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Naveen Kumar Tulluru
Department of Vegetable Science, College of Horticulture, Venkataramannagudem, Dr. Y. S. R. H. U, Andhra Pradesh, India

K Uma Jyothi
Department of Vegetable Science, College of Horticulture, Venkataramannagudem, Dr. Y. S. R. H. U, Andhra Pradesh, India

M Ravindra Babu
Horticultural Research Station, Venkataramannagudem, Dr. Y. S. R. H. U, Andhra Pradesh, India

M Paratpararao
Department of Genetics and Plant Breeding, College of Horticulture, Venkataramannagudem, Dr. Y. S. R. H. U, Andhra Pradesh, India

E Padma
Department of Vegetable Science, College of Horticulture, Venkataramannagudem, Dr. Y. S. R. H. U, Andhra Pradesh, India

V Sekhar
Department of Statistics, College of Horticulture, Venkataramannagudem, Dr. Y. S. R. H. U, Andhra Pradesh, India

Corresponding Author:
Naveen Kumar Tulluru
Department of Vegetable Science, College of Horticulture, Venkataramannagudem, Dr. Y. S. R. H. U, Andhra Pradesh, India

Studies on combining ability for growth, yield and quality attributing characters in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.)

Naveen Kumar Tulluru, K Uma Jyothi, M Ravindra Babu, M Paratpararao, E Padma and V Sekhar

Abstract
The present study was conducted at College of Horticulture, Dr. Y. S. R. Horticultural University, Venkataramannagudem, Andhra Pradesh, India during 2019-2020, to study the combining ability of ten different lines of bottle gourd. They were mated diallel fashion excluding reciprocals and their forty-five crosses were evaluated along with ten parents and two checks in Randomized block design (RBD) for growth, yield and quality attributing characters. Significant differences of analysis of variances due to GCA and SCA were observed for all the characters, it indicates predominance of non additive and additive gene action, that provides ample scope for heterosis breeding or direct selection. Out of the ten parents studied Local Round, Pusa Samridhi, Pant Lauki-3 and Kashi Ganga were found to be good general combiners for quality, yield and quality characters. Based on SCA effects, eight cross combinations *viz.*, Pusa Naveen x Arka Bahar, Pusa Naveen x Kashi Ganga, Pusa Naveen x Punjab Bahar, Pusa Samridhi x Pant Lauki-3, Pusa Samridhi x Local Round, Pusa Santhusti x Kashi Ganga, Pant Lauki-3 x Local Round, Pant Lauki-3 x Local Long were identified as promising for fruit yield per vine, fruit length and average fruit weight. The knowledge of combining ability helps in identifying good combiners for hybridization.

Keywords: Bottle gourd, randomized block design, fruit yield per vine, estimated yield per hectare

Introduction
Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) is a tropical and subtropical vine, belongs to the family cucurbitaceae with chromosome number 2 n = 22. Bottle gourd is one of the cultivated annual monoecious species. It is commonly known as white flowered gourd, ghia, lauki, calabash gourd etc. It is widely grown for edible fruit. Fruit pulp is used as an antidote against certain poisons and is good for controlling constipation, night blindness and cough. Bottle gourd seeds are good sources of lipids and proteins, micro and macro nutrients and if properly utilized, could contribute in solving the problem of malnutrition and also serve as raw material for agro-based industries (Hassan *et al*., 2008) [6].

During recent years, the commercial exploitation of hybrid vigour and selection of parents on the basis of combining ability have expanded a new alley in crop improvement. The concept of combining ability for the evaluation of parents in a crossing programme is of immense importance. Hybridization is one of the most important technique for breaking yield barriers and evolving varieties having high yielding potential. The selection of suitable parents is one of the most important step in heterosis breeding. Selection of parents on the basis of phenotypic performance alone is not a sound procedure, since phenotypically superior lines may not lead to expected degree of heterosis. Thus, one of the potential tool for identifying prospective parents for hybridization and shifting productive hybrids from a set of crosses in F_1 generation is the analysis of combining ability (Griffing, 1956) [5].

Materials and Methods
The experimental material consisted of ten parental lines *viz*., Pusa Naveen, Pusa Samridhi, Pusa Santhusti, Pusa Sandesh, Arka Bahar, Kashi Ganga, Punjab Bahar, Pant Lauki-3, Local Round and Local Long were crossed in diallel fashion excluding reciprocals during *summer*, 2019. The resultant 45 F1 hybrids along with ten parents and two checks were evaluated in randomized block design with two replications with spacing of 3.0 x 0.9 m during *kharif*, 2019. Observations were recorded on five randomly selected plants from each plot for growth, yield and quality characters *viz.*, vine length (cm), number of nodes per vine, internodal length

(cm), number of secondary branches (lateral branches) per plant, node number at which first male flower appear, node number at which first female flower appear, days to first appearance of male flower, days to first appearance of female flower, sex ratio (m:f), days to first fruit harvest, number of fruits per vine, fruit length (cm), fruit diameter (cm), fruit volume (cc), average fruit weight (g), number of seeds per fruit, fruit yield per vine (kg), fruit yield per plot (kg), estimated yield per hectare (q), total soluble solids (°b), vitamin – C (mg $100g^{-1}$).

Results and Discussion

The analysis of variances for general combining ability are highly significant for all the characters like vine length, number of nodes per vine, internodal length, number of secondary branches (lateral branches) per plant, node number at which first male flower appear, node number at which first female flower appear, days to first appearance of male flower, days to first appearance of female flower, sex ratio, days to first fruit harvest, number of fruits per vine, fruit length, fruit diameter, fruit volume, average fruit weight, number of seeds per fruit, fruit yield per vine, fruit yield per plot, estimated yield per hectare, total soluble solids and vitamin-C. The variances for specific combining ability are highly significant for all the characters studied indicating the importance of both additive and non-additive genetic components for most of the characters, except for total soluble solids (Table-1). The *gca* effects of parents were significant for most of the characters studied which indicated the existence of variability among the parents selected for hybridization (Tables-2, 3, 4). Information regarding *gca* effect of the parent is of prime importance as it helps in successful prediction of genetic potentiality of crosses.

The parents Pusa Naveen and Local Round were found to be good general combiners for earliness and yield, quality characters respectively can be used in bottle gourd breeding programme. The parents with good *gca* for the characters also exhibited good *per se* performance. Similar results for some of the characters were reported by Adarsh *et al*., (2015) [1], Shinde *et al*., (2016) [12], Rani and Reddy (2017) [11], Jayanth *et al.,* (2019) [7] in bottle gourd.

The cross combination, Pusa Sandesh x Kashi Ganga exhibited significant negative sca effects for days to first female flowering which contributed for improving the earliness trait. The cross combination, Pusa Naveen x Pusa Santhusti showed significant positive sca effects for number of fruits per vine which contributed for improving the yield traits. Similar results are conformity with the findings of Dubey and Maurya (2006) [4], Doloi *et al.* (2017) [3], Rani and Reddy (2017) [11] in bottle gourd and Divya *et al.,* (2018) [2] in ridge gourd.

The potential cross combinations, Pusa Samridhi × Local Round, Pusa Samridhi × Pant Lauki-3, Pant Lauki-3 × Local Long and Kashi Ganga × Local Round exhibited maximum and significant sca effects for fruit yield per vine (Tables-5, 6, 7). Hence, cross combinations, with higher specific combining ability effects are useful to derive high performing hybrids. Similar results were also reported by Shinde *et al*., (2016) [12], Malviya *et al*., (2017) [9], Rani and Reddy (2017) [11], Khot (2017) [8], Quamruzzaman *et al*., (2019) [10] in bottle gourd and Divya *et al.,* (2018) [2] in ridge gourd.

Table 1: Analysis of variance of combining ability analysis for growth, yield and quality attributing characters in 10x10 half diallel of bottle gourd.

Source of variation	Mean sum of squares		
	Gca	Sca	Error
Degrees of freedom	9	45	54
Characters			
Growth parameters			
Vine length (cm)	135009.80**	56159.70**	443.55
Number of nodes per vine	464.57**	400.10**	3.86
Internodal length (cm)	5.33**	2.67**	0.64
Number of secondary branches (lateral branches) per plant	2.34**	0.54**	0.13
Node number at which first male flower appear	4.88**	2.17**	0.10
Node number at which first female flower appear	34.69**	11.26**	0.60
Days to first appearance of male flower	24.25**	4.55**	0.31
Days to first appearance of female flower	18.44**	6.16**	0.18
Sex ratio (m:f)	40.59**	25.65**	0.63
Days to first fruit harvest	17.91**	5.10**	0.45
Yield parameters			
Number of fruits per vine	2.02**	1.91**	0.12
Fruit length (cm)	740.50**	71.95**	2.94
Fruit diameter (cm)	58.88**	4.14**	0.35
Fruit volume (cc)	245216.30**	165314.10**	6028.25
Average fruit weight (g)	87129.79**	211851.70**	581.69
Number of seeds per fruit	8476.87**	5749.65**	49.52
Fruit yield per vine (kg)	4.34**	4.69**	0.28
Fruit yield per plot (kg)	156.46**	169.04**	10.43
Estimated yield per hectare (q)	5958.92**	6438.82**	254.33
Quality parameters			
Total soluble solids (° B)	1.41**	0.00	0.00
Vitamin –C (mg $100g^{-1}$)	3.20**	0.08**	0.00

* and ** indicates Significance at p = 0.05 and p = 0.01, respectively. GCA - General combining ability, SCA - Specific combining ability.

Table 2: Estimates of general combining ability effects for growth characters in 10x10 half diallel of bottle gourd

S. No.	Parent	VL	NNPV	IL	NSBPP	NNMFA	NNFFFA	DFAMF
1	P1	-34.11**	-0.56	0.31	0.46**	0.28*	-2.34**	-0.96**
2	P2	-74.43**	-4.03**	0.72**	0.007	0.38**	-0.27	-1.11**
3	P3	-70.52**	-4.86**	-0.84**	-0.12	-0.07	-1.43**	-0.82**
4	P4	-72.05**	-5.03**	-1.02**	-0.30**	-1.02**	-1.53**	-1.20**
5	P5	-96.66**	-5.91**	-0.21	-0.30**	-0.77**	-1.44**	0.30
6	P6	-20.11**	1.89**	-0.67**	-0.32**	0.27**	1.62**	0.77**
7	P7	129.57**	8.87**	0.50*	0.11	-0.25**	0.67**	-0.77**
8	P8	123.65**	10.16**	0.21	-0.27**	-0.25**	0.20	-0.47**
9	P9	191.47**	5.32**	0.9**	1.03**	1.24**	2.78**	3.42**
10	P10	-76.78**	-5.82**	0.10	-0.29**	0.18*	1.74**	0.83**
	SE (gi)	13.04	1.22	0.49	0.22	0.20	0.48	0.34
	SE (gi-gj)	19.45	1.81	0.74	0.34	0.29	0.72	0.51

* and ** indicates Significance at p = 0.05 and p = 0.01, respectively.

P1 = Pusa Naveen, P2 = Pusa Samridhi, P3 = Pusa Santhusti, P4 = Pusa Sandesh, P5 = Arka Bahar, P6 = Kashi Ganga, P7 = Punjab Bahar, P8 = Pant Lauki-3, P9 = Local Round, P10 = Local Long. VL = Vine length (cm), NNPV = Number of nodes per vine, IL = Internodal length (cm), NSBPP = Number of secondary branches (lateral branches) per plant, NNFMFA = Node number at which first male flower appear, NNFFFA = Node number at which first female flower appear, DFAMF = Days to first appearance of male flower.

Table 3: Estimates of general combining ability effects for growth and yield attributing characters in 10x10 half diallel of bottle gourd

S. No.	Parent	DFAFF	SR	DFFH	NFPV	FL	FD	FV
1	P1	-1.28**	0.42	-1.03**	-0.01	1.95**	-1.51**	215.04**
2	P2	-0.16	-2.19**	-0.24	0.30**	1.92**	-0.49**	91.70**
3	P3	-0.77**	-1.21**	-1.2**	0.06	-5.19**	1.33**	25.66
4	P4	-1.02**	-1.47**	-1.85**	0.26**	-5.39**	1.44**	-221.62**
5	P5	0.08	-0.55*	0.99**	-0.38**	3.45**	-1.761**	93.37**
6	P6	0.15	1.32**	0.73**	-0.20*	7.89**	-1.96**	-74.33**
7	P7	0.56**	3.11**	-0.52**	-0.48**	-11.68**	3.49**	-75.37**
8	P8	-0.43**	2.64**	0.56**	-0.20*	10.81**	-2.65**	-201.62**
9	P9	3.14**	-1.68**	2.23**	0.90**	-10.74**	3.21**	10.04
10	P10	-0.27*	-0.37	0.39*	-0.24*	6.98**	-1.09**	137.12**
	SE (gi)	0.26	0.49	0.41	0.21	1.06	0.36	48.10
	SE (gi-gj)	0.39	0.73	0.62	0.32	1.58	0.54	71.70

* and ** indicates Significance at p = 0.05 and p = 0.01, respectively.

P1 = Pusa Naveen, P2 = Pusa Samridhi, P3 = Pusa Santhusti, P4 = Pusa Sandesh, P5 = Arka Bahar, P6 = Kashi Ganga, P7 = Punjab Bahar, P8 = Pant Lauki-3, P9 = Local Round, P10 = Local Long. DFAFF = Days to first appearance of female flower, SR = Sex ratio (m:f), DFFH = Days to first fruit harvest, NFPV = Number of fruits per vine, FL = Fruit length (cm), FD = Fruit diameter (cm), FV = Fruit volume (cc).

Table 4: Estimates of general combining ability effects for yield and quality attributing characters in 10x10 half diallel of bottle gourd.

S. No.	Parent	AFW	NSPF	FYPV	FYPP	EYPH	TSS	VIT-C
1	P1	21.82**	37.02**	-0.32*	-1.94*	-12.02**	-0.40**	-0.70**
2	P2	50.65**	21.66**	0.98**	5.92**	36.56**	0.24**	0.26**
3	P3	-107.40**	-47.62**	-0.37*	-2.26*	-13.97**	-0.06**	-0.37**
4	P4	-160.03**	-17.76**	-0.43**	-2.64**	-16.31**	-0.26**	-0.66**
5	P5	116.45**	26.47**	-0.06	-0.39	-2.41	-0.21**	0.93**
6	P6	45.94**	20.94**	0.05	0.34	2.13	0.19**	-0.09**
7	P7	58.05**	-2.41	-0.61**	-3.71**	-22.95**	-0.06**	0.35**
8	P8	29.20**	-26.71**	0.10	0.64	3.99	0.15**	0.07**
9	P9	-70.74**	-3.86	1.11**	6.69**	41.31**	0.74**	0.42**
10	P10	16.05*	-7.73**	-0.44**	-2.64**	-16.32**	-0.32**	-0.20**
	SE (gi)	14.94	4.36	0.33	2.00	9.88	0.03	0.04
	SE (gi-gj)	22.27	6.49	0.49	2.98	14.72	0.04	0.07

* and ** indicates Significance at p = 0.05 and p = 0.01, respectively.

P1 = Pusa Naveen, P2 = Pusa Samridhi, P3 = Pusa Santhusti, P4 = Pusa Sandesh, P5 = Arka Bahar, P6 = Kashi Ganga, P7 = Punjab Bahar, P8 = Pant Lauki-3, P9 = Local Round, P10 = Local Long. AFW = Average fruit weight (g), NSPF = Number of seeds per fruit, FYPV = Fruit yield per vine (kg), FYPP = Fruit yield per plot (kg), EYPH = Estimated yield per hectare (q), TSS = Total soluble solids (°B), VIT-C = Vitamin –C (mg $100g^{-1}$).

Table 5: Estimates of specific combining ability effects for growth attributing characters in 10x10 half diallel of bottle gourd.

Sl. No.	Cross	VL	NNPV	IL	NSBPP	NNMFA	NNFFFA	DFAMF
1	P1 X P2	127.86**	6.62**	-0.74	0.38	1.07 **	1.03	-0.44
2	P1 X P3	32.75	9.96**	-0.31	0.71*	0.87 **	0.18	-0.73
3	P1 X P4	304.77**	13.13**	-0.32	0.68*	0.22	0.09	2.94**
4	P1 X P5	-1.94	-1.01	0.82	0.58	-0.12	0.60	0.33
5	P1 X P6	223.21**	23.74**	-0.55	-0.49	0.72 *	1.53*	-1.12*
6	P1 X P7	-355.86**	6.25**	0.58	-0.42	1.35 **	0.58	-0.93
7	P1 X P8	-281.72**	-27.61**	1.52*	-0.44	-0.54	-1.44	-0.83
8	P1 X P9	-59.51**	1.78	1.70*	0.15	-1.04 **	-0.92	-3.67**
9	P1 X P10	62.76**	1.90	2.79**	1.58**	0.01	1.51*	-2.04**
10	P2 X P3	139.09**	21.95**	-0.17	0.26	0.97 **	4.31**	0.71
11	P2 X P4	-132.40**	-9.45**	0.81	0.79*	0.92 **	4.32**	0.19
12	P2 X P5	449.45**	29.50**	-0.18	0.14	2.47 **	6.03**	-0.31
13	P2 X P6	-107.08**	-0.34	3.98**	0.76*	0.62 *	1.26	0.67
14	P2 X P7	87.78**	16.72**	0.13	0.42	1.35**	-1.39	-0.23
15	P2 X P8	-112.63**	-11.12**	-1.19	-0.38	-0.04	0.88	0.56
16	P2 X P9	-160.47**	-26.82**	-0.98	-1.09**	-2.34 **	-3.40**	-2.92**
17	P2 X P10	-85.74**	-14.16**	0.16	-0.66	-2.28 **	-3.96**	-1.44**
18	P3 X P4	30.12	4.91**	2.40**	-0.52	1.57 **	0.28	0.10
19	P3 X P5	75.80**	5.78**	-0.09	-0.22	1.32 **	0.68	0.39
20	P3 X P6	-121.33**	1.49	-2.61**	-0.30	0.47	-2.97**	-1.41**
21	P3 X P7	-131.03**	-22.52**	0.55	-0.04	-0.58	0.96	-0.82
22	P3 X P8	-147.02**	-28.82**	2.64**	-0.20	0.41	1.53*	1.37*
23	P3 X P9	-72.09**	-24.48**	0.37	-0.86*	-2.48**	-1.24	-3.11**
24	P3 X P10	336.32**	43.28**	1.25	-0.23	0.17	0.89	-0.83
25	P4 X P5	50.04*	19.48**	0.10	0.45	1.07 **	1.79*	-0.51
26	P4 X P6	241.21**	5.16**	2.09**	-1.02**	-0.97**	-1.76*	-2.88**
27	P4 X P7	-200.17**	-18.84**	0.88	0.23	-0.83**	-0.52	-0.44
28	P4 X P8	-215.41**	-3.60	0.74	-0.07	0.66 *	0.74	-0.79
29	P4 X P9	-120.86**	-7.78**	-1.82*	-1.28**	-1.13 **	-3.13**	-0.13
30	P4 X P10	-20.99	1.86	-1.48	0.84*	-0.68 *	4.20**	0.04
31	P5 X P6	-25.16	10.04**	0.30	-0.32	-1.12 **	1.03	-1.39**
32	P5 X P7	-124.72**	-30.99**	-1.55*	0.035	1.31 **	0.58	0.14
33	P5 X P8	-26.58	21.32**	-0.68	0.42	-1.58 **	-0.74	0.84
34	P5 X P9	-179.04**	-21.43**	-0.03	-0.68*	-1.48 **	-1.72*	-4.04**
35	P5 X P10	-205.55**	-23.31**	-2.33**	-0.10	0.07	2.71**	5.58**
36	P6 X P7	-26.55	-13.25**	1.64*	-0.14	0.06	0.11	-0.11
37	P6 X P8	232.16**	21.03**	-0.20	0.34	1.86 **	4.48**	-0.21
38	P6 X P9	-62.85**	-4.69*	-0.73	0.33	0.96 **	6.30**	3.13**
39	P6 X P10	269.56**	1.44	-0.10	0.16	-0.08	6.64**	1.77**
40	P7 X P8	694.75**	37.60**	-0.43	0.10	0.69 *	-1.06	0.12
41	P7 X P9	240.46**	22.90**	0.11	1.44**	-1.70**	0.64	3.63**
42	P7 X P10	-112.32**	3.49	-1.19	-0.47	-0.84**	-2.41**	-2.18**
43	P8 X P9	-531.83**	-21.98**	-2.29**	-0.56	-0.80 **	1.92*	-3.36**
44	P8 X P10	-78.90**	-20.35**	1.21	0.21	-0.64 *	3.46**	0.26
45	P9 X P10	-83.98**	1.53	2.80**	-1.19**	0.05	-0.71	2.02**
	SE (gi)	39.09	3.65	1.48	0.67	0.60	1.44	1.03
	SE (gi-gj)	57.47	5.36	2.18	0.99	0.88	2.12	1.52

* and ** indicates Significance at p = 0.05 and p = 0.01, respectively.

P1 = Pusa Naveen, P2 = Pusa Samridhi, P3 = Pusa Santhusti, P4 = Pusa Sandesh, P5 = Arka Bahar, P6 = Kashi Ganga, P7 = Punjab Bahar, P8 = Pant Lauki-3, P9 = Local Round, P10 = Local Long. VL = Vine length (cm), NNPV = Number of nodes per vine, IL = Internodal length (cm), NSBPP = Number of secondary branches (lateral branches) per plant, NNFMFA = Node number at which first male flower appear, NNFFFA = Node number at which first female flower appear, DFAMF = Days to first appearance of male flower.

Table 6: Estimates of specific combining ability effects for growth and yield attributing characters in 10x10 half diallel of bottle gourd.

Sl. No.	Cross	DFAFF	SR	DFFH	NFPV	FL	FD	FV
1	P1 X P2	-2.67**	0.99	-1.47 *	-0.24	-4.67**	1.76**	-231.70**
2	P1 X P3	-1.06*	-3.04**	0.54	2.29**	7.51**	-1.93**	29.33
3	P1 X P4	0.78	1.60*	0.73	-0.30	5.18**	-2.58**	-628.37**
4	P1 X P5	1.28**	0.75	2.48**	-0.66*	13.0**	1.05	236.62**
5	P1 X P6	0.01	7.19**	-0.45	-0.89**	6.11**	2.59**	704.33**
6	P1 X P7	-0.30	2.11**	-1.10	-0.51	5.62**	-0.92	380.37**
7	P1 X P8	0.80*	-2.38**	-0.08	-1.54**	-12.04**	2.56**	216.62**
8	P1 X P9	-0.78	4.67**	-1.75 **	-1.82**	-3.31*	-1.33*	-605.03**
9	P1 X P10	-2.36**	4.05**	-2.91 **	-1.41**	-5.80**	1.16*	17.87
10	P2 X P3	2.41**	3.74**	1.35 *	0.02	1.44	-1.37*	-172.33*
11	P2 X P4	4.26**	-0.35	3.54 **	-0.84*	8.88**	-3.53**	-200.03**
12	P2 X P5	3.16**	2.35**	2.69 **	1.21**	-2.74	-0.009	159.96*
13	P2 X P6	2.78**	-2.05**	2.64 **	0.51	1.82	-1.10*	-472.33**
14	P2 X P7	-1.92**	5.57**	-3.39 **	-0.61	-8.57**	4.56**	-921.28**
15	P2 X P8	-1.62**	-4.95**	-2.18 **	1.16**	4.74**	0.36	104.96
16	P2 X P9	-4.50**	-4.12**	-5.14 **	0.37	6.99**	1.48**	468.29**
17	P2 X P10	-1.48**	-0.98	-0.70	-1.04**	5.77**	0.38	791.21**
18	P3 X P4	-0.33	-1.63*	-0.63	0.82*	-4.44**	3.17**	441.00**
19	P3 X P5	-0.03	1.88*	-0.08	-0.42	0.43	-0.21	-623.99**
20	P3 X P6	-1.50**	0.08	-1.22	-0.4	4.74**	-0.13	81.21
21	P3 X P7	-1.51**	-0.85	-1.56 *	-1.45**	-0.94	2.21**	-180.24*
22	P3 X P8	0.18	-3.25**	0.04	-1.37**	0.81	1.08	346.00**
23	P3 X P9	-3.69**	-3.06**	-2.91 **	-0.78*	1.41	1.27*	209.33**
24	P3 X P10	-0.48	9.95**	-0.28	-0.49	-2.97	-0.47	-567.74**
25	P4 X P5	-0.78	6.13**	-0.50	-0.86**	5.45**	-1.44*	-26.70
26	P4 X P6	-4.45**	2.16**	-3.84 **	-0.90**	2.15	-1.17*	266.00**
27	P4 X P7	-0.46	-3.90**	-0.18	-0.48	-2.65	2.07**	67.04
28	P4 X P8	-0.06	-2.58**	1.13	0.19	2.03	-2.17**	-81.70
29	P4 X P9	-2.84**	2.52**	-2.73 **	-1.86**	-4.22*	0.72	306.62**
30	P4 X P10	0.46	-2.07**	0.99	0.52	25.41**	0.43	329.54**
31	P5 X P6	-2.95**	5.67**	-3.09 **	-0.97**	2.32	0.49	-23.99
32	P5 X P7	-0.96*	-4.06**	0.56	-1.06**	13.13**	-2.93**	477.04**
33	P5 X P8	-1.36**	4.50**	-1.91 **	-0.08	-6.05**	1.83**	-296.70**
34	P5 X P9	-1.14**	-1.87*	0.21	-1.08**	1.79	0.56	-58.37
35	P5 X P10	-0.23	-4.62**	-0.45	-0.62	7.04**	0.03	-460.45**
36	P6 X P7	-1.44**	-2.69**	-0.57	-0.34	1.84	-2.21**	219.75**
37	P6 X P8	0.25	7.11**	1.03	-0.77*	1.44	0.74	-553.99**
38	P6 X P9	4.37**	-3.80**	2.07 **	1.07**	-7.98**	-0.11	-465.66**
39	P6 X P10	-0.20	1.79*	-0.09	-0.83*	3.99*	0.23	-442.74**
40	P7 X P8	-0.24	15.39**	0.19	-0.89**	1.07	-3.94**	-552.95**
41	P7 X P9	5.76**	6.26**	5.13**	-0.81*	5.49**	2.63**	310.37**
42	P7 X P10	0.38	0.14	1.16	-0.07	1.47	-2.79**	158.29*
43	P8 X P9	-3.83**	-4.53**	-1.55*	-0.10	7.13**	-4.43**	-63.37
44	P8 X P10	0.78	-5.01**	1.48*	-0.15	3.49*	1.45*	384.54**
45	P9 X P10	-2.10**	1.32	-2.48**	-0.71*	-2.88	-0.57	-352.12**
	SE (gi)	0.79	1.47	1.24	0.64	3.18	1.10	144.13
	SE (gi-gj)	1.17	2.17	1.83	0.94	4.68	1.61	211.87

* and ** indicates Significance at p = 0.05 and p = 0.01, respectively.

P1 = Pusa Naveen, P2 = Pusa Samridhi, P3 = Pusa Santhusti, P4 = Pusa Sandesh, P5 = Arka Bahar, P6 = Kashi Ganga, P7 = Punjab Bahar, P8 = Pant Lauki-3, P9 = Local Round, P10 = Local Long. DFAFF = Days to first appearance of female flower, SR = Sex ratio (m:f), DFFH = Days to first fruit harvest, NFPV = Number of fruits per vine, FL = Fruit length (cm), FD = Fruit diameter (cm), FV = Fruit volume (cc).

Table 7: Estimates of specific combining ability effects for yield and quality attributing characters in 10x10 half diallel of bottle gourd.

Sl. No.	Cross	AFW	NSPF	FYPV	FYPP	EYPH	TSS	VIT-C
1	P1 X P2	-185.22**	104.37**	-0.89	-5.38	-33.23*	0.000	-0.16*
2	P1 X P3	-717.04**	-146.80**	-1.31*	-7.91*	-48.86**	0.002	1.59**
3	P1 X P4	1.95	50.20**	0.25	1.53	9.50	0.005	-0.16*
4	P1 X P5	344.65**	13.92*	1.00*	6.03*	37.19*	-0.004	0.03

5	P1 X P6	807.64**	139.16**	2.41**	14.46**	89.30**	0.000	-0.12
6	P1 X P7	685.51**	218.09**	2.87**	17.22**	106.29**	-0.003	-0.12
7	P1 X P8	134.81**	-11.52	-1.68**	-10.12**	-62.51**	0.000	-0.13
8	P1 X P9	-61.33**	-25.81**	-2.48**	-14.88**	-91.85**	0.002	-0.12
9	P1 X P10	361.32**	-53.99**	-0.20	-1.24	-7.68	-0.001	-0.12
10	P2 X P3	33.45	-23.34**	0.17	1.05	6.49	-0.002	-0.16*
11	P2 X P4	80.17**	-43.62**	-0.59	-3.58	-22.12	0.000	-0.009
12	P2 X P5	-499.48**	-8.75	-0.93	-5.59	-34.51*	0.002	0.19**
13	P2 X P6	-118.82**	-62.30**	0.11	0.68	4.25	0.000	0.03
14	P2 X P7	634.17**	31.15**	1.96**	11.76**	72.57**	0.002	0.03
15	P2 X P8	145.99**	54.96**	2.73**	16.37**	101.08**	0.000	0.03
16	P2 X P9	571.92**	102.72**	4.55**	27.32**	168.61**	-0.003	0.03
17	P2 X P10	531.14**	-50.11**	0.73	4.38	27.06	0.000	0.03
18	P3 X P4	354.66**	13.14*	3.54**	21.28**	131.35**	0.002	-0.16*
19	P3 X P5	-43.27	28.25**	-0.62	-3.78	-23.33	0.004	0.04
20	P3 X P6	344.82**	-58.63**	1.08*	6.513*	40.20**	-0.002	-0.13
21	P3 X P7	268.69**	-68.31**	-0.99	-5.95	-36.77*	0.000	-0.12
22	P3 X P8	-197.60**	-60.52**	-2.91**	-17.52**	-108.15**	-0.003	-0.12
23	P3 X P9	468.51**	87.37**	1.44**	8.64**	53.34**	0.000	-0.13
24	P3 X P10	-331.05**	30.65**	-1.93**	-11.57**	-71.41**	-0.003	-0.12
25	P4 X P5	310.44**	14.15*	0.35	2.17	13.38	-0.004	0.19**
26	P4 X P6	-88.69**	-9.39	-1.58**	-9.48**	-58.53**	0.000	0.03
27	P4 X P7	498.67**	-73.63**	2.04**	12.24**	75.54**	-0.003	0.03
28	P4 X P8	402.70**	58.33**	2.54**	15.26**	94.18**	0.000	0.03
29	P4 X P9	-327.61**	-78.19**	-4.05**	-24.34**	-150.23**	0.002	0.03
30	P4 X P10	-279.35**	41.34**	-0.39	-2.36	-14.60	-0.001	0.03
31	P5 X P6	-336.17**	-42.77**	-2.88**	-17.31**	-106.86**	0.002	-0.25**
32	P5 X P7	640.01**	25.35**	0.54	3.29	20.34	-0.001	-0.26**
33	P5 X P8	-53.93*	-80.04**	-0.42	-2.55	-15.74	0.001	-0.25**
34	P5 X P9	156.94**	12.27	-0.72	-4.32	-26.71	0.004	-0.25**
35	P5 X P10	363.42**	-16.92*	0.77	4.63	28.62	0.001	-0.25**
36	P6 X P7	-210.75**	79.94**	-1.28*	-7.67*	-47.35**	0.002	0.07
37	P6 X P8	-70.86**	-69.01**	-1.76**	-10.58**	-65.31**	0.000	0.07
38	P6 X P9	48.58*	81.89**	2.15**	12.92**	79.73**	-0.003	0.07
39	P6 X P10	92.72**	33.19**	-1.14*	-6.86*	-42.38**	0.000	0.07
40	P7 X P8	-787.78**	-70.18**	-4.34**	-26.05**	-160.78**	0.002	0.07
41	P7 X P9	-108.65**	-98.55**	-1.42**	-8.53**	-52.67**	0.000	0.07
42	P7 X P10	-162.85**	15.98*	-0.33	-2.01	-12.43	0.002	0.07
43	P8 X P9	326.81**	8.38	1.70**	10.26**	63.34**	-0.003	0.07
44	P8 X P10	905.31**	-15.28*	4.10**	24.63**	152.05**	0.004	0.07
45	P9 X P10	-383.71**	-22.06**	-2.74**	-16.49**	-101.79**	0.002	0.07
	SE (gi)	44.77	13.06	0.99	5.99	29.60	0.09	0.14
	SE (gi-gj)	65.81	19.20	1.46	8.81	43.52	0.13	0.21

* and ** indicates Significance at p = 0.05 and p = 0.01, respectively.

P1 = Pusa Naveen, P2 = Pusa Samridhi, P3 = Pusa Santhusti, P4 = Pusa Sandesh, P5 = Arka Bahar, P6 = Kashi Ganga, P7 = Punjab Bahar, P8 = Pant Lauki-3, P9 = Local Round, P10 = Local Long. AFW = Average fruit weight (g), NSPF = Number of seeds per fruit, FYPV = Fruit yield per vine (kg), FYPP = Fruit yield per plot (kg), EYPH = Estimated yield per hectare (q), TSS = Total soluble solids (°B), VIT-C = Vitamin –C (mg $100g^{-1}$).

Conclusion

The present investigation indicates that combining ability helps in identifying good combiners and cross combinations for hybridization and to exploit heterosis. Among ten parents studied Pusa Naveen and Local Round is identified as good general combiner as it made significant contribution towards earliness and yield, quality characters. The cross combination, Pusa Sandesh x Kashi Ganga exhibited significant negative sca effects for days to first female flowering which contributed for improving the earliness trait. The cross combination, Pusa Naveen x Pusa Santhusti showed significant positive sca effects for number of fruits per vine which contributed for improving the yield traits. The potential cross combinations, Pusa Samridhi × Local Round, Pusa Samridhi × Pant Lauki-3, Pant Lauki-3 × Local Long and Kashi Ganga × Local Round exhibited maximum and significant sca effects for fruit yield per vine. These studies were prerequisite for breeding programmes.

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