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GENETIC EXPRESSION OF HETEROSIS FOR FRUIT YIELD AND YIELD COMPONENTS IN INTRASPECIFIC HYBRIDS OF OKRA (*Abelmoschus esculentus* (L.) Moench)

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SUMMARY

Heterosis breeding is a potential method to achieve improvement in production and productivity of okra that otherwise cannot be achieved through existing traditional methods. A study of heterosis in 28 okra hybrids developed through 8 × 8 half diallel mating fashion involving the inbred lines 'P-20', '9801', 'VRO-4', 'Parbhani Kranti', 'P-8', 'Hisar Unnat', 'Tulsi-I' and 'SKBS-11' was carried out at the Vegetable Experimental Farm of CSK Himachal Pradesh Agricultural University, Palampur, Himachal Pradesh, India, during the summer-rainy season of 2012 and 2013 (May to September). Heterosis over standard check was observed for the quantitative traits *viz*., days to flowering, days to first picking, first fruit producing node, nodes per plant, internodal length (cm), fruit length (cm), average fruit weight (g), plant height (cm), harvest duration (days), fruits per plant and fruit yield per plant (g). Among the traits, fruits per plant and fruit yield per plant exhibited maximum heterosis over the standard check "Hybrid Tulsi". Heterosis for yield was generally accompanied by heterosis of yield components. On the basis of heterosis and mean performance, "VRO-4 × Hisar Unnat" was the best cross-combination followed by "Tusli-I × SKBS-11", "P-20 × Tusli-I", "VRO-4 × Parbhani Kranti" and "P-8 × Tulsi-I" for fruit yield per plant. These crosses also had high heterosis for most of the component traits. These hybrids offer high scope for the exploitation of heterosis. These cross-combinations can also be released as hybrids after further field testing.

Key words: *Abelmoschus esculentus*, diallel cross, heterosis, fruit yield

Key findings: Hybridization has been the most successful approach in increasing the productivity in vegetable crops. Heterosis breeding based on the identification of the parents and their cross combinations is capable of producing hybrids and transgressive segregates. This study was, therefore, undertaken to elicit information about the nature and magnitude of heterosis for yield and its components in okra so as to formulate suitable breeding strategy and isolate potential parents and promising crosses for further exploitation.

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INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) also called as lady's finger or bhindi is a traditional vegetable crop commercially cultivated in West Africa, South and Southeast Asia, the southern United States, Brazil, Turkey and northern Australia. It is also a popular home garden vegetable in many areas. In India, it is one of the most important fruit vegetables for home consumption and also has great potential as an earner of foreign exchange. Okra accounts for 60% of the value of exported fresh vegetables, excluding the root vegetables, potato, onion and garlic, the destinations being the Middle East, Western Europe and the USA. It is grown for its immature, tender and delicious fruits which are used in a variety of ways as cooked vegetable, boiled or fried, soups, stews in meat, frozen, canned and dehydrated products. The roots and stem of okra are used as clarifier for cane juice from which brown sugar or *gur* is prepared (Chauhan, 1972) and is also used in paper industry. Its ripe seeds are roasted, ground and used as substitute for coffee in Turkey (Mehta, 1959). Nutritionally, okra green fruits are rich in vitamins (C, A and B) and minerals (Ca, P, Mg and Fe). Okra is said to be very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery (Nadkarni, 1927). Okra is a largely self-pollinated annual plant (Fryxell, 1957) with a high chromosome number of 2n = 120-132, which appears to have originated in Abyssinia (Darlington and Wylie, 1955). The popular Indian cultivars have 130 somatic chromosomes. As such there is a necessity to improve the yield per unit area to achieve the increased production from a limited land. In okra, yield levels have been improved substantially through intensive and concerted breeding efforts and further yield advances seem to be more difficult necessitating the application of newer breeding approaches. The required goal of increasing productivity in the quickest possible time can be achieved only through heterosis breeding.

The phenomenon of heterosis has been a powerful force in the evolution of crop plants and has been exploited extensively in crop production (Birchler *et al*., 2003). Heterosis for increased fruit size, fruit weight and fruits per plant in okra was first reported by Vijayaraghvan and Warriar (1946). Heterosis is expressed as relative heterosis, heterobeltiosis and standard heterosis, depending on the criteria used to compare the performance of a hybrid. However, from the practical point of view, standard heterosis is the most important of the 3 types of heterosis because it is aimed at developing desirable hybrids superior to the existing high yielding commercial varieties (Chaudhary, 1984). There has been considerable improvement in the yield of tropical okra by pedigree selection and more recently, by the development of commercial hybrids in India and Japan, based on hand emasculation and pollination. This paper reports the magnitude of heterosis for yield and its components in F_1 hybrids among selected breeding lines and cultivars in a cooler, sub temperate, sub-mountainous region and examines the underlying genetic effects by diallel analysis in order to guide the formulation of efficient breeding programs. Similar analysis has been done in okra by Sood and Sharma (2001) for different sets of genotypes in their respective studies.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Farm of Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Agricultural University, Palampur, Himachal Pradesh, India, during May to September (summer and rainy season) in 2012 and 2013. The field is located at 32° 6' N latitude, 76° 3' E longitude and 1290.8 m altitude. The location is characterized by humid, sub-temperate climate with an annual rainfall of 2500 mm of which 80% is received during June to September, having severe winters and mild summers and represents the mid-hill zone of Himachal Pradesh.

Plant material

Eight diverse inbred lines, P-20, 9801, VRO-4, Parbhani Kranti, P-8, Hisar Unnat, Tulsi-I and SKBS-11 were obtained from different parts of India. The details of these inbred lines are described in Table 1. They were maintained by selfing to get selfed seeds of the parents and crossed in a diallel design without reciprocals during summer of 2012. During summer of 2013, the 8 parents, 28 F_1's along with standard check "Hybrid Tulsi" were grown in a randomized block design with 3 replications at the Experimental Farm of Department of Vegetable Science and Floriculture, Palampur, Himachal Pradesh.

Field activities and data collection

The soil of experiment was silty clay loam and acidic (pH = 5.7). The field was ploughed and levelled properly. Raised beds were formed to facilitate drainage during the rainy season. Each entry/progeny was accommodated in 3 rows spaced 45 cm apart with an intra-row spacing of 15 cm. About 10 Mt ha^{-1} of Farm Yard manure and chemical fertilizers @ 100 kg N, 50 kg P_2O_5 and 50 kg K_2O /ha were applied. Half dose of N and full doses of P_2O_5 and K_2O were applied at the time of field preparation and the remaining half dose of N was top dressed in 2 equal amounts, first at earthing up and second after one month of first earthing up. All the recommended cultural and management practices were followed to raise a good crop.

The measurements were made on 10 competitive plants chosen at random in each entry and replication for the parameters *viz*., days to flowering, days to first picking, first fruit producing node, nodes per plant, internodal length (cm), average fruit weight (g), plant height (cm), harvest duration (days), fruits per plant and fruit yield per plant (g). For the parameters *viz*., fruit length (cm) and fruit diameter (cm), a random sample of 10 fruits/entry/replication was drawn from fourth and eighth pickings.

Statistical Analysis

SPAR I (developed by the Indian Agricultural Statistics Research Institute, New Delhi, India) software was used for statistical analysis. Data were subjected to analysis of variance (Panse and Sukhatme, 1984). Heterosis was computed by using computer software program Windowstat 8.0 (developed by Indostat Services 18, Ameerpet, Hyderabad, India).

Estimation of heterosis

The estimates of heterosis were calculated as deviation of F_1 mean from the mean values of standard check (SC) "Hybrid Tulsi" following the method of Turner (1953) and Hayes *et al.,* (1956) and expressed in percentage as:

$$SC\ \% = \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$$

The standard error for testing heterosis over standard check was calculated as:

SE for testing heterosis over SC = $\pm\sqrt{2Me/r}$ = SE (H)

The heterosis over standard check was calculated as:

$$\text{Heterosis over SC} = \frac{\overline{F_1}-\overline{SC}}{SE(H)} \times 100 = \text{'t' calculated value}$$

If the 't' calculated value for heterosis over standard check (SC) was greater than 't' tabulated values for error degree of freedom at P = 0.05 then only the results were significant.

Where SC = Standard Check; Me = Error mean sum of square; r = Number of replications, and SE(H) = Standard error (Hybrids).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among treatments for all the traits indicating the presence of appreciable genetic diversity among the parents and cross-combinations. Mean performance indicated that some of the parents used had high values or were similar to the standard check cultivar 'Hybrid Tulsi' for fruit yield and related traits (Table 2). Responses of the parents, P-20, VRO-4, Hisar Unnat and Tulsi- I were promising. Earliness is an economic character as it gives earlier yield and widens the flowering and fruiting span of the plants which results in higher fruit yield.

Table 1. Sources and characteristics of okra parents used in present investigation.

S. No.	Parents	Characteristics	Source
1.	P-20	Short internodes, fruit dark green, smooth, 5-ridged and remains tender for longer period, resistant to YVMV disease	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, HP, India
2.	9801	Plant dwarf, short internodes, fruit dark green, 5-ridged, resistant to YVMV disease	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, HP, India
3.	VRO-4	Plant dwarf, short internodes, fruit green, 5-ridged, resistant to YVMV disease	Indian Institute of Vegetable Research, Varanasi, UP, India
4.	Parbhani Kranti (PK)	Plants tall, leaves deeply lobed, fruit dark green, smooth, 5-ridged, resistant to YVMV disease	Marathwada Agricultural University, Parbhani, Maharashtra, India
5.	P-8	Plants tall, fruits medium-long, thin, green, 5-ridged, resistant to YVMV disease and tolerant to fruit borer	Punjab Agricultural University, Ludhiana, Punjab, India
6.	Hisar Unnat (HU)	Plants medium-tall, short internodes, fruit green, 5-ridged, foliage green, resistant to YVMV disease	CCS Haryana Agricultural University, Hisar, Haryana, India
7.	Tulsi-I	Plant tall, fruit green, 5-ridged, resistant to YVMV disease	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, HP, India
8.	SKBS-11	Plant tall, fruit green, 5-ridged, resistant to YVMV disease	SK University of Agricultural Sciences & Technology, Srinagar, J&K, India

Table 2. Mean performance of parents relative to standard check Hybrid Tulsi for quantitative traits in okra.

Parents and standard check	Days to 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)
P-20	52	55	1.7	16.4	9.2	13.8	1.5	17.0	150.2	57	12.5	213.6
9801	53	56	1.4	15.0	8.6	14.0	1.7	16.8	130.0	55	12.9	217.7
VRO-4	51	55	1.3	14.2	8.5	13.3	1.8	16.5	120.3	57	11.7	192.7
PK	55	57	1.6	13.7	9.9	14.1	1.8	16.0	134.9	54	11.0	175.0
P-8	53	55	1.5	14.4	9.8	14.2	2.0	16.3	141.1	58	11.2	182.1
HU	54	59	1.7	12.7	10.9	13.1	1.9	18.2	138.9	54	11.7	212.5
Tulsi- I	56	60	2.4	14.7	11.0	14.3	1.6	15.3	159.7	53	9.2	140.8
SKBS-11	54	58	2.3	13.7	11.8	13.5	1.8	17.8	162.6	55	11.2	198.3
Hybrid Tulsi	53	55	1.7	12.9	9.6	13.9	1.5	16.4	123.1	55	11.9	192.8
CD (5%)	2.6	3.2	0.4	1.6	0.9	0.9	0.2	1.7	22.1	5.1	1.8	37.5

Table 3. Heterosis (%) over standard check "Hybrid Tulsi" for quantitative traits in okra.

Cross	Days to 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)
P-20 × 9801	-3.8	-0.6	-16.0	5.4	5.7	1.4	9.4	2.4	11.5	3.7	-1.7	1.6
P-20 × VRO-4	-8.2*	-7.9*	-20.0	6.5	-8.3	1.6	10.7*	2.0	-1.8	11.8*	15.5*	18.6
P-20 × PK	-6.9*	-2.6	-24.0	8.6	-4.4	-5.4	10.7*	0.0	3.7	6.8	17.4*	18.4
P-20 × P-8	1.9	2.7	-26.0*	6.0	3.3	9.5*	9.4	1.4	9.4	1.9	6.2	9.4
P-20 × HU	-5.7*	-2.9	12.0	8.0	-2.5	-4.5	7.4	5.7	5.3	4.7	5.1	11.4
P-20 × Tulsi-I	0.6	4.2	-4.0	14.5*	10.8*	6.6	8.1	6.5	26.8*	-2.5	23.9*	32.8*
P-20 × SKBS-11	3.1	2.6	-18.0	5.2	-6.8	-3.4	-0.6	5.3	-2.0	0.4	-2.3	3.5
9801 × VRO-4	3.1	4.7	0.0	4.4	-9.8	6.1	18.0*	8.6	-5.8	-1.8	4.5	14.3
9801 × PK	-3.8	-3.2	- 20.0	1.3	-10.4*	5.0	18.7*	7.7	-9.3	1.4	9.6	19.2
9801 × P-8	1.3	1.1	-28.0*	5.2	-3.8	-2.4	8.7	3.9	1.0	-1.2	13.8	19.2
9801 × HU	3.8	3.2	-8.0	-15.8*	-4.8	0.6	12.7*	6.3	-19.7*	-6.8	-9.0	-3.0
9801 × Tulsi-I	0.0	0.1	8.0	2.1	-10.0*	5.1	16.7*	3.9	-8.0	2.9	8.4	13.4
9801 × SKBS-11	0.6	0.7	4.0	2.3	6.4	7.7*	21.3*	10.2	8.9	3.5	10.7	22.7*
VRO-4 × PK	1.9	2.9	-18.0	3.4	-13.6*	4.6	20.0*	7.7	-10.6	1.3	11.8	21.5*
VRO-4 × P-8	-1.9	-0.8	-24.0	-1.8	-20.0*	2.3	16.7*	3.5	-21.4*	5.0	6.2	10.8
VRO-4 × HU	-5.0*	-5.0	-8.0	20.0*	3.0	-0.2	16.7*	7.7	23.8*	9.2*	29.8*	40.5*
VRO-4 × Tulsi-I	0.0	1.2	-8.0	1.6	-2.6	4.7	15.4*	3.9	-1.1	-1.2	7.0	12.4
VRO-4 × SKBS-11	-5.0*	-3.2	4.0	-1.8	-3.7	5.3	16.7*	11.4*	-6.1	3.2	6.2	19.1
PK × P-8	0.6	3.4	4.0	11.7	14.5*	2.2	8.1	3.5	28.1*	0.8	10.7	15.6
PK × HU	-1.3	0.4	-18.0	2.9	6.5	3.5	12.1*	3.1	9.1	-2.6	11.2	15.6
PK × Tulsi-I	1.9	6.3*	8.0	6.5	21.3*	6.8*	9.4	-1.8	29.5*	-1.9	15.5*	14.2
PK × SKBS-11	3.1	4.9	-14.0	8.0	17.4*	-2.7	9.4	2.2	27.0*	-6.6	17.1*	20.8*
P-8 × HU	1.9	3.7	-16.0	2.9	-9.3	1.7	7.4	5.7	-5.8	-2.9	11.2	18.5
P-8 × Tulsi-I	0.6	1.1	-2.0	3.6	-5.9	3.9	0.1	7.1	-2.5	-1.2	12.1	20.8*
P-8 × SKBS-11	-2.5	-2.3	-8.0	-9.6	25.3*	-3.2	3.4	2.9	13.3	2.3	-2.3	1.5
HU × Tulsi-I	4.4	7.8*	4.0	5.2	24.8*	-2.5	21.3*	20.2*	31.3*	-7.8	-6.5	13.2
HU × SKBS-11	5.0*	4.2	16.0	-8.8	6.4	-5.2	16.7*	12.8*	-2.9	-1.3	-3.1	10.1
Tulsi-I × SKBS-11	3.8	5.0	36.0*	24.0*	13.9*	0.3	8.7	15.5*	41.3*	-7.0	14.6	33.2*
SE(d)	1.3	1.6	0.2	0.8	0.5	0.5	0.1	0.8	11.2	2.5	0.9	18.9

*Significant at 5% level.

Out of 28 crosses, significant negative heterosis for days to flowering and days to first picking over standard check was displayed by 5 F_1 hybrids *viz*., P-20 × VRO-4, P-20 × PK, P-20 × HU, VRO-4 × HU and 1 F_1 hybrid *viz*., P-20 × VRO-4, respectively (Table 3). For days to first picking, the number of hybrids revealing heterosis over standard check were less as compared to days to flowering. This implies that there exist genotypic differences in the plant processes after flowering till fruit maturity. Variable magnitude of both flowering and early maturity have also been reported by Borgaonkar *et al.,* (2005) and Singh and Syamal (2006). For first fruit producing node, only 2 cross-combinations *viz*., P-20 × P-8 and 9801 × P-8 expressed desirable negative heterosis over standard check. The number of nodes per plant is a direct component for the production of fruits, which ultimately leads to higher fruit yield in okra. Three of the hybrids (P-20 × Tulsi-I, VRO-4 × HU and Tulsi-I × SKBS-11) revealed hybrid vigor over standard check for nodes per plant. This crop bears pod at each node and the shorter the distance between the node, more will be the nodes per plant and ultimately higher the production, hence, for this trait the interest of breeder lies in search of combinations having negative heterosis. For internodal length, only 4 crosses *viz*., VRO-4 × P-8, VRO-4 × PK, 9801 × PK and 9801 × Tulsi-I could reveal economic heterosis.

Fruit length is one of the most important traits which contribute towards yield and heterosis in positive direction is desirable for this trait. Significant positive heterosis for fruit length shown by P-20 × P-8, 9801 × SKBS-11 and PK × Tulsi-I over standard check . Yadav *et al.* (2007), Bassey *et al.* (2012) and Adiger *et al.* (2013) also reported positive heterosis for fruit length in their respective studies. The consumer prefers slender fruits with lower fruit girth. None of the cross-combination was superior over standard check for fruit diameter. Average fruit weight is also one of the most important component trait which contributes for yield. Heterosis over standard check for this trait was recorded in 4 of the cross-combinations with the range of heterosis from -1.8 to 20.2%. Increased plant height is a desirable trait to realize higher yield provided the environmental conditions are otherwise conducive for growth and fruiting over a longer period. Seven hybrids expressed significant positive heterosis over standard check. This may be due to the hybrids developed through crossing between dwarf and tall parents. These findings are in consonance with Akhtar *et al.* (2010) and Adiger *et al.* (2013) who have also reported positive heterosis for average fruit weight and plant height. Increase in harvest duration contributes towards highest marketable yield in okra. It is desirable to take advantage of off-season marketing for a longer period. For this trait, only 2 hybrids were found superior over standard check.

High fruit yield is the basic objective of all the crop improvement programs and is of relevance to the farmers from economic view point. Unless a new hybrid has a potential equal to or exceeding that of current cultivars, it will fetch no success even if it has excellent quality and resistance to diseases. Heterosis for fruit yield per plant ranged from -3.0 (9801 × HU) to 40.5% (VRO-4 × HU) over standard check. The maximum heterosis for fruit yield per plant was noticed in VRO-4 × HU followed by Tulsi-I × SKBS-11, P-20 × Tulsi-I, 9801 × SKBS-11 and VRO-4 × PK. Standard heterosis for this trait has also been reported by earlier workers (Sood and Sharma, 2001; Murugan *et al.,* 2010; Bassey *et al.,* 2012 and Adiger *et al.,* 2013). The average fruit weight and fruits per plant are 2 direct components which contribute towards yield. Similarly, significant heterosis over standard check was shown by 6 cross-combinations for fruits per plant.

The *per se* performance of hybrids and their heterotic response has strong positive association (Table 4). From the mean performance of the genotypes, it is evident that, in general, the mean values of crosses were desirably higher than those of the parents for fruit length, average fruit weight, harvest duration, fruits per plant and fruit yield per plant. On other hand, the mean values of crosses were desirably lower than those of the parents for nodes per plant and plant height. Promising crosses based on significant heterosis and *per se* performance revealed that the cross, P-20 × VRO-4 was most promising for days to flowering, days to first picking and harvest duration (Table 5). The cross, VRO-4 × HU had highest heterotic effect along with superior performance for fruits per plant and fruit yield per plant. The F_1 hybrids VRO-4 × HU, Tulsi-I × SKBS-11 and P-20 × Tulsi-I exhibited highest *per se* performance for okra yield, also showed highly significant heterosis compared with the standard check. Similar trend was also observed in P-20 × VRO-4, P-20 × PK and P-20 × HU for days to flowering.

In general, lines P-20, VRO-4, Hisar Unnat and Tulsi- I were promising having high heterosis for majority of the traits. The hybrids *viz.,* VRO-4 × HU, Tulsi-I × SKBS-11 and P-20 × Tulsi-I were the most promising ones for fruit yield per plant and other traits important from consumer's view point and offer high scope for the exploitation of heterosis. These cross-combinations can also be released as hybrids after further field testing and also their exploitation in future breeding program.

Therefore, it can be concluded that heterosis breeding is advantageous compared to the open pollinated cultivars as hybrids developed have the advantage of higher yields with uniform maturity, size and color of the fruits. The results suggest that heterosis for fruit yield is obtained through component heterosis. Even the slight hybrid vigor for individual yield components may have additive or synergistic effects on yield. The study further demonstrates the presence of heterosis for important quantitative traits in okra. In the present study, the significance of the heterotic performance was highly affected by the genetic background of parental genotypes. The high heterosis among these germplasm for most of the characteristics studied indicates that the considerable potential exist in these materials for developing hybrids. The results suggest that yield of okra can be substantially increased through heterosis breeding. It also suggests that hybrid vigor is available for commercial production of hybrid okra and that isolation of pure lines from the progenies of heterotic F_1s is a possible way to enhance the fruit yield of okra.

Table 4. Mean and range of heterosis over Hybrid Tulsi for different quantitative traits in okra.

Traits	Mean of parents	Mean of hybrids	Range of heterosis
Days to flowering	54	53	-8.2 to 5.0
Days to first picking	57	56	-7.9 to 7.8
First fruit producing node	1.7	1.6	-28.0 to 36.0
Nodes per plant	14.4	13.4	-15.8 to 24.0
Internodal length (cm)	10.0	9.7	-20.0 to 25.3
Fruit length (cm)	13.8	14.1	-5.4 to 9.5
Fruit diameter (cm)	1.8	1.7	-0.6 to 21.3
Average fruit weight (g)	16.7	17.4	-1.8 to 20.2
Plant height (cm)	142.2	130.7	-21.4 to 41.3
Harvest duration (days)	56	56	-7.8 to 11.8
Fruits per plant	11.4	12.9	-9.0 to 29.8
Fruit yield per plant (g)	191.6	223.7	-3.0 to 40.5

Table 5. Heterosis and *per-se* performance of 3 top crosses for different traits in okra.

Traits	Cross	Heterosis	*Per-se* performance
Days to flowering	P-20 × VRO-4	-8.2*	49
	P-20 × PK	-6.9*	49
	P-20 × HU	-5.7*	50
Days to first picking	P-20 × VRO-4	-7.9*	51
First fruit producing node	9801 × P-8	-28.0*	1.2
	P-20 × P-8	-26.0*	1.2
Nodes per plant	Tulsi-I × SKBS-11	24.0*	16.0
	VRO-4 × HU	20.0*	15.4
	P-20 × Tulsi-I	14.5*	14.7
Internodal length	VRO-4 × P-8	-20.0*	7.7
	VRO-4 × PK	-13.6*	8.3
	9801 × PK	-10.4*	8.6
Fruit length	P-20 × P-8	9.5*	15.2
	9801 × SKBS-11	7.7*	14.9
	PK × Tulsi-I	6.8*	14.8
Average fruit weight	HU × Tulsi-I	20.2*	19.7
	Tulsi-I × SKBS-11	15.5*	18.9
	HU × SKBS-11	12.8*	18.5
Plant height	HU × SKBS-11	41.3*	173.9
	HU × Tulsi-I	31.3*	161.6
	PK × Tulsi-I	29.5*	159.4
Harvest duration	P-20 × VRO-4	11.8*	63
	VRO-4 × HU	9.2*	61
Fruits per plant	VRO-4 × HU	29.8*	15.4
	P-20 × Tulsi-I	23.9*	14.7
	P-20 × PK	17.4*	13.9
Fruit yield per plant	VRO-4 × HU	40.5*	270.9
	Tulsi-I × SKBS-11	33.2*	256.9
	P-20 × Tulsi-I	32.8*	255.9

*Significant at 5% level.

REFERENCES

Adiger S, Shanthkumar G, Gangashetti PI, Salimath PM (2013). Heterosis for fruit yield and its component traits in double cross derived inbred lines of okra (*Abelmoschus esculentus* (L.) Moench). *Indian J. Genet.* 73: 116-119.

Akhtar M, Singh JN, Shahi JP, Srivastava K (2010). Exploitation of heterosis for yield and its attributing traits in okra (*Abelmoschus esculentus* (L.) Moench). *Environ. and Ecol.* 28: 1243-1246.

Bassey EE, Okocha PI, Eka MJ, Umechuruba CI, Eneobong EE (2012). Evaluation of heterosis and variability in diallel crosses of okra in Southeastern Nigeria. *J. of Agric., Biotech. and Ecol.* 5: 20-29.

Birchler JA, Donald LA, Riddle N (2003). In search of molecular basis of heterosis. *Plant Cell* 15: 2236-2239.

Borgaonkar SB, Vaddoria MA, Dhaduk HL, Poshiya VK (2005). Heterosis in okra (*Abelmoschus esculentus* (L.) Moench). *Agri. Sci. Digest* 25: 251-253.

Chaudhary RC (1984). Introduction to Plant Breeding. Oxford and IBH, New Delhi.

Chauhan DVS (1972). Vegetable production in India. Ram Prasad and Sons, Agra.

Darlington CD, Wylie AP (1955). Chromosome Atlas of Flowering Plants. George Allen and Unwin, London, p. 519.

Fryxell PA (1957). Mode of reproduction of higher plants. *Bot. Rev.* 23: 135-233.

Hayes HK, Immer FF, Smith DC (1956). Methods of Plant Breeding. McGraw Hill Book Publishing Company, Inc. New York.

Mehta YR (1959). Vegetable growing in Uttar Pradesh. Bureau of Agricultural Information, Uttar Pradesh, Lucknow.

Murugan S, Venkatesan M, Padmanaban J, Priyadarshini M (2010). Heterosis and combining ability in *Abelmoschus esculentus* (L.) Moench for some important biometrical traits. *Int. J. Plant Sci.* 5: 281-283.

Nadkarni KM (1927). Indian Matria Medica. Nadkarni and Company, Bombay.

Panse VG, Sukhatme PV (1984). Statistical methods for Agricultural Workers. ICAR (Indian Council of Agricultural Research), New Delhi.

Singh DR, Syamal MM (2006). Heterosis in okra (*Abelmoschus esculentus* (L.) Moench). *Orissa J. Hort.* 34: 124-127.

Sood S, Sharma SK (2001). Heterosis and gene action for economic traits in okra. *SABRAO J. Breed. Genet.* 33: 41-46.

Turner JM (1953). A study of heterosis in upland cotton II Combining ability and inbreeding depression effects. *Agron. J.* 43: 487-490.

Vijayaraghvan C, Warriar VA (1946). Evaluation of high yielding hybrid bhindi (*Hibiscus esculentus*). In: Proceedings of 33rd Indian Science Congress 33: 1654 (Abst.) Section 10.

Yadav JR, Bhargava L, Kumar S, Mishra G, Yadav A, Parihar NS, Singh SP (2007). Useful heterosis for yield and its components in okra (*Abelmoschus esculentus* (L.) Moench). *Prog. Agric.* 7: 5-7.