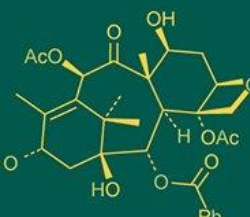
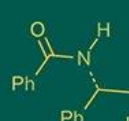


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(6): 1016-1023
www.biochemjournal.com
Received: 02-05-2026
Accepted: 07-06-2026

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Heterosis Studies in Okra (*Abelmoschus esculentus* L. Moench) for yield and its yield attributing traits

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6Ss.8890>

Abstract

The present investigation was carried out during Summer and Kharif seasons of 2025 at the Field Experimentation Centre, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences. Twelve lines and three testers were crossed in a Line $\times$ Tester mating design to produce 36 F_1 hybrids. These hybrids, along with 15 parents and two checks, were evaluated in a Randomized Block Design with three replications. Observations were recorded on important quantitative characters. Analysis of variance revealed significant differences among genotypes for all traits. Heterosis was estimated as average heterosis, heterobeltiosis, and economic heterosis. Significant positive heterosis was observed for pod yield per plant and pod yield per hectare in several hybrids. The hybrids Kashi Kranti $\times$ Pusa Sawani and Parbhani Kranti $\times$ Pusa Sawani exhibited high relative heterosis, heterobeltiosis, and economic heterosis over both checks for pod yield per plant and per hectare, along with superior performance in pod length, pod weight, number of pods per plant, and earliness traits. These hybrids also showed desirable heterosis for vegetative growth and flowering traits. The results of the present investigation demonstrated that these promising parental lines and hybrids possess considerable potential for use in future okra breeding programmes for developing high-yielding hybrids and superior varieties.

Keywords: Okra, Hybrid, Heterosis, Heterobeltiosis, Line $\times$ Tester

Introduction

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable with high nutritional value belonging to malvaceae family having chromosome number $2n=130$ and is widely cultivated in India. It has significant export potential. It is considered as an essential vegetable in tropical and sub-tropical regions of Africa and Asia. It is commonly consumed for its tender fruits. The tender fruits of bhendi (okra) are nutritious, serves as a source of vitamins, minerals and calcium (70-90 mg/100 g) in the diet. The mucilage of Okra is beneficial as a blood volume expander and can aid in curing kidney diseases and enhancing kidney function (Siemonsma and Koume, 2004) ^[14].

To meet the growing demand of nutrient rich vegetables and address the threats posed by climate changes, enhancement of nutrient quality of okra is crucial for vegetable breeding programme (Himanshi *et al.* 2026) ^[6]. The genetic architecture and the extent of heterosis play a crucial role in guiding plant breeders toward yield enhancement. The evaluation of newly developed hybrids for parental effectiveness relies heavily on heterosis studies, as they enable the identification of superior parental combinations by exhibiting maximum hybrid vigor. Selecting optimal parental lines is vital for breeders aiming to elevate the genetic yield potential of wheat varieties. The magnitude of heterosis is instrumental in identifying elite cross combinations capable of producing desirable segregants in subsequent generations (Dedaniya *et al.* 2019) ^[3]. Hybrids, owing to its stability, responsiveness to farm inputs, and superior abiotic stress tolerance, has demonstrated a 13.5% yield advantage over its parental lines (Farooq *et al.* 2014) ^[5]. Although the per se performance of parental lines has traditionally been a criterion for parental selection in hybridization programs, it does not always provide an accurate reflection of their genetic combining ability (Allard, 1960) ^[1]. Therefore, selecting a genetically superior subset of parents aligned with specific breeding objectives is essential, as managing an excessive number of crosses from an extensive

germplasm pool is both impractical and inefficient. Study of heterosis on crops is useful in identifying best parents and crosses to improve genetic makeup of okra (Maruthi *et al.* 2026) [10].

Materials and Methods

The experiment was conducted during *Summer-2025* and *Kharif 2025* at the Field Experimentation Centre, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences.. During *Summer-2025*, (first year) 17 genotypes (including checks) of Okra were evaluated under field conditions. During *Summer-2025*, 15 genotypes were also mated in line x tester design (Kempthorne, 1957) viz., 12 lines x 3 testers to obtain F₁-hybrids. During *Kharif-2025*, (second year) 36 F₁-hybrids obtained from crossing in line x tester design in second year were evaluated along with 15 parental lines and two checks to estimate heterosis. Standard agronomic practices were followed. The significance of relative heterosis, heterobeltiosis and economic heterosis was statistically using t- test.

$$\text{Relative Heterosis (h}_a\text{)\%} = \frac{F_1 - MP}{MP} \times 100$$

$$\text{Heterobeltiosis (h}_b\text{)\%} = \frac{F_1 - BP}{BP} \times 100$$

$$\text{Economic heterosis (h}_c\text{)\%} = \frac{F_1 - SC}{SC} \times 100$$

Where,

F₁ = Mean performance of the first filial generation

MP = Mean of both parents

BP = Mean of better parents

SC = Mean of high yielding standard check

Results and Discussion

Heterosis breeding in crops holds a dual advantage yield enhancement through hybrids and longterm genetic gain through the isolation of superior inbred lines making it an indispensable tool in modern crop improvement programs (Thirubhuvan *et al.* 2023) [17]. The present investigation is in close agreement with the findings of earlier Sidapara *et al.* (2021) [13]; Chandni *et al.* (2023) [2] and Dhakne *et al.* (2026) [4], thereby reinforcing the significance of heterosis breeding for yield improvement in okra.

Plant height. The relative heterosis ranged from -13.10 per cent (Pusa Makhmali × Arka Anamika) to 22.78 per cent (Kashi Satdhari × Pusa Sawani). Among the 36 F₁'s, crosses Kashi Satdhari × Pusa Sawani (22.78%), Parbhani Kranti × Pusa Sawani (18.56%) and Kashi Vibuti × Pusa Sawani (15.10%) expressed the highest significant positive relative heterosis. Heterobeltiosis ranged from -17.29 per cent (Pusa Makhmali × Arka Anamika) to 21.95 per cent (Kashi Satdhari × Pusa Sawani). A considerable number of crosses (Kashi Satdhari × Pusa Sawani; 21.95%, Parbhani Kranti × Pusa Sawani; 17.21% and Kashi Vibuti × Pusa Sawani ;14.26%) exhibited positive heterobeltiosis, suggesting the superiority of hybrids. Standard heterosis over check 1 (Kashi Bhairav) ranged from -22.00 per cent (Pusa Makhmali × Arka Anamika) to 0.76 per cent (Kashi

Satdhari × Pusa Sawani), whereas standard heterosis over check 2 (Kashi Shrishti) ranged from -20.21 per cent (Pusa Makhmali × Arka Anamika) to 3.07 per cent (Kashi Satdhari × Pusa Sawani), expressing positive standard heterosis over both the checks with values of 0.76 per cent and 3.07 per cent, respectively as increased plant height at maturity is generally associated with greater vegetative vigour and better yield potential. Similar results about positive heterosis on plant height was also reported by Sweta *et al.*, 2022 and Dhakne *et al.*, 2026 [4].

Days to first flowering. Negative heterosis is considered desirable for this trait as it contributes towards earliness, enabling early fruit set and harvesting. The relative heterosis ranged from -7.16 per cent (Parbhani Kranti × Arka Anamika) to 50.35 per cent (Kashi Vardhan × Pusa A-4). The crosses, Parbhani Kranti × Arka Anamika (-7.16%), Kashi Lalima × Pusa Sawani (-6.73%) and Utkal Gaurav × Arka Anamika (-4.54%) expressed the highest negative relative heterosis. Heterobeltiosis ranged from -8.76 per cent (Parbhani Kranti × Arka Anamika) to 46.83 per cent (Kashi Vardhan × Pusa A-4). Parbhani Kranti × Arka Anamika (-8.76%), Kashi Lalima × Pusa Sawani (-7.54%) and Kashi Chaman × Arka Anamika (-6.51%) exhibited the highest negative heterobeltiosis. Standard heterosis over check 1 (Kashi Bhairav) ranged from -10.16 per cent (Kashi Lalima × Pusa Sawani) to 41.86 per cent (Kashi Vardhan × Pusa A-4), whereas standard heterosis over check 2 (Kashi Shrishti) ranged from -0.00 per cent (Kashi Lalima × Pusa Sawani) to 57.90 per cent (Kashi Vardhan × Pusa A-4). The hybrids, Kashi Lalima × Pusa Sawani recorded the highest negative standard heterosis over both the checks with values of -10.16 per cent and -0.00 per cent, followed by Parbhani Kranti × Arka Anamika (-9.78% and 0.42%) and Parbhani Kranti × Pusa Sawani (-7.92% and 2.50%). Similar findings with negative heterosis being good for earliness were also reported by Maruthi *et al.*, 2026 [10] and Suma *et al.*, 2025 [15]. Days to first pod picking. The relative heterosis varied from -17.64 per cent (Kashi Kranti × Pusa Sawani) to 24.63 per cent (Kashi Vardhan × Pusa A-4). Among the crosses Kashi Kranti × Pusa Sawani (-17.64%), Parbhani Kranti × Pusa Sawani (-12.88%) and Kashi Vibuti × Pusa Sawani (-12.31%) expressed the highest significant negative relative heterosis. Heterobeltiosis ranged from -20.00 per cent (Kashi Kranti × Pusa Sawani) to 22.76 per cent (Kashi Vardhan × Pusa A-4). Kashi Kranti × Pusa Sawani (-20.00%), Parbhani Kranti × Pusa Sawani (-13.93%) and Kashi Satdhari × Pusa Sawani (-13.40%) exhibited the highest significant negative heterobeltiosis. Standard heterosis over check 1 (Kashi Bhairav) ranged from -24.32 per cent (Kashi Kranti × Pusa Sawani) to 10.82 per cent (Kashi Vardhan × Pusa A-4), whereas standard heterosis over check 2 (Kashi Shrishti) ranged from -16.17 per cent (Kashi Kranti × Pusa Sawani) to 22.76 per cent (Kashi Vardhan × Pusa A-4). Among the hybrids, Kashi Kranti × Pusa Sawani recorded the highest significant negative standard heterosis over both the checks with values of -24.32 per cent and -16.17 per cent, followed by Parbhani Kranti × Pusa Sawani (-23.24% and -14.97%) and Kashi Vibuti × Pusa Sawani (-21.08% and -12.57%) for negative heterosis is considered desirable for this trait as it promotes earliness in pod development and harvesting. These results about negative heterosis enhancing earliness are in accordance with Thirupathi *et al.*, 2012 [16] and Kumar *et al.*, 2023 [9].

Number of pods per plant. The relative heterosis ranged from -29.83 per cent (Kashi Lalima × Pusa A-4) to 10.68 per cent (Kashi Kranti × Pusa Sawani). Heterobeltiosis ranged from -30.21 per cent (Kashi Lalima × Pusa A-4) to 3.93 per cent (Utkal Gaurav × Pusa Sawani). Standard heterosis over check 1 (Kashi Bhairav) ranged from -21.23 per cent (Kashi Lalima × Pusa A-4) to 22.05 per cent (Utkal Gaurav × Pusa Sawani), whereas standard heterosis over check 2 (Kashi Shrishti) ranged from -18.06 per cent (Kashi Lalima × Pusa A-4) to 26.97 per cent (Utkal Gaurav × Pusa Sawani). Heterosis for number of pods per plant was also reported by Kavya *et al.*, 2019^[7].

Pod weight. The relative heterosis ranged from -9.90 per cent (Kashi Pragati × Arka Anamika) to 35.24 per cent (Parbhani Kranti × Pusa Sawani). Heterobeltiosis ranged from -10.70 per cent (Kashi Pragati × Arka Anamika) to 29.97 per cent (Kashi Kranti × Pusa Sawani). Standard heterosis over check 1 (Kashi Bhairav) ranged from -28.19 per cent (Kashi Pragati × Arka Anamika) to 8.24 per cent (Kashi Kranti × Pusa Sawani), whereas standard heterosis over check 2 (Kashi Shrishti) ranged from -19.67 per cent (Kashi Pragati × Arka Anamika) to 21.10 per cent (Kashi Kranti × Pusa Sawani). As an important yield contributing trait, heterosis for pod weight was also reported by Shinde *et al.*, 2023^[11].

Pod yield per plant. Based on relative heterosis, heterobeltiosis and economic heterosis, the most promising hybrids were identified for pod yield per plant in the present investigation. The relative heterosis ranged from -31.18 per cent (Kashi Lalima × Pusa A-4) to 49.02 per cent (Parbhani

Kranti × Pusa Sawani). The crosses Parbhani Kranti × Pusa Sawani (49.02%), Kashi Kranti × Pusa Sawani (46.79%) and Kashi Vardhan × Arka Anamika (7.69%) expressed the highest significant positive relative heterosis. Heterobeltiosis ranged from -33.33 per cent (Kashi Lalima × Pusa A-4) to 30.11 per cent (Kashi Kranti × Pusa Sawani). Among the hybrids, Kashi Kranti × Pusa Sawani (30.11%), Parbhani Kranti × Pusa Sawani (29.55%) and Kashi Vardhan × Arka Anamika (6.43%) recorded the highest significant positive heterobeltiosis, demonstrating superiority over the better parent and indicating its potential for exploitation in hybrid breeding programmes. Standard heterosis over check 1 (Kashi Bhairav) ranged from -28.89 per cent (Kashi Lalima × Pusa A-4) to 27.22 per cent (Kashi Kranti × Pusa Sawani), whereas standard heterosis over check 2 (Kashi Shrishti) ranged from -17.42 per cent (Kashi Lalima × Pusa A-4) to 47.74 per cent (Kashi Kranti × Pusa Sawani). Kashi Kranti × Pusa Sawani exhibited the highest positive standard heterosis over both the checks with values of 27.22 per cent and 47.74 per cent, closely followed by Parbhani Kranti × Pusa Sawani (26.67% and 47.10%) and Kashi Lalima × Pusa Sawani (3.89% and 20.65%). Being the most significant trait, heterosis for pod yield was also reported by Venkatesan *et al.*, 2025.

The repeated occurrence of Pusa Sawani as one of the parents in several superior hybrids indicated its importance as a good combiner for yield and yield contributing traits in okra. The promising hybrids identified may therefore be effectively utilized in heterosis breeding programmes and for the development of high yielding okra hybrid.

Table 1: Percentage heterosis in F₁ hybrids compared to Relative Heterosis, Heterobeltiosis and Economic Heterosis for characters in Okra

Hybrids	Plant height (cm) [Harvest]				Number of branches per plant [harvest]			
	Relative Heterosis	Heterobeltiosis	Economic Heterosis 1	Economic Heterosis 2	Relative Heterosis	Heterobeltiosis	Economic Heterosis 1	Economic Heterosis 2
Pusa Makhmali x Arka Anamika	-13.10 **	-17.29 **	-22.00 **	-20.21 **	2.40	-7.20 *	-13.43 **	-13.17 **
Pusa Makhmali x Pusa Sawani	-5.72	-12.12 *	-17.12 **	-15.22 **	-1.42	-9.11 *	-18.37 **	-18.13 **
Pusa Makhmali x Pusa A-4	10.55 *	2.60	-3.23	-1.02	17.33 **	10.54 **	-5.25	-4.97
Kashi Pragati x Arka Anamika	-8.69	-9.41	-21.57 **	-19.78 **	0.00	-7.19 *	-13.41 **	-13.16 **
Kashi Pragati x Pusa Sawani	-3.83	-6.65	-19.18 **	-17.33 **	3.43	-2.29	-12.24 **	-11.99 **
Kashi Pragati x Pusa A-4	14.57 **	10.72 *	-4.15	-1.95	0.70	-2.72	-16.62 **	-16.37 **
Parbhani Kranti x Arka Anamika	1.25	0.18	-14.63 **	-12.67 **	0.51	-5.94	-12.24 **	-11.99 **
Parbhani Kranti x Pusa Sawani	18.56 **	17.21 **	-2.23	0.01	8.36 *	3.25	-7.27 *	-7.00 *
Parbhani Kranti x Pusa A-4	13.75 **	11.93 *	-6.64	-4.50	-2.26	-4.76	-18.37 **	-18.13 **
Utkal Gaurav x Arka Anamika	-6.50	-7.57	-21.23 **	-19.43 **	-7.18 *	-9.06 **	-15.16 **	-14.91 **
Utkal Gaurav x Pusa Sawani	12.93 **	11.73 *	-6.95	-4.82	-6.67 *	-6.83	-16.33 **	-16.08 **
Utkal Gaurav x Pusa A-4	5.77	4.16	-13.26 **	-11.27 *	-4.11	-7.30 *	-14.87 **	-14.62 **
Kashi Chaman x Arka Anamika	-6.85	-6.97	-20.72 **	-18.90 **	-3.53	-5.94	-12.24 **	-11.99 **
Kashi Chaman x Pusa Sawani	10.96 *	8.67	-7.62	-5.50	-1.00	-1.66	-11.68 **	-11.42 **
Kashi Chaman x Pusa A-4	4.86	2.23	-13.09 **	-11.10 *	0.00	-1.64	-12.83 **	-12.57 **
HRB-53 x Arka Anamika	1.90	0.83	-14.07 **	-12.10 *	-5.58	-7.50 *	-13.70 **	-13.45 **

HRB-53 x Pusa Sawani	12.39 *	11.08 *	-7.31	-5.19	3.39	3.21	-7.30 *	-7.03 *
HRB-53 x Pusa A-4	12.47 *	10.65	-7.67	-5.56	-5.82	-7.82 *	-17.49 **	-17.25 **
Kashi Kranti x Arka Anamika	0.36	-0.16	-14.91 **	-12.97 **	-3.90	-7.50 *	-13.70 **	-13.45 **
Kashi Kranti x Pusa Sawani	10.00 *	8.15	-8.79	-6.70	8.27 **	6.15	-4.66	-4.39
Kashi Kranti x Pusa A-4	8.27	5.96	-10.63 *	-8.58	-6.78 *	-7.09	-19.83 **	-19.59 **
Kashi Satdhari x Arka Anamika	4.67	3.07	-12.16 **	-10.15 *	-9.69 **	-9.69 **	-15.74 **	-15.50 **
Kashi Satdhari x Pusa Sawani	22.78 **	21.95 **	0.76	3.07	-1.28	-3.12	-9.62 **	-9.36 **
Kashi Satdhari x Pusa A-4	6.77	5.55	-12.79 **	-10.79 *	-4.11	-7.30 *	-14.87 **	-14.62 **
Kashi Vibuti x Arka Anamika	3.12	1.61	-13.41 **	-11.43 *	-3.53	-5.94	-12.24 **	-11.99 **
Kashi Vibuti x Pusa Sawani	15.10 **	14.26 *	-5.48	-3.32	-1.00	-1.66	-11.68 **	-11.42 **
Kashi Vibuti x Pusa A-4	7.63	6.35	-12.02 *	-10.01 *	-5.23	-9.08 **	-15.17 **	-14.93 **
Kashi Lalima x Arka Anamika	7.09	6.90	-8.58	-6.48	-8.96 **	-9.39 **	-15.47 **	-15.22 **
Kashi Lalima x Pusa Sawani	8.90	6.34	-9.06	-6.97	-6.25 *	-7.57 *	-14.58 **	-14.33 **
Kashi Lalima x Pusa A-4	10.23 *	7.15	-8.36	-6.26	-8.35 **	-11.67 **	-18.37 **	-18.13 **
Kashi Vardhan x Arka Anamika	0.72	-2.31	-11.42 *	-9.39 *	-6.05 *	-7.81 *	-13.99 **	-13.74 **
Kashi Vardhan x Pusa Sawani	4.84	-0.46	-9.74 *	-7.67	-5.20	-5.21	-14.87 **	-14.62 **
Kashi Vardhan x Pusa A-4	8.47	2.53	-7.03	-4.90	-5.65	-7.79 *	-17.20 **	-16.96 **
Punjab Padmini x Arka Anamika	-0.26	-3.52	-12.03 *	-10.02 *	-9.21 **	-10.62 **	-16.62 **	-16.37 **
Punjab Padmini x Pusa Sawani	2.65	-2.80	-11.37 *	-9.34 *	-6.80 *	-7.10 *	-16.03 **	-15.79 **
Punjab Padmini x Pusa A-4	13.85 **	7.34	-2.13	0.11	-6.29 *	-8.71 *	-17.49 **	-17.25 **

Table 2: Heterosis estimates for days to first flowering and days to first pod picking in okra hybrids

Hybrids	Days to first flowering				Days to first pod picking			
	Relative Heterosis	Heterobeltiosis	Economic Heterosis 1	Economic Heterosis 2	Relative Heterosis	Heterobeltiosis	Economic Heterosis 1	Economic Heterosis 2
Pusa Makhmali x Arka Anamika	4.39	1.71	0.57	11.94	2.66	0.00	-5.95	4.19
Pusa Makhmali x Pusa Sawani	5.06	4.13	-0.56	10.68	0.61	0.61	-10.27 **	-0.60
Pusa Makhmali x Pusa A-4	5.74	4.20	0.67	12.06	1.81	1.20	-8.65 **	1.20
Kashi Pragati x Arka Anamika	2.34	0.00	-1.12	10.06	0.59	-1.72	-7.57 *	2.39
Kashi Pragati x Pusa Sawani	2.37	1.76	-2.83	8.16	-2.12	-2.42	-12.44 **	-3.00
Kashi Pragati x Pusa A-4	7.09	5.84	2.25	13.82	13.51 **	13.17 **	2.16	13.17 **
Parbhani Kranti x Arka Anamika	-7.16	-8.76	-9.78	0.42	-5.67	-9.20 **	-14.60 **	-5.40
Parbhani Kranti x Pusa Sawani	-3.56	-3.57	-7.92	2.50	-12.88 **	-13.93 **	-23.24 **	-14.97 **
Parbhani Kranti x Pusa A-4	10.57	9.92	6.20	18.21	19.51 **	17.37 **	5.95	17.37 **
Utkal Gaurav x Arka Anamika	-4.54	-5.08	-5.08	5.65	-2.86	-3.41	-8.11 *	1.79
Utkal Gaurav x Pusa Sawani	8.85	6.40	6.40	18.43	-7.92 **	-10.80 **	-15.14 **	-5.99
Utkal Gaurav x Pusa A-4	0.58	-1.12	-1.12	10.06	6.71 *	3.98	-1.08	9.58 **
Kashi Chaman x	-4.17	-6.51	-2.81	8.18	-2.52	-4.92	-5.95	4.19

Arka Anamika								
Kashi Chaman x Pusa Sawani	-1.42	-5.44	-1.69	9.42	-7.47 *	-12.02 **	-12.97 **	-3.59
Kashi Chaman x Pusa A-4	1.40	-2.18	1.69	13.19	7.43 *	2.73	1.62	12.57 **
HRB-53 x Arka Anamika	12.37	11.07	9.83	22.25 *	-0.58	-1.72	-7.57 *	2.39
HRB-53 x Pusa Sawani	-1.17	-1.74	-5.08	5.65	-7.46 *	-8.82 *	-16.22 **	-7.19 *
HRB-53 x Pusa A-4	4.20	4.19	0.66	12.05	0.30	-0.58	-8.65 **	1.20
Kashi Kranti x Arka Anamika	-2.57	-2.84	-3.39	7.54	-0.86	-1.14	-6.49 *	3.59
Kashi Kranti x Pusa Sawani	3.29	1.24	0.67	12.06	-17.64 **	-20.00 **	-24.32 **	-16.17 **
Kashi Kranti x Pusa A-4	17.87 *	16.20	15.55	28.61 *	6.43 *	4.00	-1.62	8.98 *
Kashi Satdhari x Arka Anamika	0.29	-1.09	0.57	11.94	1.98	0.56	-2.71	7.78 *
Kashi Satdhari x Pusa Sawani	10.24	6.89	8.68	20.97	-9.87 **	-13.40 **	-16.21 **	-7.18 *
Kashi Satdhari x Pusa A-4	-2.91	-5.33	-3.74	7.14	-2.88	-6.13	-9.18 **	0.60
Kashi Vibuti x Arka Anamika	1.75	0.00	-1.12	10.06	3.51	1.72	-4.33	5.98
Kashi Vibuti x Pusa Sawani	-0.64	-0.65	-5.13	5.60	-12.31 **	-13.10 **	-21.08 **	-12.57 **
Kashi Vibuti x Pusa A-4	4.12	3.51	0.00	11.31	10.45 **	10.12 **	0.00	10.78 **
Kashi Lalima x Arka Anamika	2.01	1.12	-0.01	11.30	3.77	2.88	-3.24	7.19 *
Kashi Lalima x Pusa Sawani	-6.73	-7.54	-10.16	-0.00	2.39	0.59	-7.03 *	2.99
Kashi Lalima x Pusa A-4	8.68	8.37	5.30	17.20	13.02 **	11.70 **	3.24	14.37 **
Kashi Vardhan x Arka Anamika	8.87	5.14	3.96	15.71	10.72 **	6.90 *	0.54	11.38 **
Kashi Vardhan x Pusa Sawani	2.40	0.58	-3.96	6.90	-3.97	-4.84	-15.14 **	-5.99
Kashi Vardhan x Pusa A-4	50.35 **	46.83 **	41.86 **	57.90 **	24.63 **	22.76 **	10.82 **	22.76 **
Punjab Padmini x Arka Anamika	-1.44	-2.29	-3.39	7.54	0.29	-0.57	-6.49 *	3.59
Punjab Padmini x Pusa Sawani	0.30	-0.57	-3.39	7.54	-5.95 *	-7.60 *	-14.60 **	-5.40
Punjab Padmini x Pusa A-4	2.04	1.75	-1.13	10.05	8.29 **	7.02 *	-1.08	9.58 **

Table 3: Heterosis estimates for number of pods per plant and pod weight in okra (*Abelmoschus esculentus* (L.) Moench) hybrids

Hybrids	Number of pods per plant				Pod weight			
	Relative Heterosis	Heterobeltiosis	Economic Heterosis 1	Economic Heterosis 2	Relative Heterosis	Heterobeltiosis	Economic Heterosis 1	Economic Heterosis 2
Pusa Makhmali x Arka Anamika	-4.26	-10.22	6.53	10.83	10.14	1.30	-18.54 **	-8.87
Pusa Makhmali x Pusa Sawani	-15.63	-20.50 *	-6.64	-2.87	16.44 *	5.42	-12.21	-1.78
Pusa Makhmali x Pusa A-4	-17.82 *	-21.09 *	-10.93	-7.34	33.01 **	17.20 *	3.80	16.12 *
Kashi Pragati x Arka Anamika	-4.50	-12.00	4.41	8.62	-9.90	-10.70	-28.19 **	-19.67 **
Kashi Pragati x Pusa Sawani	2.53	-5.08	11.46	15.96	-1.07	-3.63	-19.74 **	-10.21
Kashi Pragati x Pusa A-4	-17.15	-21.88 *	-11.83	-8.27	-2.27	-7.56	-18.12 **	-8.40
Parbhani Kranti x Arka Anamika	-7.89	-16.02	-0.35	3.67	-6.35	-10.15	-27.75 **	-19.17 **
Parbhani Kranti x Pusa Sawani	10.17	0.92	18.52	23.30 *	35.24 **	27.61 **	6.27	18.89 **
Parbhani Kranti x Pusa	-18.60 *	-24.06 *	-14.29	-10.83	8.50	-0.50	-11.87	-1.41

A-4								
Utkal Gaurav x Arka Anamika	-10.76	-13.19	3.00	7.16	-2.28	-4.44	-19.61 **	-10.07
Utkal Gaurav x Pusa Sawani	6.30	3.93	22.05 *	26.97 *	-5.69	-6.16	-21.06 **	-11.69
Utkal Gaurav x Pusa A-4	-25.68 **	-25.90 **	-16.37	-12.99	0.17	-2.34	-13.51 *	-3.24
Kashi Chaman x Arka Anamika	-7.01	-15.56	0.19	4.23	8.87	5.45	-9.52	1.22
Kashi Chaman x Pusa Sawani	-1.39	-10.04	5.64	9.91	7.47	5.89	-9.15	1.64
Kashi Chaman x Pusa A-4	-1.32	-8.33	3.47	7.64	3.66	2.04	-9.63	1.10
HRB-53 x Arka Anamika	-11.13	-16.02	-0.35	3.67	-6.69	-10.21	-21.92 **	-12.65
HRB-53 x Pusa Sawani	-10.96	-15.45	-0.71	3.30	-1.81	-3.88	-16.43 **	-6.50
HRB-53 x Pusa A-4	-7.16	-10.15	1.41	5.50	6.66	5.68	-6.40	4.72
Kashi Kranti x Arka Anamika	-12.81	-21.80 *	-7.21	-3.47	2.60	2.43	-17.64 **	-7.86
Kashi Kranti x Pusa Sawani	10.68	-0.28	17.11	21.83	32.48 **	29.97 **	8.24	21.10 **
Kashi Kranti x Pusa A-4	-5.80	-13.59	-2.48	1.46	6.99	1.89	-9.75	0.96
Kashi Satdhari x Arka Anamika	-5.66	-12.30	4.06	8.26	-1.61	-2.34	-20.29 **	-10.82
Kashi Satdhari x Pusa Sawani	-18.00 *	-23.41 *	-10.05	-6.42	19.63 **	18.44 *	-1.36	10.35
Kashi Satdhari x Pusa A-4	-6.40	-10.93	0.53	4.59	9.58	5.28	-6.75	4.32
Kashi Vibuti x Arka Anamika	-9.05	-9.52	7.35	11.69	4.00	2.64	-15.25 *	-5.19
Kashi Vibuti x Pusa Sawani	-13.47	-13.48	1.60	5.71	7.44	6.98	-10.91	-0.33
Kashi Vibuti x Pusa A-4	-24.11 **	-25.58 **	-12.62	-9.09	10.74	6.99	-5.24	6.01
Kashi Lalima x Arka Anamika	-3.50	-6.35	11.11	15.60	0.63	-6.98	-11.87	-1.41
Kashi Lalima x Pusa Sawani	-15.93	-18.00	-3.70	0.18	21.19 **	13.86 *	7.87	20.68 **
Kashi Lalima x Pusa A-4	-29.83 **	-30.21 **	-21.23 *	-18.06	-1.05	-4.27	-9.31	1.46
Kashi Vardhan x Arka Anamika	-4.12	-6.10	11.41	15.91	11.29	10.11	-9.54	1.20
Kashi Vardhan x Pusa Sawani	-11.05	-12.44	2.82	6.97	10.68	9.92	-8.45	2.42
Kashi Vardhan x Pusa A-4	-27.77 **	-28.05 **	-18.16	-14.85	8.43	4.50	-7.45	3.54
Punjab Padmini x Arka Anamika	-18.54 *	-19.26 *	-2.47	1.47	10.79	7.67	-13.43 *	-3.14
Punjab Padmini x Pusa Sawani	-21.67 **	-22.76 *	-6.69	-2.93	3.78	-0.83	-17.41 **	-7.60
Punjab Padmini x Pusa A-4	-22.97 **	-25.50 **	-10.00	-6.37	18.82 **	10.30	-2.31	9.29

Table 4: Heterosis estimates for pod length, pod diameter and pod yield per plant in okra (*Abelmoschus esculentus* (L.) Moench) hybrids

Hybrids	Pod length				Pod diameter				Pod yield per plant			
	Relative Heterosis	Heterobeltiosis	Economic Heterosis 1	Economic Heterosis 2	Relative Heterosis	Heterobeltiosis	Economic Heterosis 1	Economic Heterosis 2	Relative Heterosis	Heterobeltiosis	Economic Heterosis 1	Economic Heterosis 2
Pusa Makhmali x Arka Anamika	9.39	0.72	-20.03 **	-11.07	6.38	-2.12	-9.05	1.69	4.35	-8.77	-13.33	0.65
Pusa Makhmali x Pusa Sawani	10.74	-0.92	-16.15 **	-6.76	7.31	-2.89	-6.38	4.67	-2.63	-15.91	-17.78	-4.52
Pusa Makhmali x Pusa A-4	19.15 **	3.89	-6.69	3.76	20.62 **	6.22	8.93	21.79 **	7.79	-7.78	-7.78	7.10
Kashi Pragati x Arka Anamika	-10.42	-11.17	-29.47 **	-21.57 **	-12.90	-13.61	-19.72 **	-10.25	-14.38	-21.64 *	-25.56 **	-13.55
Kashi Pragati x Pusa Sawani	-5.62	-9.28	-23.23 **	-14.63 *	-9.08	-11.43	-14.62 *	-4.54	1.26	-8.52	-10.56	3.87
Kashi Pragati x	-	-18.27 **	-26.59 **	-18.37 **	-	-16.06 *	-13.92	-3.76	-	-27.22 **	-27.22	-15.48

Pusa A-4	12.55 *				11.24				18.63 *		**	
Parbhani Kranti x Arka Anamika	-14.07 *	-17.26 *	-29.05 **	-21.10 **	-9.55	-13.11	-19.26 **	-9.73	-13.62	-23.98 *	-27.78 **	-16.13
Parbhani Kranti x Pusa Sawani	18.56 **	17.78 *	1.00	12.31	7.58	1.56	-2.09	9.47	49.02 **	29.55 **	26.67 **	47.10 **
Parbhani Kranti x Pusa A-4	-9.87	-11.91	-20.88 **	-12.02	-1.73	-9.84	-7.54	3.37	-11.61	-23.89 *	-23.89 *	-11.61
Utkal Gaurav x Arka Anamika	-3.02	-5.22	-21.18 **	-12.35	-5.49	-7.63	-10.09	0.52	-12.02	-12.28	-16.67	-3.23
Utkal Gaurav x Pusa Sawani	-14.44 *	-15.17 *	-28.22 **	-20.18 **	-13.05 *	-13.47	-15.78 *	-5.84	1.16	-0.57	-2.78	12.90
Utkal Gaurav x Pusa A-4	-9.96	-13.29	-22.12 **	-13.40	-9.23	-11.54	-9.28	1.43	-26.29 **	-28.33 **	-28.33 **	-16.77
Kashi Chaman x Arka Anamika	6.55	3.11	-12.49 *	-2.69	3.56	0.23	-0.46	11.28	1.25	-5.26	-10.00	4.52
Kashi Chaman x Pusa Sawani	-2.54	-2.68	-17.41 **	-8.16	-1.36	-2.80	-3.48	7.91	5.85	-2.27	-4.44	10.97
Kashi Chaman x Pusa A-4	-7.45	-10.00	-19.16 **	-10.11	-6.09	-7.58	-5.22	5.97	1.52	-7.22	-7.22	7.74
HRB-53 x Arka Anamika	-8.56	-12.04	-24.41 **	-15.94 *	-11.15	-14.53 *	-14.04	-3.89	-17.61 *	-19.30	-23.33 *	-10.97
HRB-53 x Pusa Sawani	-11.02	-11.70	-24.11 **	-15.62 *	-9.66	-11.53	-11.02	-0.52	-13.53	-16.48	-18.33	-5.16
HRB-53 x Pusa A-4	-3.85	-5.92	-15.50 *	-6.04	-2.57	-3.51	-1.04	10.64	-1.16	-5.56	-5.56	9.68
Kashi Kranti x Arka Anamika	-3.85	-7.71	-20.33 **	-11.40	-2.31	-2.37	-9.28	1.43	-10.10	-19.30	-23.33 *	-10.97
Kashi Kranti x Pusa Sawani	15.85 *	14.70 *	-0.98	10.11	-1.04	-2.89	-6.38	4.67	46.79 **	30.11 **	27.22 **	47.74 **
Kashi Kranti x Pusa A-4	-7.50	-9.30	-18.53 **	-9.41	-2.49	-7.13	-4.76	6.49	1.27	-11.11	-11.11	3.23
Kashi Satdhari x Arka Anamika	-3.55	-4.33	-22.80 **	-14.16 *	-6.25	-7.11	-12.06	-1.69	-6.88	-12.87	-17.22	-3.87
Kashi Satdhari x Pusa Sawani	8.82	6.29	-10.05	0.02	9.90	8.90	4.99	17.38 *	-1.54	-9.09	-11.11	3.23
Kashi Satdhari x Pusa A-4	-1.30	-6.32	-15.85 *	-6.43	0.00	-3.85	-1.39	10.25	3.34	-5.56	-5.56	9.68
Kashi Vibuti x Arka Anamika	0.67	-0.72	-18.94 **	-9.86	-2.89	-4.25	-8.47	2.33	-5.23	-5.78	-9.44	5.16
Kashi Vibuti x Pusa Sawani	-2.66	-4.37	-19.07 **	-10.01	-1.39	-1.81	-5.34	5.84	-7.16	-7.95	-10.00	4.52
Kashi Vibuti x Pusa A-4	-0.22	-4.75	-14.45 *	-4.87	1.05	-2.38	0.12	11.93	-15.01	-16.67	-16.67	-3.23
Kashi Lalima x Arka Anamika	-2.71	-10.07	-15.87 *	-6.45	-5.90	-13.03 *	-4.76	6.49	-2.48	-7.81	-1.67	14.19
Kashi Lalima x Pusa Sawani	15.25 *	9.76	2.68	14.18 *	-9.52	-14.94 *	-6.84	4.15	1.63	-2.60	3.89	20.65
Kashi Lalima x Pusa A-4	-10.64	-12.42	-18.07 **	-8.90	-9.63	-12.50	-4.18	7.13	-31.18 **	-33.33 **	-28.89 **	-17.42
Kashi Vardhan x Arka Anamika	7.44	6.21	-13.69 *	-4.03	2.28	1.10	-3.83	7.52	7.69	6.43	1.11	17.42
Kashi Vardhan x Pusa Sawani	-0.85	-2.82	-17.76 **	-8.55	0.42	-0.24	-3.83	7.52	-0.87	-3.41	-5.56	9.68
Kashi Vardhan x Pusa A-4	-2.56	-7.20	-16.65 **	-7.31	-1.06	-4.64	-2.20	9.34	-21.61 *	-24.44 *	-24.44 *	-12.26
Punjab Padmini x Arka Anamika	7.26	4.31	-17.18 **	-7.91	1.99	-0.75	-7.77	3.11	-9.52	-11.11	-15.56	-1.94
Punjab Padmini x Pusa Sawani	-7.22	-12.49	-25.94 **	-17.65 *	-5.98	-10.11	-13.34	-3.11	-18.48 *	-21.02 *	-22.78 *	-10.32
Punjab Padmini x Pusa A-4	18.55 **	8.78	-2.29	8.65	2.56	-4.75	-2.32	9.21	-7.83	-11.67	-11.67	2.58

Conclusion

The heterosis study revealed significant positive heterosis for pod yield per plant among several hybrids. Based on relative heterosis, heterobeltiosis and standard heterosis, several promising hybrids were identified for pod yield per plant in the present investigation. The hybrids Kashi Kranti × Pusa Sawani and Parbhani Kranti × Pusa Sawani exhibited high relative heterosis, heterobeltiosis and economic heterosis over both checks for pod yield and associated traits. These hybrids also showed superiority for important yield contributing characters such as pod length, pod weight and number of pods per plant. The repeated occurrence of Pusa Sawani in superior cross combinations indicated its importance as a good combiner for yield and related traits. Therefore, these promising parents and hybrids may be effectively utilized in future okra improvement and heterosis breeding programmes for the development of high yielding hybrids and varieties.

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