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Estimation of heterosis for fruit yield and horticultural traits in okra (*Abelmoschus esculentus* (L.) Moench)

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Abstract
A line x tester study was conducted at Experimental Farm, Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur during Summer-Rainy season of 2018 using 12 lines and two diverse testers to measure the extent of heterosis over better parent and standard commercial check 'Palam Komal'. The overall maximum positive significant heterosis for fruit yield per plant was observed in cross Parbhani Kranti x Hisar Unnat (2.47%) over better parent and (48.37%) over standard check. Negatively heterotic crosses over standard check like P-23 x 9801 and Japan 5 Ridged x Hisar Unnat for days to 50 per cent flowering (-5.23% and -4.98%, respectively) were important for earliness in okra. Out of 24 cross-combinations, 20 crosses exhibited significant standard heterosis in any given direction for fruit yield per plant. Cross-combination Parbhani Kranti x Hisar Unnat exhibited high standard heterosis and *per se* performance for fruit yield per plant thus could be exploited commercially after further evaluation.

Keywords: Heterosis, fruit yield, horticultural traits, *Abelmoschus esculentus* (L.) Moench

Introduction
Okra (*Abelmoschus esculentus* (L.) Moench) is tropical African in origin. It is extensively grown for its tender green pods, which are consumed after cooking. Good amount of proteins, carbohydrates, vitamins (A, B and C) and minerals are present in pods (Owolarafe and Shatonde 2004; Gopalan *et al*., 2007; Arapitsas, 2008 and Dilruba *et al*., 2009) [11, 5, 1, 2] thus plays an important role in human diet (Kahlon *et al*., 2007; Saifullah and Rabbani, 2009) [7, 16]. India is the largest producer and consumer of okra in the world. Despite India being the largest producer, okra is neglected because of less number of high yielding open-pollinated varieties. It is an often-cross pollinated vegetable crop and presence of heterosis was demonstrated for the first time by Vijayaraghavan and Warrier (1946) [19]. Since then, heterosis for yield and its components was extensively studied. There have been reports of considerable heterosis for fruit yield and component traits in okra (Partap and Dhankar, 1980; Elangovan *et al*., 1981; Partap *et al.*, 1981; Mehta *et al.*, 2007; Weerasekara *et al.*, 2007; Jindal *et al.*, 2009) [13, 3, 14, 10, 20, 6]. The ease in emasculation and ample number of seeds per pod supports the exploitation of heterosis in okra. Heterosis breeding based on the identification of the parents and their cross-combinations can produce the highest level of transgressive segregants (Falconer, 1960) [4]. Hybrid vigour in sufficient amount is necessary for success of the hybrids. Therefore, the heterosis must be determined for the exploitation of valuable hybrid combinations and their commercial utilization. The selection of parents to be involved in a hybridization programme depends upon the nature and magnitude of heterobeltiosis and standard heterosis. Magnitude of heterosis helps in selecting desirable parents for development of superior F_1 hybrids and also helps in choice of suitable cross-combinations for commercial exploitation. Henceforth, present investigation was undertaken to determine the nature and magnitude of heterosis for fruit yield and horticultural traits in okra.

Materials and Methods
The experimental materials for the present investigation consisted of 12 diverse genotypes and two testers crossed following line x tester approach to develop 24 F_1 hybrids (Table 1). These 24 F_1 cross-combinations were evaluated using Complete Randomized Block Design with three replications at Experimental Farm of Department of Vegetable Science & Floriculture, CSK, Himachal Pradesh Krishi Vishwavidyalaya, Palampur, (HP) during summer-rainy season of year 2018. Hybrids were raised at a spacing of 45 cm x 15 cm. The observations were recorded on 10 randomly selected plants for the traits *viz.*, days to 50 per cent flowering,

days to first picking, first fruit producing node, nodes per plant, internodal length (cm), fruit length (cm), fruit diameter (cm), average fruit weight (g), plant height (cm), harvest duration (days), fruits per plant, fruit yield per plant (g), ridges per fruit, dry matter (%) and mucilage (%). Analysis of variance was carried out following the model of Panse and Sukhatme (1989) [12]. Heterosis was calculated over better parent (heterobeltiosis) and standard check (Palam Komal), following the method given by Kempthorne (1957) [8]. The test for significance of heterosis was accomplished by the Student's 't' test (Student, 1908) [17].

Table 1: List of lines, testers and their crosses

S. No.	Lines	S. No.	Lines
1.	P-20	9.	P-23
2.	VRO-4	10.	Japan Red
3.	Parbhani Kranti	11.	Japan 5 Ridged
4.	P-8	12.	Japan Round
5.	Tulsi-1		**Testers**
6.	SKBS-11		
7.	VRO-6	1.	9801
8.	IC-169468	2.	Hisar Unnat
Crosses			
1.	P-20 x 9801	13.	VRO-6 x 9801
2.	P-20 x Hisar Unnat	14.	VRO-6 x Hisar Unnat
3.	VRO-4 x 9801	15.	IC-169468 x 9801
4.	VRO-4 x Hisar Unnat	16.	IC-169468 x Hisar Unnat
5.	Parbhani Kranti x 9801	17.	P-23 x 9801
6.	Parbhani Kranti x Hisar Unnat	18.	P-23 x Hisar Unnat
7.	P-8 x 9801	19.	Japan Red x 9801
8.	P-8 x Hisar Unnat	20.	Japan Red x Hisar Unnat
9.	Tulsi-1 x 9801	21.	Japan 5 Ridged x 9801
10.	Tulsi-1 x Hisar Unnat	22.	Japan 5 Ridged x Hisar Unnat
11.	SKBS-11 x 9801	23.	Japan Round x 9801
12.	SKBS-11 x Hisar Unnat	24.	Japan Round x Hisar Unnat

Results and Discussion

Analysis of variance

ANOVA (Table 2) showed that mean squares due to parents were significant for all the traits under study except fruit diameter and average fruit weight while mean squares due to crosses were significant for all the studied characters except fruit diameter. Mean squares due to parents versus crosses, which are a measure of the importance of average heterosis, were found significant for all the traits except first fruit producing node, internodal length, fruit length, fruit diameter and harvest duration.

Table 2: Analysis of variance for heterosis in okra

Source of variation	Replication	Parent	Hybrid	Parent vs Hybrid	Error
Traits df	2	13	23	1	74
Days to 50 per cent flowering	0.10	139.37*	23.77*	263.86*	1.86
Days to first picking	0.59	67.89*	15.65*	194.57*	2.81
First fruit producing node	0.04	3.18*	2.57*	1.01	0.26
Nodes per plant	2.12	50.23*	16.90*	95.69*	8.51
Internodal length (cm)	0.98	16.23*	12.63*	0.09	1.62
Fruit length (cm)	0.15	3.01*	1.17*	0.00	0.50
Fruit diameter (cm)	0.03	0.19	0.06	0.41	0.14
Average fruit weight (g)	2.90	8.28	12.63*	25.80*	5.25
Plant height (cm)	23.68	7104.46*	4251.65*	10680.66*	52.09
Harvest duration (days)	0.02	19.08*	12.24*	3.98	2.88
Fruits per plant	2.85	42.39*	14.11*	100.24*	8.38
Fruit yield per plant (g)	0.07	10183.51*	6698.83*	46849.43*	15.27
Ridges per fruit	0.11	7.35*	0.58*	7.60*	0.04
Dry matter (%)	0.03	3.14*	1.51*	2.41*	0.40
Mucilage (%)	0.001	0.19*	0.40*	0.71*	0.001

*Significant at 5% level

Perusal of Table 3 revealed that heterotic performance over better parent towards earliness (days to 50 per cent flowering) was maximum negative in crosses Japan 5 Ridged x Hisar Unnat (-7.27%). For first fruit producing node, Japan Red x Hisar Unnat (-42.86%) recorded significant desirable heterobeltiosis. Maximum desirable heterosis over the better parent for plant height was recorded in cross-combination P-23 x 9801 (-10.62%). Range varied from -10.62% (P-23 x 9801) to 109.29% (Japan 5 Ridged x Hisar Unnat). The heterotic increase in the number of fruits per plant over their better parent varied from -46.88% (Japan Red x 9801) to -4.79% (Parbhani Kranti x Hisar Unnat). Highest significant heterosis over better parent for fruit yield per plant was observed in Parbhani Kranti x Hisar Unnat (2.47%) and range varied from -50.31% (Japan Red x 9801) to 2.47% (Parbhani Kranti x Hisar Unnat). For ridges per fruit, significant

heterobeltiosis was observed for Parbhani Kranti x 9801 (9.68%) followed by SKBS-11 x 9801 (6.77%). Seven hybrids recorded significant heterobeltiosis in desirable direction for mucilage, highest being VRO-6 x 9801 alongwith Japan Round x 9801 (56.00%) followed by SKBS-11 x Hisar Unnat (53.04%) and P-23 x Hisar Unnat (39.13%). The five best cross-combinations exhibiting high fruit yield were Parbhani Kranti x Hisar Unnat (326.66 g), P-8 x Hisar Unnat (318.40 g), Parbhani Kranti x 9801 (310.11 g), VRO-4 x Hisar Unnat (310.00 g) and P-8 x 9801 (301.00 g). According to Swaminathan *et al.*, (1972) [18] heterobeltiosis of more than 20% over better parent could offset the cost of hybrid seed. Thus, the crosses showing more than 20% of heterobeltiosis may be exploited for hybrid okra production.

Two cross-combinations showed significant standard heterosis for days to 50 per cent first flowering highest being P-23 x 9801 (-5.23%), followed by Japan 5 Ridged x Hisar Unnat (-4.98%). Eight cross-combinations exhibited significant economic heterosis for nodes per plant with best three combinations being Parbhani Kranti x Hisar Unnat (45.47%), VRO-6 x Hisar Unnat (45.11%) and Japan Round x Hisar Unnat (38.63%). Three cross-combinations manifested negative significant standard heterosis over standard check for internodal length, highest being Japan Round x 9801 (-35.12%) followed by Japan 5 Ridged x 9801 (-32.78%) and IC-169468 x 9801 (-26.47%). Further perusal of data revealed that three cross-combinations had standard heterosis in desirable direction for plant height and Japan Round x 9801 (-22.96%) was followed by P-23 x 9801 (-18.22%) and Japan 5 Ridged x 9801 (-14.01%). Five cross-combinations exhibited significant standard heterosis for fruits per plant where Parbhani Kranti x Hisar Unnat (42.48%) was followed by VRO-6 x Hisar Unnat (36.72%) and IC-169468 x 9801 (33.51%). Out of 24, 12 crosses displayed significant standard heterosis for fruit yield with best three combinations being Parbhani Kranti x Hisar Unnat (48.37%), P-8 x Hisar Unnat (44.62%) and Parbhani Kranti x 9801 (40.86%).

Table 3: Estimation of heterosis (%) over better parent and standard check in okra

S. No.	Hybrids	Quantitative traits								
		Days to 50 per cent flowering			Days to first picking			First fruit producing node		
		Mean	Better parent	Standard check	Mean	Better parent	Standard check	Mean	Better parent	Standard check
1.	P-20 x 9801	47.67	7.53*	1.43	50.00	-3.85	-1.96	2.90	61.11*	132.00*
2.	P-20 x Hisar Unnat	50.11	0.22	6.62*	55.00	4.43	7.84*	3.00	25.00	140.00*
3.	VRO-4 x 9801	46.33	4.51	-1.43	51.00	-1.92	0.00	1.80	12.50	44.00
4.	VRO-4 x Hisar Unnat	47.67	-0.91	1.43	51.00	-1.92	0.00	1.60	0.00	28.00
5.	Parbhani Kranti x 9801	47.00	6.02*	0.00	50.00	-3.85	-1.96	1.80	0.00	44.00
6.	Parbhani Kranti x Hisar Unnat	50.16	0.32	6.72*	52.00	-1.27	1.96	1.66	-30.83	32.80
7.	P-8 x 9801	49.67	12.05*	5.68*	54.00	3.85	5.88*	2.00	11.11	60.00
8.	P-8 x Hisar Unnat	49.00	-2.00	4.26	52.00	-1.27	1.96	2.80	12.00	124.00*
9.	Tulsi-1 x 9801	50.11	13.04*	6.62*	53.00	1.92	3.92	2.20	22.22	76.00*
10.	Tulsi-1 x Hisar Unnat	50.00	0.00	6.38*	55.00	4.43	7.84*	1.90	-5.00	52.00
11.	SKBS-11 x 9801	45.00	1.51	-4.26	51.00	-1.92	0.00	1.60	-11.11	28.00
12.	SKBS-11 x Hisar Unnat	50.47	0.94	7.38*	55.00	4.43	7.84*	2.00	-9.09	60.00
13.	VRO-6 x 9801	46.66	5.26*	-0.72	50.00	-3.85	-1.96	2.00	11.11	60.00
14.	VRO-6 x Hisar Unnat	49.33	-1.34	4.96*	52.00	-1.27	1.96	2.20	10.00	76.00*
15.	IC-169468 x 9801	45.33	2.26	-3.55	51.00	4.08	0.00	1.25	-30.56	0.00
16.	IC-169468 x Hisar Unnat	47.51	7.17*	1.09	51.00	4.08	0.00	1.45	-34.09	16.00
17.	P-23 x 9801	44.54	0.47	-5.23*	50.00	-3.85	-1.96	2.00	11.11	60.00
18.	P-23 x Hisar Unnat	48.00	4.10	2.13	51.00	-1.92	0.00	2.40	0.00	92.00*
19.	Japan Red x 9801	54.11	22.06*	15.13*	56.00	7.69*	9.80*	3.00	66.67*	140.00*
20.	Japan Red x Hisar Unnat	56.33	12.66*	19.85*	59.00	12.03*	15.69*	1.60	-42.86*	28.00
21.	Japan 5 Ridged x 9801	47.33	6.77*	0.70	53.00	1.92	3.92	2.20	37.50	76.00*
22.	Japan 5 Ridged x Hisar Unnat	44.66	-7.27*	-4.98*	52.00	-1.27	1.96	1.75	9.37	40.00
23.	Japan Round x 9801	46.67	5.28*	-0.70	51.00	-1.92	0.00	3.20	77.78*	156.00*
24.	Japan Round x Hisar Unnat	50.13	0.25	6.65*	54.00	2.53	5.88*	5.80	123.08*	364.00*
	SE(d)		1.11	1.11		1.37	1.37		0.42	0.42

*Significant at 5% level

S. No.	Hybrids	Quantitative traits								
		Nodes per plant			Internodal length			Fruit length		
		Mean	Better parent	Standard check	Mean	Better parent	Standard check	Mean	Better parent	Standard check
1.	P-20 x 9801	20.20	-21.09*	18.96	7.99	32.56	-22.02*	12.40	-10.01*	-12.06*
2.	P-20 x Hisar Unnat	22.40	-17.04	31.92*	9.06	2.57	-11.64	13.10	1.87	-7.09
3.	VRO-4 x 9801	19.00	-25.78*	11.90	8.48	40.68*	-17.24	14.20	-1.11	0.71
4.	VRO-4 x Hisar Unnat	22.40	-17.04	31.92*	11.38	29.02*	11.02	13.10	-8.77*	-7.09
5.	Parbhani Kranti x 9801	20.11	-21.45*	18.43	9.96	65.17*	-2.83	14.82	-0.40	5.11
6.	Parbhani Kranti x Hisar Unnat	24.70	-8.52	45.47*	10.18	-8.07	-0.68	13.52	-9.14*	-4.11
7.	P-8 x 9801	19.75	-22.85*	16.31	8.45	40.08*	-17.59	13.24	-3.92	-6.10
8.	P-8 x Hisar Unnat	22.40	-17.04	31.92*	9.55	-13.73	-6.80	13.01	2.04	-7.73
9.	Tulsi-1 x 9801	20.10	-21.48*	18.37	7.98	32.34	-22.15*	12.99	-5.73	-7.87

10.	Tulsi-1 x Hisar Unnat	23.50	-12.96	38.40*	9.07	-15.73	-11.48	12.45	2.05	-11.70*
11.	SKBS-11 x 9801	18.60	-27.34*	9.54	12.91	114.10*	25.95*	14.07	-4.42	-0.21
12.	SKBS-11 x Hisar Unnat	19.20	-28.89*	13.07	13.83	24.92*	34.96*	13.17	-10.53*	-6.60
13.	VRO-6 x 9801	22.00	-14.06	29.56*	8.05	33.55	-21.43*	13.66	-0.87	-3.12
14.	VRO-6 x Hisar Unnat	24.64	-8.74	45.11*	8.22	-8.36	-19.80	13.05	-0.08	-7.45
15.	IC-169468 x 9801	21.40	-16.41	26.03	7.54	24.99	-26.47*	13.74	-0.29	-2.55
16.	IC-169468 x Hisar Unnat	19.00	-29.63*	11.90	11.96	66.27*	16.68	12.97	-4.21	-8.01*
17.	P-23 x 9801	15.80	-38.28*	-6.95	8.75	45.11*	-14.63	13.34	-3.19	-5.39
18.	P-23 x Hisar Unnat	19.80	-26.67*	16.61	9.82	0.61	-4.23	12.21	0.08	-13.40*
19.	Japan Red x 9801	16.00	-37.50*	-5.77	11.83	96.13*	15.38	13.96	-0.43	-0.99
20.	Japan Red x Hisar Unnat	17.80	-34.07*	4.83	13.25	29.22*	29.30*	13.08	-6.70	-7.23
21.	Japan 5 Ridged x 9801	21.15	-17.38	24.56	6.89	14.26	-32.78*	12.60	-8.56*	-10.64*
22.	Japan 5 Ridged x Hisar Unnat	19.75	-26.85*	16.31	12.21	62.34*	19.15	12.41	1.72	-11.99*
23.	Japan Round x 9801	19.60	-23.44*	15.43	6.65	10.28	-35.12*	13.26	-3.77	-5.96
24.	Japan Round x Hisar Unnat	23.54	-12.81	38.63*	9.13	28.70*	-10.89	12.97	1.17	-8.01*
	SE(d)		2.38	2.38		1.04	1.04		0.57	0.57

*Significant at 5% level

S. No.	Hybrids	Quantitative traits								
		Fruit diameter			Average fruit weight			Plant height		
		Mean	Better parent	Standard check	Mean	Better parent	Standard check	Mean	Better parent	Standard check
1.	P-20 x 9801	1.59	22.31	7.43	13.80	-2.17	-10.23	161.20	11.63*	-4.47
2.	P-20 x Hisar Unnat	1.84	41.54	24.32	12.29	-13.67	-20.05	200.16	38.61*	18.61*
3.	VRO-4 x 9801	1.71	4.91	15.54	12.60	-10.73	-18.08	159.42	13.87*	-5.53
4.	VRO-4 x Hisar Unnat	1.82	4.00	22.97	16.13	13.27	4.90	241.60	72.57*	43.17*
5.	Parbhani Kranti x 9801	1.88	15.34	27.03	18.30	17.51	18.99	197.10	27.66*	16.80*
6.	Parbhani Kranti x Hisar Unnat	1.98	4.76	33.78	15.39	-1.13	0.11	251.00	37.76*	48.74*
7.	P-8 x 9801	1.68	3.07	13.51	17.12	21.36	11.36	166.51	7.84*	-1.33
8.	P-8 x Hisar Unnat	1.96	14.62	32.43	17.05	19.71	10.86	210.40	19.55*	24.68*
9.	Tulsi-1 x 9801	1.70	4.29	14.86	16.17	14.60	5.16	158.10	8.88*	-6.31
10.	Tulsi-1 x Hisar Unnat	2.01	19.64	35.81	11.24	-21.09	-26.92*	209.95	44.59*	24.41*
11.	SKBS-11 x 9801	1.70	4.29	14.86	17.13	21.38	11.38	237.00	53.50*	40.44*
12.	SKBS-11 x Hisar Unnat	1.92	10.34	29.73	14.04	-1.43	-8.71	262.40	69.95*	55.50*
13.	VRO-6 x 9801	1.61	1.90	8.78	12.68	-10.16	-17.56	175.50	13.67*	4.00
14.	VRO-6 x Hisar Unnat	1.92	21.52	29.73	12.34	-13.37	-19.77	201.15	26.03*	19.20*
15.	IC-169468 x 9801	1.76	7.98	18.92	14.23	0.83	-7.48	160.10	4.10	-5.13
16.	IC-169468 x Hisar Unnat	1.85	3.93	25.00	15.42	8.26	0.26	220.00	43.04*	30.37*
17.	P-23 x 9801	1.56	-4.29	5.41	14.31	1.39	-6.96	138.00	-10.62*	-18.22*
18.	P-23 x Hisar Unnat	1.83	10.91	23.65	10.95	-23.08	-28.77*	193.79	-4.16	14.84*
19.	Japan Red x 9801	1.71	54.05*	15.54	13.69	-3.00	-10.99	185.80	20.34*	10.10*
20.	Japan Red x Hisar Unnat	2.02	81.98*	36.49	13.25	-6.95	-13.83	232.00	16.23*	37.48*
21.	Japan 5 Ridged x 9801	1.77	8.59	19.59	12.00	-26.13*	-21.94	145.10	27.73*	-14.01*
22.	Japan 5 Ridged x Hisar Unnat	2.04	4.62	37.84	12.03	-25.97*	-21.76	237.75	109.29*	40.89*
23.	Japan Round x 9801	1.78	9.20	20.27	13.13	-6.97	-14.63	130.00	-7.01	-22.96*
24.	Japan Round x Hisar Unnat	1.96	7.69	32.43	13.10	-8.01	-14.81	215.10	53.86*	27.47*
	SE(d)		0.30	0.30		1.87	1.87		5.89	5.89

*Significant at 5% level

S. No.	Hybrids	Quantitative traits								
		Harvest duration			Fruits per plant			Fruit yield per plant		
		Mean	Better parent	Standard check	Mean	Better parent	Standard check	Mean	Better parent	Standard check
1.	P-20 x 9801	51.33	-11.65*	-9.55*	16.34	-28.85*	9.08	225.21	-31.00*	2.29
2.	P-20 x Hisar Unnat	53.00	-8.49*	-6.61*	18.39	-17.96	22.76	220.40	-30.87*	0.11
3.	VRO-4 x 9801	52.73	-9.24*	-7.08*	16.20	-29.48*	8.12	200.25	-38.65*	-9.04*
4.	VRO-4 x Hisar Unnat	56.11	-3.12	-1.13	19.80	-11.67	32.18*	310.00	-2.76*	40.81*
5.	Parbhani Kranti x 9801	54.00	-7.06*	-4.85*	17.23	-24.96*	15.04	310.11	-4.99*	40.86*
6.	Parbhani Kranti x Hisar Unnat	56.85	-1.85	0.18	21.34	-4.79	42.48*	326.66	2.47*	48.37*
7.	P-8 x 9801	57.22	-1.51	0.83	17.61	-23.34*	17.53	301.00	-7.78*	36.72*
8.	P-8 x Hisar Unnat	56.75	-2.02	0.00	19.21	-14.29	28.26	318.40	-0.13	44.62*
9.	Tulsi-1 x 9801	55.77	-4.02	-1.73	17.83	-22.35*	19.05	280.12	-14.18*	27.23*
10.	Tulsi-1 x Hisar Unnat	56.33	-2.75	-0.74	19.81	-11.63	32.24*	220.10	-30.96*	-0.03
11.	SKBS-11 x 9801	56.15	-3.36	-1.06	16.51	-28.13*	10.19	276.60	-15.26*	25.64*
12.	SKBS-11 x Hisar Unnat	55.86	-3.56	-1.57	17.18	-23.36*	14.69	235.40	-26.16*	6.92*
13.	VRO-6 x 9801	50.00	-13.94*	-11.89*	19.26	-16.14	28.57	240.42	-26.34*	9.20*

14.	VRO-6 x Hisar Unnat	56.50	-2.45	-0.44	20.48	-8.64	36.72*	250.22	-21.51*	13.65*
15.	IC-169468 x 9801	57.05	-1.81	0.53	20.00	-12.92	33.51*	280.12	-14.18*	27.23*
16.	IC-169468 x Hisar Unnat	57.95	0.05	2.11	17.50	-21.93*	16.82	254.95	-20.03*	15.80*
17.	P-23 x 9801	57.00	-1.89	0.44	13.00	-43.40*	-13.22	185.40	-43.20*	-15.79*
18.	P-23 x Hisar Unnat	56.15	-3.06	-1.06	17.20	-23.27*	14.82	186.80	-41.41*	-15.15*
19.	Japan Red x 9801	53.55	-7.83*	-5.64*	12.20	-46.88*	-18.56	162.20	-50.31*	-26.33*
20.	Japan Red x Hisar Unnat	55.00	-5.04*	-3.08	15.60	-30.41*	4.14	201.00	-36.95*	-8.70*
21.	Japan 5 Ridged x 9801	56.20	-3.27	-0.97	18.21	-20.71	21.56	215.12	-34.09*	-2.29
22.	Japan 5 Ridged x Hisar Unnat	55.95	-3.40	-1.41	17.75	-20.82	18.49	209.00	-34.44*	-5.07*
23.	Japan Round x 9801	57.72	-0.65	1.71	16.00	-30.33*	6.81	208.20	-36.21*	-5.43*
24.	Japan Round x Hisar Unnat	56.01	-3.30	-1.30	16.20	-27.73*	8.14	210.12	-34.09*	-4.56*
	SE(d)		1.38	1.38		2.36	2.36		3.19	3.19

*Significant at 5% level

S. No.	Hybrids	Quality traits								
		Ridges per fruit			Dry matter			Mucilage		
		Mean	Better parent	Standard check	Mean	Better parent	Standard check	Mean	Better parent	Standard check
1.	P-20 x 9801	5.17	0.00	-10.92*	6.11	-8.12	0.99	0.98	-2.00	6.52
2.	P-20 x Hisar Unnat	5.80	5.45	0.00	6.07	-8.72	0.33	1.01	-12.17*	9.78*
3.	VRO-4 x 9801	5.47	5.81	-5.75*	6.75	-1.89	11.57	0.94	-6.00	2.17
4.	VRO-4 x Hisar Unnat	5.17	-6.06*	-10.92*	6.10	-11.34	0.83	1.28	11.30*	39.13*
5.	Parbhani Kranti x 9801	5.67	9.68*	-2.30	6.25	-4.43	3.31	0.98	-2.00	6.52
6.	Parbhani Kranti x Hisar Unnat	5.10	-7.27*	-12.07*	5.41	-7.04	-10.58	0.56	-51.30*	-39.13*
7.	P-8 x 9801	5.37	3.87	-7.47*	6.21	-5.05	2.64	1.44	33.33*	56.52*
8.	P-8 x Hisar Unnat	5.10	-7.27*	-12.07*	5.71	-5.46	-5.62	1.04	-9.57*	13.04*
9.	Tulsi-1 x 9801	5.22	0.97	-10.06*	6.83	-9.30	12.89	1.09	-2.68	18.48*
10.	Tulsi-1 x Hisar Unnat	5.07	-7.88*	-12.64*	6.59	-12.48	8.93	1.14	-0.87	23.91*
11.	SKBS-11 x 9801	5.52	6.77*	-4.89	6.65	-0.45	9.92	0.72	-28.00*	-21.74*
12.	SKBS-11 x Hisar Unnat	5.23	-4.85	-9.77*	6.52	-2.40	7.77	1.76	53.04*	91.30*
13.	VRO-6 x 9801	5.17	0.00	-10.92*	7.11	-9.54	17.52*	1.56	56.00*	69.57*
14.	VRO-6 x Hisar Unnat	5.38	-2.12	-7.18*	7.12	-9.41	17.69*	1.42	23.48*	54.35*
15.	IC-169468 x 9801	5.25	1.61	-9.48*	7.18	-7.12	18.68*	1.20	-11.76*	30.43*
16.	IC-169468 x Hisar Unnat	5.20	-5.45	-10.34*	7.01	-9.31	15.87	1.32	-2.94	43.48*
17.	P-23 x 9801	5.07	-1.94	-12.64*	6.44	-1.83	6.45	0.68	-32.00*	-26.09*
18.	P-23 x Hisar Unnat	5.25	-4.55	-9.48*	5.98	-8.84	-1.16	1.60	39.13*	73.91*
19.	Japan Red x 9801	7.00	-7.89*	20.69*	7.10	-8.97	17.36*	0.40	-64.29*	-56.52*
20.	Japan Red x Hisar Unnat	6.33	-16.67*	9.20*	7.30	-6.41	20.66*	0.96	-16.52*	4.35
21.	Japan 5 Ridged x 9801	5.20	0.65	-10.34*	7.76	-8.35	28.26*	0.95	-5.00	3.26
22.	Japan 5 Ridged x Hisar Unnat	5.53	0.61	-4.60	7.65	-9.65	26.45*	0.44	-61.74*	-52.17*
23.	Japan Round x 9801	5.40	4.52	-6.90*	8.10	-8.37	33.88*	1.56	56.00*	69.57*
24.	Japan Round x Hisar Unnat	5.40	-1.82	-6.90*	7.98	-9.73	31.90*	0.91	-20.87*	-1.09
	SE(d)		0.16	0.16		0.51	0.51		0.03	0.03

*Significant at 5% level

For ridges per fruit, two cross-combinations *viz.*, Japan Red x 9801 (20.69%) and Japan Red x Hisar Unnat (9.20%) recorded significant standard heterosis. In case of dry matter, nine hybrids exhibited significant desirable heterosis, highest being Japan Round x 9801 (33.88%) followed by Japan Round x Hisar Unnat (31.90%) and Japan 5 Ridged x 9801 (28.26%). 13 hybrids out of 24 showed significant standard heterosis for mucilage where top three combinations were SKBS-11 x Hisar Unnat (91.30%), P-23 x Hisar Unnat (73.91%) and VRO-6 x 9801; Japan Round x 9801 (69.57%).

High fruit yield is the primary objective of all the crop improvement programmes and is of significance to the farmers from economic point of view. Unless a new hybrid has a potential equal to or exceeding that of current cultivars, it will be unsuccessful even if it has excellent quality and resistance to diseases. Cross Parbhani Kranti x Hisar Unnat revealed hybrid vigour for fruit yield per plant over better parent while 12 cross-combinations *viz.*, Parbhani Kranti x Hisar Unnat, P-8 x Hisar Unnat, Parbhani Kranti x 9801, VRO-4 x Hisar Unnat, P-8 x 9801, Tulsi-1 x 9801, IC-169468 x 9801, SKBS-11 x 9801, IC-169468 x Hisar Unnat, VRO-6 x Hisar Unnat, VRO-6 x 9801 and SKBS-11 x Hisar Unnat showed hybrid vigour over standard check (Palam Komal). Hybrid vigour for fruit yield per plant have also been reported by Patel *et al.*, (2015) [15] and Makdoomi *et al.*, (2018) [9].

Conclusion

Yield components are important and must be considered to increase the yield through selections. In the present study, heterosis was observed for most of the characters including fruit yield, fruits per plant, nodes per plant, lesser internodal length and shorter plant height. Cross-combination P-23 x 9801 exhibiting high negative heterosis over standard check for days to 50 per cent flowering (-5.23%) and cross Japan Red x Hisar Unnat displaying high negative heterosis over better parent for first fruit producing node (-42.86%) are, therefore, important to exploit heterosis for earliness in okra. For fruit yield per plant, cross-combinations Parbhani Kranti x Hisar Unnat (48.37%), P-8 x Hisar Unnat (44.62%) and Parbhani Kranti x 9801 (40.86%) displayed significant

heterosis over standard check (Palam Komal), thus could be exploited for commercial cultivation after further evaluation.

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