
TCR-1674 x JPM-20-16-39	-3.71	-17.58 **	-25.35 **	-16.26**	-29.03 **	-39.13 **	-8.32	-20.83 **	-33.22 **	-9.65	-22.71 **	-32.95 **
TCR-1674 X HRB-9-2	-2.81	-6.92	-39.98 **	3.55	-5.63	-43.74 **	-6.63	-13.18	-46.75 **	-1.95	-8.60	-43.63 **
JPM-20-16-39 x HRB-9-2	-7.82	-23.88 **	-31.05 **	-13.05*	-31.67 **	-41.39 **	9.43	-9.37	26.09	8.79	-8.78	20.25

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 12 : Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for shelf life in okra

Cross combination	V.R.Gudem			Lam			Vonipenta			Pooled		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
VRO-3 X VRO-6	6.80	0.00	-19.82 *	6.80	0.00	0.00	-6.8	-12.73	-22.33 **	2.20	0.00	-14.78 *
VRO-3 X 440-10-1	0.00	-18.26 *	-9.91	-15.77*	-27.25 **	0.00	-11.00	-27.25 **	-11.00	-9.05	-24.18 **	-7.33
VRO-3 X TCR-1674	12.57	0.00	-9.91	0.00	0.00	0.00	12.57	0.00	0.00	8.31	0.00	-3.67
VRO-3 X JPM-20-16-39	0.00	0.00	-30.03 **	-6.80	-12.73	-12.73	0.00	0.00	-22.33 **	-2.44	-4.77	-22.33 **
VRO-3 X HRB-9-2	12.57	0.00	-9.91	12.36	12.36	12.36	12.57	0.00	0.00	12.43 *	3.81	0.00
VRO-6 X 440-10-1	36.59 **	17.98*	30.03 **	22.33 **	0.00	37.45 **	26.18 **	8.99	33.33 **	28.55 **	9.09	33.33 **
VRO-6 X TCR-1674	5.82	0.00	-9.91	6.80	0.00	0.00	5.82	0.00	0.00	6.12	0.00	-3.67
VRO-6 X JPM-20-16-39	20.00 *	12.36	-9.91	14.59	14.59	0.00	6.80	0.00	-11.00	13.78 *	8.74	-7.33
VRO-6 X HRB-9-2	29.45 **	22.33*	10.21	33.20 **	24.72**	24.72 **	17.46 *	11.00	11.00	26.44 **	19.15**	14.78 *
440-10-1 X TCR-1674	19.94 **	8.99	20.12 *	36.59 **	17.98**	62.17 **	29.84 **	17.98**	44.33 **	28.72 **	15.09**	40.67 **
440-10-1 X JPM-20-16-39	-11.00	-27.25 **	-19.82 *	-11.00	-27.25 **	0.00	-22.33**	-36.51 **	-22.33 **	-14.73**	-30.27 **	-14.78 *
440-10-1 X HRB-9-2	29.84 **	17.98*	30.03 **	26.18 **	8.99	49.81 **	19.94 **	8.99	33.33 **	25.37 **	12.09*	37.00 **
TCR-1674 x JPM-20-16-39	0.19	-11.00	-19.82 *	6.80	0.00	0.00	0.19	-11.00	-11.00	2.43	-7.50	-10.89
TCR-1674 X HRB-9-2	0.00	0.00	-9.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-3.67
JPM-20-16-39 x HRB-9-2	-12.57	-22.33 *	-30.03 **	-6.80	-12.73	-12.73	-12.57	-22.33 **	-22.33 **	-10.73	-19.38 **	-22.33 **

* and ** indicate significance of values at P=0.05 and 0.01, respectively

For shelf life in pooled analysis it is evident that, average heterosis for 15 hybrids was in the range of -14.73 to 28.72 per cent. Heterobeltiosis was in the range of -30.27 to 19.15 per cent. The standard heterosis over Samrat ranged from -22.33 to 40.67 per cent. Four hybrids recorded significantly longer shelf life than the standard check Samrat (Table 12). These results are conformity with the findings of Sankeet *et al*. (2017).

Conclusion:

The present investigation reveals that the cross combinations combinations *viz.,* 440-10-1 x HRB-9-2, VRO-6 x HRB-9-2, TCR-1674 x HRB-9-2, VRO-6 x JPM-20-16-39 and VRO-3 x HRB-9-2 were identified as stable with desirable heterosis for fruit yield and other important traits.

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