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Assessment of heterosis for growth parameters in anthocyanin-rich okra (*Abelmoschus esculentus* L.) hybrids

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Abstract

The study entitled "Assessment of Heterosis for Growth Parameters in Anthocyanin-Rich Okra (*Abelmoschus esculentus* L.) Hybrids" was conducted during 2025-26 at the Department of Vegetable Science, College of Horticulture, Hiriya, Karnataka. Fifteen F_1 hybrids were developed by crossing six diverse anthocyanin-rich okra genotypes in a half-diallel mating design (excluding reciprocals). These hybrids, along with their parental lines and two standard checks (Arka Nikita and Pusa Lal Bhindi-1), were evaluated in a Randomized Complete Block Design with three replications. Analysis of variance indicated significant differences among the genotypes for all the growth parameters studied, indicating substantial genetic variability. Considerable heterosis was observed for plant height, number of branches per plant, stem girth, internodal length, days to 50 percent flowering and days to first fruit harvest. The hybrid Harihara Local $\times$ Kashi Lalima recorded the highest desirable standard heterosis for plant height (10.33%), days to 50 percent flowering (-10.97%) and days to first fruit harvest (-10.04%), while also exhibiting superior heterotic performance for number of branches per plant and stem girth. Desirable negative heterosis was also observed for internodal length, indicating the potential for developing compact plant architecture. The predominance of non-additive gene action governing these growth traits suggests that heterosis breeding can be effectively exploited for the development of vigorous, compact and early-maturing anthocyanin-rich okra hybrids.

Keywords: Anthocyanin-rich okra, heterosis, growth parameters, half-diallel and gene action

Introduction

Okra [*Abelmoschus esculentus* (L.)], belonging to the family Malvaceae ($2n = 130$), is an important warm-season vegetable crop cultivated throughout the tropical and subtropical regions of the world. It is valued for its tender immature fruits, which are rich in dietary fibre, vitamins, minerals, proteins, mucilage and bioactive compounds that contribute significantly to human nutrition and health (Gemede *et al.*, 2015) [6]. India is the leading producer of okra, accounting for a major share of global production due to its favourable agro-climatic conditions and widespread cultivation. In addition to its nutritional importance, okra possesses medicinal properties owing to the presence of antioxidants, phenolic compounds and mucilage, which exhibit antidiabetic, antimicrobial and anti-inflammatory activities.

Recently, coloured or anthocyanin-rich okra genotypes have gained considerable attention because of their high anthocyanin content, which imparts attractive red to purple pigmentation and enhances the antioxidant potential of the fruits (Zhang *et al.*, 2021) [20]. Anthocyanins are natural flavonoid pigments associated with reduced oxidative stress and protection against several chronic diseases, thereby increasing the nutritional and commercial value of coloured okra. The utilization of anthocyanin-rich genotypes in hybrid breeding offers an opportunity to combine superior nutritional quality with improved agronomic performance.

Despite its economic importance, the productivity of okra remains constrained by the limited genetic potential of many cultivated varieties and their susceptibility to biotic and abiotic stresses. Development of high-performing hybrids through heterosis breeding has become an effective strategy for improving crop performance.

Heterosis or hybrid vigour, refers to the superior performance of F_1 hybrids over their parents and has been widely exploited in okra to enhance vegetative growth, earliness, yield and adaptability. The expression of heterosis is mainly attributed to favourable dominance and non-additive gene interactions, which can be effectively utilized to develop superior hybrids.

Growth parameters such as plant height, number of branches per plant, stem girth, internodal length, days to 50 percent flowering and days to first fruit harvest are important determinants of plant vigour and productivity in okra. Vigorous vegetative growth promotes efficient light interception, improved photosynthetic activity and greater assimilate production, while early flowering and harvesting enable early market supply and increased cropping efficiency. Therefore, the assessment of heterosis for these growth traits provides valuable information for identifying promising hybrid combinations suitable for commercial cultivation and future breeding programmes.

Keeping these aspects in view, the present investigation was undertaken to assess the magnitude and direction of heterosis for important growth parameters in anthocyanin-rich okra (*Abelmoschus esculentus* L.) hybrids. The study aimed to identify superior hybrid combinations exhibiting enhanced vegetative growth and earliness that could serve as potential genetic resources for the development of high-performing anthocyanin-rich okra hybrids.

Materials and Methods

The present investigation was conducted at the Department of Vegetable Science, College of Horticulture, Hiriya,

Karnataka, during the year 2025-26. The experimental material consisted of six diverse okra parental genotypes, namely Red Okra, Double Colour Okra, Harihara Local, Kashi Lalima, CP-104-15-6 and AP-77-7-29 (Table 1.). The six parental genotypes were crossed in a half-diallel mating design (excluding reciprocals) to generate fifteen F_1 hybrids. The parents, F_1 hybrids and two standard checks (Arka Nikita and Pusa Lal Bhindi-1) were evaluated in a Randomized Complete Block Design (RCBD) with three replications. Each experimental plot consisted of 15 plants spaced at 60 cm between rows and 30 cm between plants. Agronomic practices including irrigation, weeding, and pest management were applied uniformly across all plots. Observations were recorded on five randomly selected plants from each plot for six growth parameters, namely plant height (cm), number of branches per plant, stem girth (cm), internodal length (cm), days to 50 percent flowering and days to first fruit harvest.

Statistical Analysis

The experimental data were analysed by analysis of variance (ANOVA) for a Randomized Complete Block Design (RCBD) following the procedure of Panse and Sukhatme (1985). Heterosis was estimated as mid-parent heterosis, better parent heterosis and standard heterosis over the two commercial checks (Arka Nikita and Pusa Lal Bhindi-1) following the method of Fonseca and Patterson (1968). Superior hybrids were identified based on the magnitude of desirable heterosis for the growth parameters evaluated and their performance relative to the standard checks.

Table 1: Salient features of parental materials used in the study

Sl. No.	Parents	Source	Pigments
1	Red Okra	Sahaja Seeds	Dark Red (183B)
2	Double Colour Okra	Sahaja Seeds	Brilliant Yellow Green (142B), Greyish Red (176A)
3	Harihara Local	Farmers Collection from Harihara	Dark Red (187B)
4	Kashi Lalima	ICAR-IIVR, Varanasi	Greyish Purple (N77A)
5	CP-104-15-6	Advanced Breeding Line, COH, Hiriya	Moderate Yellowish Green (138A)
6	AP-77-7-29	Advanced Breeding Line, COH, Hiriya	Moderate Olive Green (137B)
Standard Checks			
7	Arka Nikita (SC1)	ICAR-IIHR, Bengaluru	Strong Yellowish Green (143A)
8	Pusa Lal Bhindi-1 (SC2)	ICAR-IARI, New Delhi	Dark Purplish Red (N79A)

Results and Discussion

Per se performance

The analysis of variance revealed significant differences among the genotypes for all six traits, indicating the presence of substantial genetic variability and scope for hybrid improvement in okra (Table 2 and 3). Significant differences among parents were observed for number of branches per plant and stem girth, whereas plant height, internodal length, days to 50 percent flowering and days to first fruit harvest showed comparatively lower variation among the parents. Significant variation among hybrids for number of branches per plant, stem girth, internodal length and days to 50 percent flowering indicated ample scope for exploiting heterosis in anthocyanin-rich okra breeding. Furthermore, the significant differences between parents and hybrids for all the growth parameters confirmed the expression of hybrid vigour and the existence of considerable genetic divergence among the parental lines. Similar findings were reported by Dhall *et al.* (2003) [4], Darshini and Pujar (2022) [3], Ranga *et al.* (2024) [15] and

Keerthana *et al.* (2025) [8].

Heterosis

Considerable variation in heterosis was observed among the fifteen F_1 hybrids for all the growth parameters studied (Table 4-7). Plant height exhibited significant variation in heterotic response with fourteen hybrids exhibited positive mid-parent heterosis, thirteen showed positive better parent heterosis and ten hybrids expressed significant positive standard heterosis over Arka Nikita. The hybrid Harihara Local $\times$ Kashi Lalima recorded the highest heterosis over the mid-parent (6.09%), better parent (5.93%) and Arka Nikita (10.33%), while the highest standard heterosis over Pusa Lal Bhindi-1 (11.34%). Positive heterosis for plant height reflects enhanced vegetative vigour resulting from favourable allelic interactions and increased assimilate production during the early stages of crop growth. The predominance of positive heterosis indicates the importance of dominance and over-dominance effects, suggesting that non-additive gene action played a major role in the

inheritance of this trait. Similar findings were reported by Mundhe *et al.* (2022) ^[11], Chavan *et al.* (2021) ^[2] and Ajit *et al.* (2024) ^[1].

Number of branches per plant exhibited considerable heterotic variation among the hybrids. Twelve hybrids exhibited positive mid-parent heterosis, whereas nine hybrids exhibited positive better parent heterosis. The hybrid Harihara Local × Kashi Lalima recorded the highest heterosis over the mid-parent (55.05%), better parent (40.83%) and both standard checks, followed by Red Okra × Kashi Lalima. Increased branching enhances canopy development and provides more sites for flowering and fruit production, making positive heterosis desirable for this trait. These findings are in agreement with those of Patel *et al.* (2016) ^[14], Jakasania (2022) ^[7] and Ajit *et al.* (2024) ^[1].

Stem girth showed significant heterosis in both positive and negative directions. Positive heterosis is desirable because thicker stems improve plant vigour and support higher fruit load. The hybrid Harihara Local × Kashi Lalima recorded the highest mid-parent heterosis (26.06%) and better parent heterosis (24.29%), indicating favourable non-additive gene interactions for this trait. Similar results were reported by Panchal *et al.* (2021) ^[12].

Internodal length exhibited significant heterotic effects in both directions, although negative heterosis was considered desirable as shorter internodes contribute to compact plants with increased fruit-bearing nodes. Several hybrids exhibited significant negative heterosis over the mid-parent, better parent and standard checks, indicating the effectiveness of complementary parental interactions in

reducing internodal length. Similar observations were reported by Panchal *et al.* (2021) ^[12] and Koli *et al.* (2020) ^[9].

Days to 50 percent flowering exhibited significant negative heterosis among the hybrids evaluated. All fifteen hybrids expressed desirable negative mid-parent and better-parent heterosis. The hybrid Harihara Local × Kashi Lalima recorded the highest negative heterosis over the mid-parent (-9.02%), better parent (-10.59%), Arka Nikita (-10.97%) and Pusa Lal Bhindi-1 (-11.73%). The consistent expression of negative heterosis indicates the predominance of non-additive gene effects governing flowering time. Early flowering is a desirable attribute in okra as it contributes to earliness and can increase the effective harvesting period. Similar results have been reported by Sapavadiya *et al.* (2019) ^[16], Suganthi *et al.* (2019) ^[18].

Days to first fruit harvest exhibited significant negative heterosis over the better parent and standard checks. The hybrid Harihara Local × Kashi Lalima exhibited the maximum desirable heterosis over the mid-parent (-8.06%), better parent (-10.04%), Arka Nikita (-10.04%) and Pusa Lal Bhindi-1 (-10.40%), indicating its superiority for earliness. Negative heterosis for this trait is desirable because it enables earlier harvesting and reflects the combined effects of rapid vegetative growth and early reproductive development. The superiority of the hybrids indicates that non-additive gene action played a predominant role in the inheritance of earliness. Similar results have been reported by Mundhe *et al.* (2022) ^[11], Shwetha *et al.* (2021) ^[17] and Vekariya *et al.* (2019) ^[19].

Table 2: ANOVA for six various growth parameters in okra

Character	Replication	Genotypes	Parents	Hybrid	Parent vs Hybrid	Check vs Hybrid	Error
DF	2	21	5	14	1	1	42
Plant height (cm)	6.14	22.89*	9.26	16.67	92.33**	134.89**	10.52
Number of branches per plant	0.04	1.18**	0.80**	1.02**	3.72**	3.69**	0.07
Stem girth (cm)	2.36	6.18**	10.29**	4.15**	13.44**	9.49*	1.63
Internodal length (cm)	0.64	2.02**	0.59	0.82**	1.60*	27.76**	0.31
Days taken for 50 percent flowering	4.79	5.71**	1.27	4.65**	34.17**	20.56**	1.20
Days to first fruit harvest	0.12	7.12*	3.29	5.04	50.82**	19.02*	3.19

Table 3: Per se performance of parents, their hybrids for growth parameters

Parents/Hybrids	Plant height (cm)	Number of branches per plant	Stem girth (cm)	Internodal length (cm)	Days taken for 50 percent flowering	Days to first fruit harvest
Red Okra	120.83	2.49	16.80	10.61	51.22	54.89
Double Colour Okra	115.93	3.68	19.43	9.97	50.56	53.11
Harihara Local	119.67	2.76	16.16	10.08	51.44	54.22
Kashi Lalima	119.32	3.38	15.71	10.63	49.67	51.89
CP-104-15-6	120.47	2.45	14.38	11.04	50.33	53.44
AP-77-7-29	118.66	2.57	14.52	10.96	50.34	54.11
Red Okra × Double Colour Okra	120.76	2.84	17.37	9.75	49.67	51.89
Red Okra × Harihara Local	123.32	2.72	16.20	10.03	49.67	53.11
Red Okra × Kashi Lalima	124.29	4.13	18.62	9.45	47.00	49.78
Red Okra × CP-104-15-6	122.41	3.34	16.14	10.34	49.33	53.56
Red Okra × AP-77-7-29	122.59	3.47	17.40	10.26	50.00	51.45
Double Colour Okra × Harihara Local	119.81	3.59	16.31	10.17	47.67	51.67
Double Colour Okra × Kashi Lalima	119.64	3.27	16.46	9.93	49.33	51.44
Double Colour Okra × CP-104-15-6	120.53	3.63	16.27	10.37	49.56	51.67
Double Colour Okra × AP-77-7-29	119.65	3.81	16.23	10.68	49.00	52.89
Harihara Local × Kashi Lalima	126.77	4.76	20.09	9.29	46.00	48.78
Harihara Local × CP-104-15-6	122.41	3.43	18.04	10.51	50.00	52.22
Harihara Local × AP-77-7-29	120.68	2.92	16.53	10.72	50.22	50.45
Kashi Lalima × CP-104-15-6	125.66	3.67	18.45	9.58	48.00	52.89
Kashi Lalima × AP-77-7-29	119.38	3.45	16.26	10.86	49.00	50.67
CP-104-15-6 × AP-77-7-29	119.51	2.37	17.49	11.02	50.00	51.89

Table 4: Average heterosis of the promising crosses in okra

Hybrids	Plant height (cm)	Number of branches per plant	Stem girth (cm)	Internodal length (cm)	Days taken for 50 percent flowering	Days to first fruit harvest
Red Okra × Double Colour Okra	2.01	-7.94	-4.12	-5.25	-2.40	-3.91
Red Okra × Harihara Local	2.56	3.62	-1.74	-3.01	-3.24	-2.65
Red Okra × Kashi Lalima	3.51	40.72**	14.54 *	-11.01 *	-6.83 **	-6.76 *
Red Okra × CP-104-15-6	1.46	35.22 **	3.48	-4.54	-2.85	-1.12
Red Okra × AP-77-7-29	2.37	37.15 **	11.10	-4.87	-1.54	-5.60 *
Double Colour Okra × Harihara Local	1.71	11.49	-8.35	1.48	-6.54 **	-3.73
Double Colour Okra × Kashi Lalima	1.71	-7.37	-6.32	-3.66	-1.55	-2.02
Double Colour Okra × CP-104-15-6	1.97	18.43 **	-3.77	-1.32	-1.76	-3.03
Double Colour Okra × AP-77-7-29	2.00	21.92 **	-4.41	1.99	-2.87	-1.35
Harihara Local × Kashi Lalima	6.09**	55.05 **	26.06 **	-10.25 *	-9.02 **	-8.06 **
Harihara Local × CP-104-15-6	1.95	31.67 **	18.11 **	-0.41	-1.75	-2.99
Harihara Local × AP-77-7-29	1.27	9.57	7.77	1.87	-1.31	-6.87 *
Kashi Lalima × CP-104-15-6	4.80 *	25.90**	22.64 **	-11.58 **	-4.0 *	0.42
Kashi Lalima × AP-77-7-29	0.33	15.97*	7.60	0.57	-2.00	-4.40
CP-104-15-6 × AP-77-7-29	-0.05	-5.58	21.02 **	0.12	-0.67	-3.51

Table 5: Heterobeltiosis of the promising crosses in okra

Hybrids	Plant height (cm)	Number of branches per plant	Stem girth (cm)	Internodal length (cm)	Days taken for 50 percent flowering	Days to first fruit harvest
Red Okra × Double Colour Okra	-0.05	-22.83**	-10.60 *	-8.10	-3.04	-5.46 *
Red Okra × Harihara Local	2.07	-1.45	-3.61	-5.47	-3.45 *	-3.24
Red Okra × Kashi Lalima	2.86	22.19 **	10.81	-11.10 **	-8.25 **	-9.30 **
Red Okra × CP-104-15-6	1.31	34.14 **	-3.97	-6.40	-3.69 *	-2.42
Red Okra × AP-77-7-29	1.45	35.05 **	3.55	-6.39	-2.39	-6.27 *
Double Colour Okra × Harihara Local	0.12	-2.45	-16.06 **	0.96	-7.34 **	-4.72
Double Colour Okra × Kashi Lalima	0.27	-11.14	-15.29 **	-6.65	-2.42	-3.14
Double Colour Okra × CP-104-15-6	0.05	-1.36	-16.26 **	-6.10	-1.98	-3.32
Double Colour Okra × AP-77-7-29	0.83	3.53	-16.49 **	-2.62	-3.08	-2.26
Harihara Local × Kashi Lalima	5.93**	40.83**	24.29 **	-12.60 **	-10.59 **	-10.04 **
Harihara Local × CP-104-15-6	1.61	24.28**	11.61	-4.77	-2.81	-3.69
Harihara Local × AP-77-7-29	0.84	5.80	2.29	-2.25	-2.37	-6.97 **
Kashi Lalima × CP-104-15-6	4.31	8.58	17.46 **	-13.22 **	-4.64 **	-1.04
Kashi Lalima × AP-77-7-29	0.05	2.07	3.52	-0.94	-2.66	-6.36 *
CP-104-15-6 × AP-77-7-29	-0.80	-7.78	20.46 **	-0.24	-0.67	-4.10

Table 6: Standard heterosis of the promising crosses in okra (Arka Nikita)

Hybrids	Plant height (cm)	Number of branches per plant	Stem girth (cm)	Internodal length (cm)	Days taken for 50 percent flowering	Days to first fruit harvest
Red Okra × Double Colour Okra	5.10 *	24.56 **	13.14	-26.89 **	-3.87 *	-4.30
Red Okra × Harihara Local	7.33 **	19.30*	5.50	-24.79 **	-3.87 *	-2.05
Red Okra × Kashi Lalima	8.16 **	81.14 **	21.28 **	-29.14 **	-9.03 **	-8.19 **
Red Okra × CP-104-15-6	6.53 **	46.49 **	5.10	-22.51 **	-4.52 **	-1.23
Red Okra × AP-77-7-29	6.69 **	52.19 **	13.33 *	-23.06 **	-3.23	-5.12
Double Colour Okra × Harihara Local	4.27	57.46 **	6.23	-23.74 **	-7.74 **	-4.72
Double Colour Okra × Kashi Lalima	4.12	43.42 **	7.21	-25.59 **	-4.52 **	-5.13
Double Colour Okra × CP-104-15-6	4.90 *	59.21 **	5.97	-22.26 **	-4.08 *	-4.72
Double Colour Okra × AP-77-7-29	4.13	67.11 **	5.69	-19.97 **	-5.16 **	-2.47
Harihara Local × Kashi Lalima	10.33 **	108.78**	30.85 **	-30.34 **	-10.97 **	-10.04 **
Harihara Local × CP-104-15-6	6.54 **	50.44 **	17.49 *	-21.16 **	-3.23	-3.69
Harihara Local × AP-77-7-29	5.03 *	28.07 **	7.69	-19.67 **	-2.79	-6.97 **
Kashi Lalima × CP-104-15-6	9.36 **	60.97 **	20.19 **	-28.16 **	-7.10 **	-2.46
Kashi Lalima × AP-77-7-29	3.90	51.32 **	5.93	-18.59 **	-5.16 **	-6.56 *
CP-104-15-6 × AP-77-7-29	4.01	3.95	13.92 *	-17.42 **	-3.23	-4.30

Table 7: Standard heterosis of the promising crosses in okra (Pusa Lal Bhindi-1)

Hybrids	Plant height (cm)	Number of branches per plant	Stem girth (cm)	Internodal length (cm)	Days taken for 50 percent flowering	Days to first fruit harvest
Red Okra × Double Colour Okra	6.06 **	20.34 *	14.50 *	-21.49 **	-4.69 **	-4.69
Red Okra × Harihara Local	8.31**	15.25	6.77	-19.24 **	-4.68 **	-2.45
Red Okra × Kashi Lalima	9.16**	75.00 **	22.74 **	-23.91 **	-9.81 **	-8.57 **
Red Okra × CP-104-15-6	7.51**	41.53 **	6.37	-16.80 **	-5.33 **	-1.63
Red Okra × AP-77-7-29	7.67**	47.03 **	14.70 *	-17.39 **	-4.05 *	-5.50 *
Double Colour Okra × Harihara Local	5.23*	52.12 **	7.52	-18.11 **	-8.53 **	-5.10
Double Colour Okra × Kashi Lalima	5.07*	38.56 **	8.50	-20.09 **	-5.33 **	-5.51 *
Double Colour Okra × CP-104-15-6	5.86*	53.81 **	7.25	-16.53 **	-4.90 **	-5.10
Double Colour Okra × AP-77-7-29	5.08*	61.44 **	6.97	-14.06 **	-5.97 **	-2.86
Harihara Local × Kashi Lalima	11.34**	101.70 **	32.43 **	-25.20 **	-11.73 **	-10.40 **
Harihara Local × CP-104-15-6	7.51**	45.34 **	18.92 **	-15.35 **	-4.05 *	-4.08
Harihara Local × AP-77-7-29	5.99**	23.73 **	8.99	-13.74 **	-3.62 *	-7.34**
Kashi Lalima × CP-104-15-6	10.36 **	55.51 **	21.64 **	-22.86 **	-7.89 **	-2.85
Kashi Lalima × AP-77-7-29	4.85 *	46.19 **	7.21	-12.58 **	-5.97 **	-6.94 *
CP-104-15-6 × AP-77-7-29	4.96*	0.42	15.30 *	-11.32 **	-4.05 *	-4.69

Conclusion

The present study revealed significant heterotic expression for the growth parameters of anthocyanin-rich okra, indicating the presence of substantial genetic variability among the parental lines. Desirable positive heterosis was observed for plant height, number of branches per plant and stem girth, whereas significant negative heterosis for internodal length, days to 50 percent flowering and days to first fruit harvest indicated the potential for developing compact and early-maturing hybrids. Among the hybrids evaluated, Harihara Local × Kashi Lalima consistently exhibited superior heterotic performance for most of the growth traits, followed by Red Okra × Kashi Lalima. The predominance of non-additive gene action governing these traits suggests that heterosis breeding can be effectively exploited for the development of vigorous, early and anthocyanin-rich okra hybrids with improved agronomic performance.

References

- Ajit K, Bahadur V, Lal GM. Study on genetic variability and correlation in okra (*Abelmoschus esculentus* L.). International Journal of Research in Agronomy. 2024;7(5):125-128.
- Chavan SS, Jagtap VS, Dhakne VR, Veer DR, Sargar PR. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. Pharma Innovation Journal. 2021;10(10):749-753.
- Darshini TK, Pujar MS. Combining ability for yield and yield components in okra [*Abelmoschus esculentus* (L.) Moench]. International Journal of Agricultural Sciences. 2022;18:359-365.
- Dhall RK, Dhall SP, Singh K. Studies on heterosis in okra (*Abelmoschus esculentus* L. Moench). Journal of Research, Punjab Agricultural University. 2003;40(1):9-15.
- Fonseca S, Patterson F. Hybrid vigour in a seven parent diallel cross in common winter wheat (*Triticum aestivum* L.). Crop Science. 1968;8:85-88.
- Gemedede HF, Ratta N, Haki GD, Woldegiorgis AZ, Beyene F. Nutritional quality and health benefits of okra (*Abelmoschus esculentus*): A review. Food Science and Quality Management. 2015;33:87-96.
- Jakasania U. Estimation of hybrid vigour and combining ability for fruit yield and its attributing traits in okra [*Abelmoschus esculentus* (L.) Moench] [thesis]. Junagadh: Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agricultural University; 2022.
- Keerthana S, Joshi JL, Selvam YA, Ruban S. Heterosis and combining ability in okra [*Abelmoschus esculentus* (L.) Moench] via line × tester design. Biochemistry and Cellular Archives. 2024;24(1):1371-1541.
- Koli HK, Patel AI, Vshai JM, Chaudhari BN. Study of heterosis for fruit yield and its component traits in okra [*Abelmoschus esculentus* (L.) Moench]. International Journal of Current Microbiology and Applied Sciences. 2020;9(9):1930-1937.
- Kumar R, Kumar GS. Identification of best hybrid combination for fruit yield and its component traits in okra [*Abelmoschus esculentus* (L.) Moench]. Journal of Pharmacognosy and Phytochemistry. 2019;8(1):1875-1877.
- Mundhe SS, Pole SP, Khandebharad PR, Patil AR. Heterosis studies for yield and yield component traits in okra (*Abelmoschus esculentus* (L.) Moench). Pharma Innovation Journal. 2022;12:837-842.
- Panchal KN, Bhalekar MN, Kshirsagar DB, Joshi VR, Kute NS. Heterosis for fruit yield and its component traits in okra (*Abelmoschus esculentus* L. Moench). Pharma Innovation Journal. 2021;10(8):1192-1200.
- Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. 4th ed. New Delhi: ICAR Publications; 1985.
- Patel BG, Patel AI. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. Annals of Agriculture and Environmental Science. 2016;1(1):15-20.
- Ranga AD, Vikram A, Kumar R, Dogra RK, Sharma R, Sharma HR. Exploitation of heterosis and combining ability potential for improvement in okra (*Abelmoschus esculentus* L.). Scientific Reports. 2024;14(1):24539.
- Sapavadiya SB, Kachhadia VH, Savaliya JJ, Sapavadiya MH, Shekhawat VS. Heterosis studies in okra (*Abelmoschus esculentus* (L.) Moench). Pharma Innovation Journal. 2019;8:408-411.
- Shwetha A, Mulge R, Khot RK. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench] for growth and earliness parameters through half diallel analysis. Pharma Innovation Journal. 2021;10(6):1250-1254.
- Suganthi S, Sathiskumar P, Kamaraj A, Shanmugapriya R. Exploitation of heterosis through diallel analysis in

- bhendi [*Abelmoschus esculentus* (L.) Moench]. Journal of Pharmacognosy and Phytochemistry. 2019;2:598-601.
19. Vekariya RD, Patel AI, Modha KG, Mali SC. Study of heterosis over environments for fruit yield and its related traits in okra [*Abelmoschus esculentus* (L.) Moench]. International Journal of Chemical Studies. 2019;7:484-490.
20. Zhang Y, Zhang T, Zhao Q, Xie X, Li Y, Chen Q, *et al.* Comparative transcriptome analysis of the accumulation of anthocyanins revealed the underlying metabolic and molecular mechanisms of purple pod coloration in okra (*Abelmoschus esculentus* L.). Foods. 2021;10(9):2180.