

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(8): 1718-1723
www.biochemjournal.com
Received: 19-06-2026
Accepted: 22-07-2026

Gujjal Rekha

M.Sc. (Hort.) in Vegetable
Science, Department of
Horticulture, College of
Agriculture, University of
Agricultural Sciences,
Dharwad, Karnataka, India

Dr. Hiremath SM

Professor (Horticulture) and
Head, AICRP (Potato),
Department of Horticulture,
College of Agriculture,
University of Agricultural
Sciences, Dharwad,
Karnataka, India

Dr. Manjunatha GO

Professor and Head,
Department of Horticulture,
College of Agriculture,
University of Agricultural
Sciences, Dharwad,
Karnataka, India

Dr. Desai SA

Professor (GPB) and Associate
Director of Extension,
University of Agricultural
Sciences, Dharwad,
Karnataka, India

Corresponding Author:**Gujjal Rekha**

M.Sc. (Hort.) in Vegetable
Science, Department of
Horticulture, College of
Agriculture, University of
Agricultural Sciences,
Dharwad, Karnataka, India

Exploitation of heterosis for yield and quality traits in cucumber (*Cucumis sativus* L.)

Gujjal Rekha, Hiremath SM, Manjunatha GO and Desai SA

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i8Ss.9656>

Abstract

The present investigation was conducted at Vegetable Unit, Department of Horticulture, College of Agriculture, University of Agricultural Sciences, Dharwad, during 2025-26. Eight diverse parental lines were crossed in a half-diallel mating design excluding reciprocals to generate 28 F_1 hybrids. Analysis of variance revealed significant differences among the genotypes for most of the traits, indicating the existence of genetic variability. Significant heterosis over better parent, commercial check and standard check was observed for various traits, highlighting the scope for hybrid breeding. Among the hybrids, Swarna Sheetal x Poinsette ($P_1 \times P_3$) exhibited superior heterosis for vine length, fruit length and primary branches, whereas Poinsette x Arka Veera ($P_3 \times P_7$) showed desirable heterosis for earliness and yield traits. The hybrid Poinsette x Arka Veera ($P_3 \times P_7$) recorded the highest fruit yield per vine (1.92 kg), with heterosis of 51.18% over the commercial check and 48.83% over the standard check, followed by Swarna Sheetal x Poinsette ($P_1 \times P_3$) (49.60 and 47.28%, respectively). The hybrid Poinsette x Arka Veera ($P_3 \times P_7$) also recorded the maximum number of fruits per vine (13.00), average fruit weight (176.00 g), first female flower appearance (31.70 days), sex ratio (6.37) and first fruit harvest (43.60 days). For quality traits, Swarna Sheetal x Swarna Ageti ($P_1 \times P_5$) recorded highest total soluble solids (5.14 °Brix) and Arka Veera x Nethra ($P_7 \times P_8$) for moisture content (95.96%) with maximum standard heterosis.

Keywords: Cucumber, heterosis, heterobeltiosis, standard heterosis, F_1 hybrids, yield, quality traits, hybrid breeding

Introduction

Cucumber (*Cucumis sativus* L.) is an important warm-season vegetable crop belonging to the family *Cucurbitaceae* and is widely cultivated in tropical and subtropical regions owing to its high economic value, short crop duration and wider adaptability. India is considered one of the primary centres of origin (De Candolle, 1883) ^[5] and possesses considerable genetic diversity, providing ample scope for genetic improvement. The tender fruits are consumed fresh, cooked or processed into pickles and are valued for their high moisture, vitamins and mineral content.

Cucumber exhibits considerable genetic variability and is highly amenable to hybrid breeding due to its monoecious flowering habit, large flowers, high fruit set and abundant seed production. The increasing demand for early, uniform and high-yielding hybrids has enhanced the importance of heterosis breeding in cucumber. However, productivity is often constrained by the cultivation of low-yielding cultivars, genetic impurities, variations in fruiting behaviour and susceptibility to pests and diseases. Hence, development of superior hybrids with desirable earliness, yield and quality remains an important objective of cucumber breeding programmes.

Heterosis breeding is an effective approach for exploiting genetic variability and improving economically important traits. Hayes and Jones (1916) ^[7] were the first to report heterosis in cucumber. It refers to the superior performance of F_1 hybrids over their parents for one or more desirable traits. The magnitude of heterosis varies with parental combinations; therefore, evaluation of diverse parents and their hybrids is essential for identifying superior cross combinations. Estimation of heterosis over the better parent, commercial check and standard check provides useful information for identifying hybrids with commercial potential.

Therefore, the present investigation was undertaken to estimate heterosis for growth, earliness, yield and quality traits in cucumber using 28 F_1 hybrids, with the objective of identifying superior heterotic hybrids for commercial exploitation and future cucumber breeding programmes.

Materials and Methods

The present investigation was conducted during late *kharif* 2025 and summer 2026 at the Vegetable Unit, Department of Horticulture, College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka, India. Eight diverse parental lines, namely Swarna Sheetal (P_1), Himangi (P_2), Poinsette (P_3), Belagavi Local (P_4), Swarna Ageti (P_5), Dharwad Local (P_6), Arka Veera (P_7) and Nethra (P_8), were crossed in a half-diallel mating design excluding reciprocals to generate 28 F_1 hybrids. The experimental material comprising 28 F_1 hybrids, eight parents, one commercial check (Rayanna) and one standard check (Kashi Nutan) was evaluated during summer 2026 in a randomized block design with two replications. Each experimental unit consisted of a single row accommodating 10 plants at a spacing of 1.5 m x 0.75 m.

All the recommended agronomic practices, including irrigation, weeding, fertilizer application and plant protection measures, were followed to raise a healthy crop (Anon., 2022) ^[2]. In each replication, five plants were randomly selected from each plot for recording observations on growth, yield and quality traits, namely vine length, number of primary branches, days to first female flower appearance, node number at which first female flower appears, sex ratio, days to first fruit harvest, fruit length, average fruit weight, number of fruits per vine, fruit yield per vine, total soluble solids and moisture content.

The experimental data were subjected to analysis of variance following the procedure suggested by Singh and Chaudhary (1977) ^[11]. Heterosis was estimated over the better parent (heterobeltiosis), commercial check (Rayanna) and standard check (Kashi Nutan) according to the method described by Turner (1953) ^[12]. The significance of heterotic effects was tested following the procedure described by Wynne *et al.* (1970) ^[14].

Results and Discussion

The results of analysis of variance revealed non-significant effects of replications for all the characters studied, indicating uniformity of the experimental conditions. Highly significant variations among genotypes for most of the traits suggested the presence of substantial genetic variability in the experimental material. Significant mean squares due to parents and hybrids for the majority of the characters reflected considerable variability among the parental lines and differential performance of their crosses. Further, significant parent vs. hybrid effects for several traits indicated the manifestation of heterotic effects resulting from the recombination of diverse parental genomes (Table 1). The mean performance of the parents, hybrids and checks for the characters studied is presented in Table 2. Such variability among the experimental material provided scope for the identification of superior heterotic combinations. Similar findings were also reported by Nimitha *et al.* (2018) ^[9].

Vigorous growth and earliness are important objectives in cucumber breeding, particularly for the development of high-yielding hybrids with early market availability. The

estimates of heterobeltiosis, heterosis over the commercial check and standard check for growth traits are presented in Tables 3, 4 and 5, respectively. Significant positive heterobeltiosis for vine length at 90 DAS was expressed by 11 hybrids, with $P_1 \times P_3$ (Swarna Sheetal x Poinsette) recording the highest significant heterobeltiosis (23.49%). For number of primary branches at 90 DAS, 10 hybrids showed significant positive heterobeltiosis, with $P_1 \times P_3$ (Swarna Sheetal x Poinsette) recording the highest significant value (16.15%). Significant positive heterosis over the commercial check was observed in 14 hybrids for vine length and 13 hybrids for primary branches, while 18 hybrids showed significant positive heterosis over the standard check. $P_1 \times P_3$ (Swarna Sheetal x Poinsette) recorded the highest significant heterosis over the commercial check for vine length (31.44%) and primary branches (25.83%), as well as over the standard check (40.88 and 32.45%, respectively). The superior performance of hybrids for both growth traits indicates a favourable parental combination for enhancing vegetative vigour and branching in cucumber. Similar findings were also reported by Umeh *et al.* (2021) ^[13] and Chinatu *et al.* (2024) ^[4].

Significant negative heterosis for days to first female flower appearance was expressed by 21, 19 and 12 hybrids over the better parent, commercial check and standard check, respectively. The hybrid $P_3 \times P_7$ (Poinsette x Arka Veera) recorded the highest significant negative heterosis over the better parent (-31.24%), commercial check (-30.18%) and standard check (-24.88%). Similar findings were also reported in cucumber by Malav and Verma (2018) ^[8]. For node number at which first female flower appears, 15 hybrids showed significant negative heterosis over the better parent, while 7 hybrids each exhibited significant negative heterosis over the commercial and standard checks. $P_2 \times P_3$ (Himangi x Poinsette) cross recorded the highest negative heterobeltiosis (-49.06%), whereas $P_3 \times P_7$ (Poinsette x Arka Veera) recorded the highest negative heterosis over the commercial check (-43.48%) and standard check (-38.10%). For sex ratio, significant negative heterosis was observed in 12 hybrids over the better parent and 2 hybrids each over the commercial and standard checks. For days to first fruit harvest, significant negative heterosis was observed in 16, 19 and 5 hybrids over the better parent, commercial check and standard check, respectively. $P_3 \times P_7$ (Poinsette x Arka Veera) exhibited the highest significant negative heterosis over the better parent (-19.41%), commercial check (-23.10%) and standard check (-13.15%). Such desirable negative heterosis for flowering and earliness traits may reflect favourable genetic interactions between the parental lines, particularly in the cross $P_3 \times P_7$, resulting in earlier flowering and fruit harvest. Similar observations of significant negative heterosis for flowering and earliness traits in cucumber were also reported by Sahoo and Singh (2020) ^[10] in cucumber.

Yield and its component traits are important determinants of productivity and market value in cucumber. For number of fruits per vine, significant positive heterosis was observed in 8 hybrids over the better parent, 16 hybrids over the commercial check and 9 hybrids over the standard check. $P_1 \times P_6$ (Swarna Sheetal x Dharwad Local) hybrid showed the maximum heterobeltiosis (21.35%), whereas $P_3 \times P_7$ (Poinsette x Arka Veera) showed the greatest advantage over the commercial (52.94%) and standard (44.44%) checks. For fruit length, 5 hybrids expressed significant

positive heterobeltiosis, with $P_4 \times P_5$ (Belagavi Local $\times$ Swarna Ageti) showing the maximum heterobeltiosis (15.55%); $P_1 \times P_3$ (Swarna Sheetal $\times$ Poinsette) was superior to the commercial and standard checks by 21.24 and 30.05%, respectively. In average fruit weight, significant positive heterosis was expressed by 9 hybrids over the better parent, 5 hybrids over the commercial check and 2 hybrids over the standard check. The maximum heterobeltiosis was observed in $P_2 \times P_4$ (Himangi $\times$ Belagavi Local) (12.04%), while $P_3 \times P_7$ (Poinsette $\times$ Arka Veera) exceeded the commercial and standard checks by 13.26 and 10.87%, respectively. For the major economic trait, fruit yield per vine, 9 hybrids showed significant positive heterobeltiosis, while 13 hybrids were superior to both the commercial and standard checks. $P_1 \times P_3$ (Swarna Sheetal $\times$ Poinsette) expressed the maximum heterobeltiosis (32.37%), whereas $P_3 \times P_7$ (Poinsette $\times$ Arka Veera) showed the greatest superiority over the commercial (51.18%) and standard (48.83%) checks. The superior yield of $P_3 \times P_7$ (Poinsette $\times$ Arka Veera) may be associated with its favourable performance for number of fruits per vine and average fruit

weight, suggesting a complementary contribution of yield components towards enhanced productivity. Similar positive heterotic responses for yield and its component traits in cucumber have been reported by Abd Rabou (2020) [1], Chinatu *et al.* (2024) [4] and Dhali *et al.* (2025) [6].

For total soluble solids (TSS), significant positive heterosis was observed in several hybrids, with $P_3 \times P_8$ (Poinsette $\times$ Nethra) showing the maximum significant heterobeltiosis (20.54%), while $P_1 \times P_5$ (Swarna Sheetal $\times$ Swarna Ageti) exhibited the highest significant heterosis over both the commercial and standard checks. For moisture content, $P_3 \times P_4$ (Poinsette $\times$ Belagavi Local) expressed the highest heterobeltiosis (1.25%), whereas $P_7 \times P_8$ (Arka Veera $\times$ Nethra) showed the greatest positive heterosis over the commercial (2.85%) and standard (3.61%) checks. The desirable heterotic response for TSS and moisture content suggests the possibility of improving fruit quality through exploitation of heterosis. Similar findings for heterosis for quality traits in cucumber were also reported by Umeh *et al.* (2021) [13] and Bisht *et al.* (2023) [3].

Table 1: Analysis of variance for growth, yield and quality parameters in cucumber

Sources/Character	Mean sum of squares					
	Replication	Genotype	Parent	Hybrid	Parent vs. Hybrid	Error
Degrees of freedom	1	36	7	27	1	36
Vine length (m) at 90 DAS	0.0050	0.1227**	0.0278*	0.1445**	0.2725**	0.0113
No. of primary branches per vine at 90 DAS	0.0086	1.2141**	0.5371**	1.4505**	0.7722**	0.0370
Days for first female flower appearance	0.7400	44.6891**	14.6286**	49.6701**	149.0414**	0.4656
Node No. at which first female flower appearance	0.2272	2.3082	2.9714**	2.2939**	0.3286	0.2674
Sex ratio	0.2098	16.7222**	19.3497**	16.5910**	10.1843	3.3777
Days to first fruit harvest	0.0012	41.6822**	29.9886**	45.9923**	22.8604**	0.9462
No. of fruits per vine	0.7201	3.7325**	5.1749**	3.4874**	1.7086**	0.0643
Fruit length (cm)	2.6486	4.9488**	9.8500*	3.2478**	20.4915**	0.8929
Average fruit weight (g)	0.8866	450.4956**	157.8314**	556.3374**	11.6143	29.0138
Fruit yield (kg/vine)	0.8649	0.1522**	0.1028**	0.1744**	0.0422**	0.0014
Total soluble solids ($^{\circ}$ Brix)	0.0753	0.2657**	0.0624	0.2938**	0.0768	0.0396
Moisture content (%)	1.3640	3.4433**	4.4588**	3.2976**	3.1256**	0.1191

Note: * -Significant at 5% level of probability

** -Significant at 1% level of probability DAS-Days after sowing

Table 2: *Per se* performance of parents, hybrids and checks for growth, yield and quality parameters in cucumber

Parent/ Hybrid/Check	Growth parameters						Yield parameters				Quality parameters	
	VL-90 DAS	NPB-90 DAS	DFFA	NFFA	SR	DFHA	NFPV	FL (cm)	AFW (g)	FYPV (kg/vine)	TSS ($^{\circ}$ Brix)	MC (%)
P ₁	2.07	6.00	46.30	4.60	14.26	54.70	8.50	15.30	152.15	1.31	3.92	94.84
P ₂	1.80	5.90	43.00	5.30	9.47	51.60	7.90	15.84	142.40	1.22	3.84	94.45
P ₃	2.05	6.50	46.10	3.10	7.36	54.10	10.40	21.07	153.50	1.39	4.09	91.47
P ₄	1.88	4.95	48.80	6.00	16.22	59.90	7.30	18.33	138.00	0.97	4.34	91.17
P ₅	1.91	5.30	45.40	6.40	16.19	55.00	7.50	13.00	133.00	0.89	4.31	94.18
P ₆	2.17	6.20	45.10	5.40	12.52	55.10	8.90	18.85	152.00	1.21	4.15	92.80
P ₇	2.02	6.30	39.90	3.50	11.55	46.40	12.10	20.81	158.15	1.47	4.19	95.03
P ₈	1.99	5.90	47.00	3.50	11.66	56.00	8.60	20.34	140.60	1.24	4.02	93.74
P ₁ $\times$ P ₂	2.31	5.55	45.50	4.30	9.84	55.60	9.00	18.10	157.00	1.62	3.90	92.68
P ₁ $\times$ P ₃	2.55	7.55	34.10	2.70	8.07	44.50	10.10	22.72	169.50	1.84	4.65	93.60
P ₁ $\times$ P ₄	2.45	5.35	44.60	5.30	12.57	52.60	8.50	20.42	146.00	1.64	4.20	91.57
P ₁ $\times$ P ₅	1.81	4.20	43.70	5.70	13.93	55.90	8.70	16.53	139.90	1.15	5.14	94.28
P ₁ $\times$ P ₆	2.44	7.00	41.70	4.25	10.32	51.80	10.80	19.89	168.70	1.28	3.67	93.14
P ₁ $\times$ P ₇	2.41	6.60	35.70	3.75	13.43	45.70	9.60	20.36	163.50	1.41	4.02	95.42
P ₁ $\times$ P ₈	2.10	5.40	41.60	3.30	12.27	48.20	9.40	21.67	148.10	1.61	3.98	93.77
P ₂ $\times$ P ₃	2.21	6.20	37.50	2.70	13.17	46.50	8.40	18.55	148.60	1.02	3.88	93.58
P ₂ $\times$ P ₄	2.19	6.65	39.70	5.30	9.26	52.40	8.40	19.08	159.55	1.11	3.80	91.96
P ₂ $\times$ P ₅	1.76	4.10	46.50	6.00	16.21	56.30	8.00	17.27	116.80	0.81	4.33	93.71
P ₂ $\times$ P ₆	1.90	6.10	39.00	4.50	11.04	53.90	8.60	20.41	150.00	1.25	4.41	93.37
P ₂ $\times$ P ₇	2.14	6.55	37.90	4.70	12.12	50.30	9.20	18.65	156.50	1.55	4.14	95.18

P ₂ x P ₈	2.04	6.60	40.30	3.30	14.21	49.80	9.00	19.24	158.70	1.15	4.35	94.09
P ₃ x P ₄	1.80	6.10	42.80	3.30	10.52	57.20	7.60	19.39	160.00	1.19	3.92	92.59
P ₃ x P ₅	2.10	5.80	43.00	4.65	12.95	55.20	8.90	18.44	118.70	1.21	4.37	95.20
P ₃ x P ₆	2.35	7.00	50.20	4.00	11.37	61.45	10.40	20.78	164.30	1.37	4.30	93.86
P ₃ x P ₇	2.50	7.35	31.70	2.60	6.37	43.60	13.00	22.00	176.00	1.92	3.98	95.87
P ₃ x P ₈	2.08	6.90	42.10	2.90	10.34	53.20	9.40	21.73	150.90	1.31	4.93	94.87
P ₄ x P ₅	1.61	5.00	51.40	6.10	16.65	60.60	8.10	21.18	121.20	0.79	5.01	92.29
P ₄ x P ₆	1.84	6.90	48.40	5.60	14.96	58.10	8.50	19.90	142.20	1.01	3.99	91.88
P ₄ x P ₇	2.24	6.10	41.10	4.70	10.81	52.00	8.30	20.58	140.80	1.34	3.88	94.93
P ₄ x P ₈	1.82	5.60	51.20	4.85	10.84	61.40	8.00	18.10	156.53	1.61	4.17	92.98
P ₅ x P ₆	1.83	5.75	38.50	6.30	12.95	49.90	8.30	18.65	139.90	1.15	4.58	94.38
P ₅ x P ₇	2.27	6.10	45.50	4.50	10.09	53.60	9.20	21.41	145.50	1.48	3.73	95.91
P ₅ x P ₈	1.88	5.60	41.10	4.80	14.53	50.90	9.20	18.38	132.50	1.64	3.89	94.98
P ₆ x P ₇	2.50	6.85	35.50	4.30	7.20	50.90	10.40	18.50	171.45	1.84	4.00	95.35
P ₆ x P ₈	2.23	6.40	38.60	5.40	8.17	52.10	9.30	20.90	168.30	1.55	3.98	93.51
P ₇ x P ₈	2.40	6.70	39.80	4.50	11.76	54.60	12.70	18.61	165.25	1.43	4.02	95.96
CC (Rayanna)	1.94	6.00	45.40	4.6	11.50	56.70	8.50	18.74	155.40	1.27	3.41	93.30
SC (Kashi Nutan)	1.81	5.70	42.20	4.2	10.62	50.20	9.00	17.47	158.75	1.29	4.08	92.64
S. Em±	0.03	0.13	0.48	0.36	1.29	0.68	0.17	0.67	0.21	0.02	0.14	0.24
CD at 5%	0.09	0.39	1.38	1.04	3.69	1.97	0.51	1.92	0.60	0.07	0.40	0.70

Note: CC-Commercial check, SC-Standard check, VL-90DAS-Vine length at 90 days after sowing, NPB-90DAS-Number of primary branches at 90 days after sowing, DFFA-Days to first female appearance, NFFA-Node at which first female appears, DFHA-Days to first fruit harvest, NFPV-Number of fruits per vine, FL-Fruit length, AFW-Average fruit weight, FYPV-Fruit yield per vine, TSS-Total soluble solids and MC-Moisture content

Table 3: Magnitude of heterosis over better parent for growth, yield and quality parameters in cucumber

Hybrid	Growth parameters						Yield parameters				Quality parameters	
	VL-90 DAS	NPB-90DAS	DFFA	NFFA	SR	DFHA	NFPV	FL (cm)	AFW (g)	FYPV (kg/vine)	TSS (°Brix)	MC (%)
P ₁ x P ₂	11.62*	-7.50 *	-1.73	-18.87	-30.92*	1.65	5.88*	14.27*	3.19	23.66 **	0.51	-2.30 **
P ₁ x P ₃	23.49**	16.15 **	-26.35**	-41.30 **	-43.41**	-18.64**	-2.42	7.83	10.42 **	32.37 **	13.69 **	-1.30 **
P ₁ x P ₄	18.64**	-10.83 **	-8.61**	-11.67	-22.50*	-12.19**	0.00	11.40*	-4.04	25.19 **	-3.23	-3.40 **
P ₁ x P ₅	-12.35*	-30.00 **	-5.62**	-10.94	-13.96	1.64	2.35	8.03*	-8.05 *	-12.21 **	19.26 **	-0.60
P ₁ x P ₆	12.44*	12.90 **	-9.94**	-21.30 *	-27.63*	-5.99**	21.35**	5.50	10.88 **	-2.30	-11.57 *	-1.80 **
P ₁ x P ₇	16.46**	4.76	-22.89**	-21.88 *	-5.82	-16.45**	-20.66**	-2.16	3.38	-4.08	-4.18	0.41
P ₁ x P ₈	1.45	-10.00 **	-11.49**	-28.26 *	-13.96	-13.93**	9.30*	6.54	-2.66	22.90 **	-0.99	-1.10 **
P ₂ x P ₃	8.07	-4.61	-18.66**	-49.06 **	39.09*	-14.05**	-18.84**	-11.96**	-3.19	-26.61 **	-5.13	-0.92 *
P ₂ x P ₄	16.53**	12.71 **	-18.65**	-11.67	-42.91**	-12.52**	6.33*	4.09	12.04 **	-9.38 *	-12.44 **	-2.60 **
P ₂ x P ₅	-8.12	-30.50 **	2.42	-6.25	0.12	2.36	1.27	9.02*	-17.98 **	-33.87 **	0.46	-0.78 *
P ₂ x P ₆	-12.44*	-1.61	-13.53**	-16.66	-11.82	-2.18	-3.37	8.28*	-1.32	2.04	6.27	-1.10 **
P ₂ x P ₇	5.94	3.96	-11.86**	-11.32	4.94	-2.52	-23.97**	-10.38*	-1.04	5.78	-1.19	0.16
P ₂ x P ₈	2.26	11.86 **	-14.26**	-37.74 **	21.92	-11.07**	4.65	-5.41	11.45 **	-7.25	8.08	-0.38
P ₃ x P ₄	-11.98*	-6.15 *	-12.30**	-45.00 **	-35.14**	-4.51**	-26.57**	-7.97	4.23	-14.38 **	-9.68 *	1.25 **
P ₃ x P ₅	2.69	-10.76 **	-6.72**	-27.34 **	-20.01	0.36	-14.01**	-12.48**	-22.67 **	-12.94 **	1.39	1.08 **
P ₃ x P ₆	8.29	7.69 **	8.89**	-25.93 **	-9.18	11.52**	0.48	-1.38	7.04 *	-1.43	3.61	1.14 **
P ₃ x P ₇	22.25**	13.07 **	-31.24**	-25.71 **	-44.84**	-19.41**	7.44**	4.41	11.29 **	30.65 **	-5.01	0.88 **
P ₃ x P ₈	1.47	6.15 *	-10.43**	-17.14	-11.32	-5.00**	-9.18**	3.13	-1.69	-5.75	20.54 **	1.21 **
P ₄ x P ₅	-15.97**	-5.66	5.33**	-4.69	2.65	1.17	8.00*	15.55**	-12.17 **	-18.55 **	15.44 **	-2.00 **
P ₄ x P ₆	-15.44**	11.29 **	-0.82	-6.67	-7.77	-3.00	-4.49	5.57	-6.45	-16.52 **	-8.06	-0.99 **
P ₄ x P ₇	10.89*	-3.17	-15.78**	-21.67 *	-33.35**	-13.19**	-31.40**	-1.11	-10.97 **	-8.84 *	-10.60 *	-1.10
P ₄ x P ₈	-8.34	-5.08	4.92**	-19.17 *	-33.17**	2.50	-6.98*	-11.01*	11.33 **	29.83 **	-3.92	-0.81 *
P ₅ x P ₆	-15.81**	-7.23 *	-15.20**	-1.56	-20.01	-9.44**	-6.74*	-1.06	-7.96 *	-4.95	6.26	0.21
P ₅ x P ₇	12.38*	-3.17	0.22	-29.69 *	-37.68**	-2.55	-23.97**	2.88	-8.00 *	1.02	-13.46 **	0.92 *
P ₅ x P ₈	-5.53	-5.08	-12.55**	-25.00 **	-10.24	-9.11**	6.98*	-9.64*	-5.76	32.25 **	-9.74 *	0.85 *
P ₆ x P ₇	14.98**	8.73 **	-21.29**	-20.37 *	-42.49**	-7.62**	-13.64**	-11.10*	8.41 *	20.10 **	-4.53	0.33
P ₆ x P ₈	2.77	3.22	-17.87**	0.00	-34.74*	-6.96**	4.49	2.75	10.72 **	25.00 **	-4.10	-0.25
P ₇ x P ₈	18.56**	6.34 *	-15.32**	-6.25	0.86	-2.50	4.95**	-10.57*	4.59	-2.72	-4.06	0.98 **

Note: * -Significant at 5% level of probability, ** -Significant at 1% level of probability, VL-90DAS-Vine length at 90 days after sowing, NPB-90DAS-Number of primary branches at 90 days after sowing, DFFA-Days to first female appearance, NFFA-Node at which first female appears, DFHA-Days to first fruit harvest, NFPV-Number of fruits per vine, FL-Fruit length, AFW-Average fruit weight, FYPV-Fruit yield per vine, TSS-Total soluble solids and MC-Moisture content

Table 4: Magnitude of heterosis over commercial check (Rayanna) for growth, yield and quality parameters in cucumber

Hybrid	Growth parameters						Yield parameters				Quality parameters	
	VL-90 DAS	NPB-90DAS	DFFA	NFFA	SR	DFHA	NFPV	FL (cm)	AFW (g)	FYPV (kg/vine)	TSS (°Brix)	MC (%)
P ₁ x P ₂	18.81**	-7.50 *	0.22	-6.52	-30.92*	-1.94	5.88*	-3.42	1.03	27.55 **	14.37 *	-0.66
P ₁ x P ₃	31.44**	25.83 **	-24.89**	-41.30 **	-43.41**	-21.51**	18.82**	21.24**	9.07 *	49.60 **	36.36 **	0.32
P ₁ x P ₄	26.29**	-10.83 **	-1.76	15.22	-22.50*	-7.23**	0.00	8.96	-6.05	29.13 **	23.17 **	-1.90 **
P ₁ x P ₅	-6.70	-30.00 **	-3.74	23.91 *	-13.96	-1.41	2.35	4.22	-9.97 **	-9.44 *	50.73 **	1.05 **
P ₁ x P ₆	25.77**	16.66 **	-8.15**	-7.61	-27.63*	-8.64**	27.06**	6.14	8.56 *	0.88	7.62	-0.17
P ₁ x P ₇	23.97**	10.00 **	-21.37**	-18.48	-5.82	-19.40**	12.94**	8.64	5.21	11.02 **	17.74 **	2.27 **
P ₁ x P ₈	7.99	-10.00 **	-8.37**	-28.26 *	-13.96	-14.99**	10.59**	15.64**	-4.70	26.77 **	16.72 **	0.50
P ₂ x P ₃	13.92*	3.33	-17.40**	-41.30 **	39.09*	-17.99**	-1.18	-1.01	-4.38	-19.68 **	13.78 **	0.30
P ₂ x P ₄	12.63*	10.83 **	-12.56**	15.22	-42.91**	-7.58**	-1.18	1.81	2.67	-12.59 **	11.44	-1.40 **
P ₂ x P ₅	-9.54	-31.66 **	2.42	30.43 **	0.12	-0.71	-5.88*	2.83	-24.84 **	-36.22 **	26.98 **	0.44
P ₂ x P ₆	-2.06	1.66	-14.10**	-2.17	-11.82	-4.94**	1.18	8.91	-3.47	-1.57	29.33 **	0.08
P ₂ x P ₇	10.31	9.16 **	-16.52**	2.17	4.94	-11.29**	8.24**	-0.48	0.71	22.44 **	21.41 **	2.02 **
P ₂ x P ₈	4.90	10.00 **	-11.23**	-28.26 *	21.92	-12.17**	5.88*	2.67	2.12	-9.44 *	27.42 **	0.85 *
P ₃ x P ₄	-7.22	1.66	-5.73**	-28.26 *	-35.14**	0.88	-10.59**	3.47	2.96	-6.29	14.96 **	-0.76 *
P ₃ x P ₅	8.25	-3.33	-5.29**	1.08	-20.01	-2.65	4.71*	-1.60	-23.62 **	-4.72	28.15 **	2.04 **
P ₃ x P ₆	21.13**	16.66 **	10.57**	-13.04	-9.18	8.38**	22.35**	10.89*	5.73	7.87	26.10 **	0.60
P ₃ x P ₇	28.87**	22.50 **	-30.18**	-43.48 **	-44.84**	-23.10**	52.94**	17.33 **	13.26 **	51.18 **	16.72 **	2.75 **
P ₃ x P ₈	6.96	15.00 **	-7.27**	-36.96 **	-11.32	-6.17**	10.59**	15.95**	-2.90	3.14	44.57 **	1.68 **
P ₄ x P ₅	-17.27**	-16.66 **	13.22**	32.61 **	2.65	6.88**	-4.71*	13.02**	-22.01 **	-37.79 **	46.92 **	-1.10 **
P ₄ x P ₆	-5.41	15.00 **	6.61**	21.74 *	-7.77	2.47	0.00	6.19	-8.49 *	-20.47 **	17.01 **	-1.50 **
P ₄ x P ₇	15.46**	1.66	-9.47**	2.17	-33.35**	-8.29**	-2.35	9.82	-9.40 *	5.51	13.78	1.75 **
P ₄ x P ₈	-6.03	-6.66 *	12.78**	5.43	-33.17**	8.29**	-5.88*	-3.42	3.30	26.77 **	22.29 **	-0.34
P ₅ x P ₆	-5.82	-4.16	-15.20**	36.96 **	-20.01	-11.99**	-2.35	-0.48	-9.97 **	-9.44 *	34.31 **	1.16 **
P ₅ x P ₇	17.01**	1.66	0.22	-2.17	-37.68**	-5.47**	8.24**	14.25**	-6.37	16.92 **	9.38	2.79 **
P ₅ x P ₈	-3.09	-6.66 *	-9.47**	4.35	-10.24	-10.23**	8.24**	-1.92	-14.74 **	29.13 **	14.08 **	1.80 **
P ₆ x P ₇	28.61**	14.16 **	-21.81**	-6.52	-42.49**	-10.23**	22.94**	-1.28	10.33 **	44.88 **	17.30 **	2.19 **
P ₆ x P ₈	14.95*	6.66 *	-14.98**	17.39	-34.74*	-8.11**	9.41**	11.53*	8.30 *	22.04 **	16.72 **	0.23
P ₇ x P ₈	23.45**	11.66 **	-12.33**	-2.17	0.86	-3.70*	49.41**	-0.69	6.34	12.59 **	17.89 **	2.85 **

Note: *-Significant at 5% level of probability, **Significant at 1% level of probability, VL-90DAS-Vine length at 90 days after sowing, NPB-90DAS-Number of primary branches at 90 days after sowing, DFFA-Days to first female appearance, NFFA-Node at which first female appears, DFHA-Days to first fruit harvest, NFPV-Number of fruits per vine, FL-Fruit length, AFW-Average fruit weight, FYPV-Fruit yield per vine, TSS-Total soluble solids and MC-Moisture content

Table 5: Magnitude of heterosis over standard check (Kashi Nutan) for growth, yield and quality parameters in cucumber

Hybrid	Growth parameters						Yield parameters				Quality parameters	
	VL-90 DAS	NPB-90DAS	DFFA	NFFA	SR	DFHA	NFPV	FL (cm)	AFW (g)	FYPV (kg/vine)	TSS (°Brix)	MC (%)
P ₁ x P ₂	27.35**	-2.63	7.82**	2.38	-7.34	10.76**	0.00	3.61	-1.10	25.58 **	-4.53	0.06
P ₁ x P ₃	40.88**	32.45 **	-19.19**	-35.71 **	-24.01	-11.35**	12.22**	30.05**	6.77	47.28 **	13.83 **	1.06 **
P ₁ x P ₄	35.36**	-6.14	5.69**	26.19 **	18.36	4.78**	-5.56*	16.89**	-8.03 *	27.13 **	2.82	-1.13 **
P ₁ x P ₅	0.00	-26.31 **	3.55**	35.71 **	31.17*	11.35**	-3.33	11.79*	-11.88 **	-10.85 **	25.83 **	1.79 **
P ₁ x P ₆	34.81**	22.80 **	-1.18	1.19	-2.82	3.19	20.00**	13.85**	6.27	-0.77	-10.16 *	0.56 *
P ₁ x P ₇	32.87**	15.78 **	-15.40**	-10.71	26.46*	-8.96**	6.67**	16.54**	2.99	9.30 *	-1.71	3.02 **
P ₁ x P ₈	15.75**	-5.26	-1.42	-21.43 *	15.54	-3.98**	4.44*	24.04**	-6.71	24.80 **	-2.57	1.24 **
P ₂ x P ₃	22.10**	8.77 **	-11.14**	-35.71 **	23.96	-7.37**	-6.67**	6.18*	-6.39	-20.93 **	-5.02	1.04 **
P ₂ x P ₄	20.72**	16.66 **	-5.92**	26.19 **	-12.81	4.38**	-6.67**	9.22*	0.50	-13.95 **	-6.98	-0.71 *
P ₂ x P ₅	-3.04	-28.07 **	10.19**	42.86 **	52.64**	12.15**	-11.11**	10.30*	-26.43 **	-37.20 **	6.00	1.18 **
P ₂ x P ₆	4.97	7.01 *	-7.58**	7.14	3.95	7.37**	-4.44*	16.83**	-5.51	-3.10	7.96	0.81 *
P ₂ x P ₇	18.23**	14.91 **	-10.19**	11.90	14.12	0.20	2.22	6.75*	-1.42	20.54 **	1.35	2.76 **
P ₂ x P ₈	12.43*	15.78 **	-4.50**	-21.43 *	33.80*	-0.80	0.00	10.13*	-0.03	-10.85 **	6.36	1.59 **
P ₃ x P ₄	-0.55	7.01 *	1.42	-21.43 *	-0.94	13.94**	-15.56**	10.99*	0.79	-7.75	-4.04	-0.03
P ₃ x P ₅	16.02**	1.75	1.90	10.71	21.94	9.96**	-1.11	5.55*	-25.23 **	-6.20	6.98	2.79 **
P ₃ x P ₆	29.83**	22.80 **	18.96**	-4.76	7.06	22.41**	15.56**	18.95**	3.50	6.20	5.26	1.34 **
P ₃ x P ₇	38.12**	28.94 **	-24.88**	-38.10 **	-40.01**	-13.15**	44.44**	25.93*	10.87 **	48.83 **	-2.57	3.51 **
P ₃ x P ₈	14.64	21.05 **	-0.24	-30.95 *	-2.64	5.98**	4.44*	24.38**	-4.95	1.55	20.69 **	2.43 **
P ₄ x P ₅	-11.33	-12.28 **	21.80**	45.24 **	56.78**	20.72**	-10.00**	21.23**	-23.65 **	-38.75 **	22.64 **	-0.36
P ₄ x P ₆	1.38	21.05 **	14.69**	33.33 **	40.87**	15.74**	-5.56*	13.91**	-10.42 **	-21.70 **	-2.33	-0.80 *
P ₄ x P ₇	23.76**	7.01 *	-2.61	11.90	1.79	3.59	-7.78**	17.80**	-11.31 **	3.87	-5.02	2.49 **
P ₄ x P ₈	0.77	-1.75	21.33**	15.48	2.07	22.31**	-11.11**	3.61	1.12	24.80 **	2.08	0.39
P ₅ x P ₆	0.94	0.86	-8.77**	50.00 **	21.94	-0.60	-7.78**	6.75*	-11.88 **	-10.85 **	12.12 **	1.90 **
P ₅ x P ₇	25.41**	7.01 *	7.82**	7.14	-4.99	6.77**	2.22	22.55**	-8.35 *	15.11 **	-8.69	3.55 **
P ₅ x P ₈	3.87	-1.75	-2.61	14.29	36.82**	1.39	2.22	5.21	-16.54 **	27.13 **	-4.77	2.55 **
P ₆ x P ₇	38.12**	20.17 **	-15.88**	2.38	-32.20**	1.39	16.11**	5.90*	8.00 *	42.63 **	-2.08	2.94 **
P ₆ x P ₈	23.20**	12.28 **	-8.53**	28.57 *	-23.07	3.78	3.33	19.63**	6.02	20.15 **	-2.57	0.96 **
P ₇ x P ₈	32.32**	17.54 **	-5.69**	7.14	10.73	8.76**	41.11**	6.53*	4.10	10.85 **	-1.59	3.61 **

Note: *-Significant at 5% level of probability, **Significant at 1% level of probability, VL-90DAS-Vine length at 90 days after sowing, NPB-90DAS-Number of primary branches at 90 days after sowing, DFFA-Days to first female appearance, NFFA-Node at which first female appears, DFHA-Days to first fruit harvest, NFPV-Number of fruits per vine, FL-Fruit length, AFW-Average fruit weight, FYPV-Fruit yield per vine, TSS-Total soluble solids and MC-Moisture content

Conclusion

The study identified $P_3 \times P_7$ (Poinsette x Arka Veera) as the most promising hybrid, combining desirable earliness with superior yield performance, particularly for number of fruits per vine, average fruit weight and fruit yield per vine. The hybrid $P_1 \times P_3$ (Swarna Sheetal x Poinsette) also exhibited superior performance for growth traits, fruit length and fruit yield, while $P_1 \times P_5$ (Swarna Sheetal x Swarna Ageti) and $P_7 \times P_8$ (Arka Veera x Nethra) were promising for TSS and moisture content, respectively. The superior performance of these hybrids may be attributed to favourable genetic interactions between the parental lines, resulting in desirable heterosis for important economic traits. Hence, $P_3 \times P_7$ (Poinsette x Arka Veera) may be further evaluated under multi-location trials and considered for commercial exploitation in cucumber hybrid breeding programmes.

References

1. Abd Rabou A M. Heterosis and combining ability in cucumber under salt condition. Plant Archives 2020;20(2):9643-9650.
2. Anonymous. Package of practices for horticultural crops, University of Horticultural Sciences 2022, Bagalkot, Karnataka, India.
3. Bisht YS, Singh DK, Singh NK, Singh SS, Bhatt R, Kumar M, Chauhan A. Nutrients profiling for investigating variation and its effect on heterosis and combining ability of cucumber (*Cucumis sativus*). Indian J Agric Sci. 2023 Jul 1;93:732-737.
4. Chinatu L N, Adedoyin C and James M S. Prospects of increased production of cucumber (*Cucumis sativus* L.) through heterosis. Nigeria Agricultural Journal 2024;55(1):24-34.
5. De Candolle A. Origine des plantes cultivées. G. Baillière et cie; 1883.
6. Dhall RK, Hegde SN, Singathiya P, Manchanda P. Heterotic potential and combining ability for yield and quality attributes in slicing cucumber (*Cucumis sativus* L.). Scientific Reports. 2025 Dec 16;15(1):43937.
7. Hayes HK, Jones DF. First generation crosses in cucumbers. Connecticut Agricultural Experiment Station Annual Report. 1916;40:319-322.
8. Malav N and Verma S. Heterosis in cucumber (*Cucumis sativus* L.). Int J Chem Stud 2018;6(3):1538-1540.
9. Nimitha K, Acharya RR, Parmar DJ. Exploitation of hybrid vigour through diallel analysis in cucumber (*Cucumis sativus* L.). Electronic Journal of Plant Breeding. 2018;9(1):60-65.
10. Sahoo TR, Singh DK. Exploitation of heterosis in cucumber for earliness, yield and yield contributing traits under protected structure. International Journal of Chemical Studies. 2020;8(1):918-25.
11. Singh RK, Chaudhary BD. Biometrical methods in quantitative genetic analysis. New Delhi, India: Kalyani Publishers; 1977.
12. Turner JJ. A study of heterosis in Upland cotton II. Combining ability and inbreeding effects. Agronomy Journal. 1953;45(10):487-490.
13. Umeh OA, Ngwuta AA, Onyishi GC, Anyanwu CP. Heterosis for yield and its components in cucumber (*Cucumis sativus* L.) in Owerri Southeastern Nigeria. Int J Agric Rural Dev. 2021;24:5704-5710.
14. Wynne JC, Emery DA, Rice PW. Combining ability estimates in *Arachis hypogaea* L. II. field performance of F1 hybrids 1. Crop Science. 1970 Nov;10(6):713-715.