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Combining Ability Studies for Fruit Yield and its Components in Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl.]

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ABSTRACT: Forty five bottle gourd genotypes comprising 36 hybrids and 9 parents were evaluated in four different environments for combining ability analysis for days to opening first female flower, days to opening first male flower, number of node bearing first female flower, number of node bearing first male flower, vine length (cm), days to first picking, fruit length (cm), fruit equatorial diameter (cm), number of fruits per plant, average fruit weight per plant (kg), days to last picking and fruit yield per plant (kg). The data were analyzed as per Method-II, Model-I of Griffing (1956). The results revealed that, both additive and non-additive gene effects played an important role in the genetic control of the traits studied. The σ^2_{GCA} / σ^2_{SCA} ratio was more than unity for days to first opening female flower, days to first opening male flower, vine length, fruit equatorial diameter and number of fruits per plant indicates the preponderance of additive gene action for these traits, while for number of node bearing first female flower, number of node bearing first male flower, days to first picking, fruit length and fruit yield per plant, non-additive gene action played an important role in its improvement. For days to last picking and average fruit weight per plant, both additive and non-additive gene actions were equally important. On pooled basis, parents ABG 1, NDBG 132, Arka Bahar and Pusa Naveen were found good general combiners for fruit yield per plant. On the basis of significant positive sca effects for fruit yield per plant, ABG 1 × Arka Bahar (1.69), Punjab Long × DBG 5 (1.63) and Samrat × DBG 6 (1.10) were three best hybrids, are expected through-off transgressive segregants in segregating generation.

Keywords: Bottle gourd, Combining ability, Gene action.

INTRODUCTION

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl. 2n = 2x = 22], also known as white flower gourd, Ghiakadoo or Lauki, is an important cucurbitaceous vegetable crop belongs to family *Cucurbitaceae* and subfamily *Cucurbitoidae*. The *Lagenaria siceraria* is the only annual and monoecious cultivated species of bottle gourd, while other species are wild, perennial and dioecious. In India, bottle gourd is cultivated in 157 million hectares during 2017-18 with production of 2683 million tones and productivity of 17.08 tonnes per hectare (Anon., 2018). According to De Candolle (1882), bottle gourd has been found in wild form in South Africa and India. However, Cutler and Whitaker (1961) are of the view that probably it is indigenous to tropical Africa on the basis of variability in seeds and fruits.

Bottle gourd is a highly cross pollinated crop because of its monoecious sex form and it exhibits large amount of variation for its quantitative traits. The crop is well suited for improvement through inbreeding followed by selection without significant loss in vigour. Therefore, high yielding inbreds can be developed easily with desired uniformity in important morphological traits.

The selection of parents to be included in hybridization programme is a vital step for plant breeders for the improvement of complex quantitative trait, such as fruit yield and its components in crops like bottle gourd. The use of parents of known superior genetic value ensures much better achievement. It needs extensive and meticulous genetic assessment of available germplasm as well as newly developed promising lines, which could be used in future breeding programme or could be directly released as a cultivar after thorough testing.

Among the various mating designs, diallel technique suggested by Schmidt (1919) and Hayman (1954), and elaborated by Griffing (1956) is a useful methodology for evaluating parents and crosses for their combining ability effects and understanding the nature of gene effects. Diallel analysis gives overall genetic architecture of the polygenic characters in a single generation.

MATERIALS AND METHODS

The experimental material comprised of 45 entries includes nine parents (ABG 1, Punjab Long, NDBG 132, Arka Bahar, Pusa Naveen, DBG 5, Samrat, DBG 6 and Santosh) and their 36 F_1s developed through half diallel mating design excluding reciprocals. Parent ABG 1 was used as a standard check. The materials were evaluated following Randomized Block Design replicated thrice over four environments during *kharif* 2018 and *summer* 2019 at Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh. Each entry was grown in a single row plot of 10 m length keeping row-to-row and plant-to-plant distance of 2 m and 1 m, respectively. The recommended cultural practices and plant protection measures were pursued to raise a healthy crop of bottle gourd. Four environments were created by date of sowing in two different seasons. Five competitive plants per entry in each replication in each environment were selected randomly for recording observations on different characters *viz.*, number of node bearing first female flower, number of node bearing first male flower, vine length (cm), days to first picking, fruit length (cm), fruit equatorial diameter (cm), number of fruits per plant, average fruit weight per plant (kg), days to last picking and fruit yield per plant (kg). The characters, days to opening first female flower and days to opening first male flower were recorded on plot basis. The data were analyzed for heterosis and combining ability as per Method-II, Model-I of Griffing (1956).

RESULTS AND DISCUSSION

The analysis of variance for combining ability by partitioning the total genetic variance into general combining ability and specific combining ability was carried out by the procedure suggested by Griffing (1956) Method-2 and Model-I for twelve different characters pooled over environments. Across the environments (Table 1), mean squares due to general combining ability, specific combining ability and environments were significant for all characters studied except for fruit length due to environments. The significant difference of gca and sca indicated that, both additive and non-additive gene effects played an important role in the genetic control of the traits studied. These results are in accordance with the findings of Shaikh *et al.,* (2012), Kumar *et al.* (2014), Adarsh *et al.*, (2015), Rani and Reddy (2017), Mishra *et al.,* (2019), Quamruzzaman *et al.,* (2019), Khot *et al.,* (2021) and Patel and Mehta (2021). The mean squares due to gca x environment interactions were significant for number of node bearing first male flower, vine length, fruit equatorial diameter and average fruit weight per plant, while mean squares due to sca x environment interactions were significant for all the traits studied.

Table 1: Analysis of variance and variance estimates for combining ability for different characters in pooled over environments in bottle gourd.

Source of variation	GCA	SCA	Environments (E)	GCA x Environment	SCA x Environment	Error	σ^2_{GCA}	σ^2_{SCA}	$\sigma^2_{GCA}/\sigma^2_{SCA}$
d f	8	36	3	24	108	352			
Days to first opening female flower	160.32**	15.06**	76.98**	3.73	1.42**	2.45	3.58	3.15	1.14
Days to first opening male flower	123.69**	9.32**	99.76**	2.07	1.78*	2.00	2.76	1.83	1.51
Number of node bearing first female flower	2.34**	0.46**	40.33**	0.07	0.10**	0.06	0.05	0.10	0.50
Number of node bearing first male flower	2.48**	0.70**	38.50**	1.80**	0.15**	0.09	0.05	0.15	0.33
Vine length (m)	2.54**	0.31**	2.24**	0.47**	0.23**	0.12	0.05	0.04	1.25
Days to first picking	77.44**	14.19**	72.68**	2.15	2.31**	3.43	1.68	2.69	0.62
Fruit length (cm)	102.35**	26.07**	5.77	4.42	3.71**	5.05	2.21	5.25	0.42
Fruit equatorial diameter (cm)	7.01**	0.41**	0.29**	0.11**	0.11**	0.05	0.16	0.09	1.78
Number of fruits per plant	25.36**	2.37**	70.05**	0.18	0.23**	0.43	0.57	0.48	1.19
Average fruit weight per plant (kg)	0.061**	0.008**	0.006**	0.003**	0.002**	0.001	0.001	0.001	1.00
Days to last picking	190.97**	25.81**	111.32**	1.49	2.32**	9.30	4.13	4.12	1.00
Fruit yield per plant (kg)	8.14**	2.48**	33.18**	0.39	0.20**	0.31	0.18	0.54	0.33

*, ** Indicates significance at P = 0.005 and P = 0.01 levels, respectively

Across the environments, the σ^2_{GCA} / σ^2_{SCA} ratio was more than unity for days to first opening female flower, days to first opening male flower, vine length, fruit equatorial diameter and number of fruits per plant indicates the preponderance of additive gene action for these traits, while for number of node bearing first female flower, number of node bearing first male flower, days to first picking, fruit length and fruit yield per plant, non-additive gene action played an important role in its improvement. For days to last picking and average fruit weight per plant, both additive and non-additive gene actions were equally important. The predominance of non-additive gene action for fruit yield and some its component traits were also reported by Ray *et al.* (2015), Janaranjani *et al.,* (2016), Shinde *et al*., (2016), Rani and Reddy (2017), Mishra *et al.*, (2019), Khot *et al.,* (2021) and Patel and Mehta (2021).

Across the environments, the parents were classified as good, average and poor general combiners for different characters on the basis of estimates of general combining ability effects (Table 2). None of the parent was good general combiner for all the characters studied. However, the parents ABG 1, NDBG 132, Arka Bahar and Pusa Naveen were found to be good general combiners for fruit yield per plant; NDBG 132, DBG 5, Samrat and Santosh for days to first opening female flower; ABG 1 NDBG 132, DBG 5 and Santosh for days to first opening male flower; ABG 1, Arka Bahar, DBG 5 and Santosh for number of node bearing first female flower; Arka Bahar, DBG 5 and Samrat for number of node bearing first male flower; ABG 1, Arka Bahar and Samrat for vine length; Punjab Long, NDBG 132, Samrat, DBG 6 and Santosh for days to first picking; ABG 1 and NDBG 132 for fruit length; Arka Bahar, Pusa Naveen, DBG 6 and Santosh for fruit equatorial diameter; ABG 1, Punjab Long, NDBG 132 and Pusa Naveen for number of fruits per plant; Arka Bahar and DBG 5 for average fruit weight per plant; and ABG 1, Arka Bahar, Pusa Naveen and DBG 5 for days to last picking were found to be good general combiners, as they exhibited significant and desirable gca effects across the environments.

It was evident from the Table 2 that, on pooled basis, parent NDBG 132 was also found good general combiner for days to first opening female flower, days to first opening male flower, days to first picking and number of fruits per plant. The other best general combiners for fruit yield per plant, ABG 1 for days to opening first male flower, number of node bearing first female flower, vine length, fruit length, number of fruits per plant and days to last picking; Arka Bahar for number of node bearing first female flower, number of node bearing first male flower, vine length, fruit equatorial diameter, average fruit weight per plant and days to last picking; and Pusa Naveen for fruit equatorial diameter, number of fruits per plant and days to last picking, were found good general combiners.

Table 2: Estimates of general combining ability effects of parents in pooled over environments for various characters in bottle gourd.

Sr. No.	Parents	Days to first opening female flower	Days to first opening male flower	Number of node bearing first female flower	Number of node bearing first male flower	Vine length (m)	Days to first picking
1	ABG 1	A	G	G	P	G	P
2	Punjab Long	P	A	A	P	P	G
3	NDBG 132	G	G	P	A	A	G
4	ArkaBahar	P	P	G	G	G	P
5	Pusa Naveen	A	P	P	P	A	P
6	DBG 5	G	G	G	G	P	P
7	Samrat	G	A	P	G	G	G
8	DBG 6	P	P	P	P	P	G
9	Santosh	G	G	G	A	P	G

Contd….

Sr. No.	Parents	Fruit length (cm)	Fruit equatorial diameter (cm)	Number of fruits per plant	Average fruit weight per plant (kg)	Days to last picking	Fruit yield per plant (kg)
1	ABG 1	G	P	G	P	G	G
2	Punjab Long	P	P	G	P	P	A
3	NDBG 132	G	P	G	A	P	G
4	ArkaBahar	A	G	P	G	G	G
5	Pusa Naveen	A	G	G	A	G	G
6	DBG 5	A	P	P	G	G	P
7	Samrat	P	P	P	P	P	P
8	DBG 6	A	G	P	A	A	P
9	Santosh	P	G	P	A	P	P

G = Good parent having significant gca effect in desired direction, A = Average parent having either positive or negative, but non-significant gca effect, and P = Poor parent having significant gca effect in undesired direction

From the above results, it was evident that use of parents ABG 1, NDBG 132, Arka Bahar and Pusa Naveen in future breeding programme would be more useful in augmenting genes for high yield in bottle gourd. It was further noted that involvement of these parents in hybridization resulted into hybrids expressing useful heterosis for different traits. Among the ten most promising hybrids based on *per se* performance (Table 3), ABG 1, NDBG 132, Arka Bahar and Pusa Naveen were involved in nine hybrids *viz*., ABG 1 × Arka Bahar, Punjab Long x NDBG 132, NDBG 132 × Arka Bahar, Arka Bahar × Pusa Naveen, NDBG 132 × Samrat, ABG 1 × NDBG 132, NDBG 132 × Pusa Naveen, Pusa Naveen × Samrat and ABG 1 × Punjab Long. Of the promising hybrids, ABG 1 × Arka Bahar, Punjab Long x NDBG 132, NDBG 132 × Arka Bahar were the most promising hybrid expressed 43.82, 30.28 and 27.69 per cent significant and positive standard heterosis over the environments for fruit yield per plant. These hybrids also manifested significant and positive standard heterosis over the environments for fruit equatorial diameter and average fruit weight per plant.

The estimates of sca effects of hybrids (Table 4) revealed that none of the hybrid was constantly superior for all the characters. Considering the high and significant sca effects of the hybrids across the environments for fruit yield per plant, the best ten best hybrids were ABG 1 × Arka Bahar, Punjab Long × DBG 5, Samrat × DBG 6, Pusa Naveen × Samrat, DBG 6 × Santosh, Punjab Long × NDBG 132, ABG 1 × Punjab Long, NDBG 132 × Samrat, Punjab Long × Pusa Naveen and Arka Bahar ×Pusa Naveen. Out of these ten hybrids, three hybrids DBG 6 × Santosh, Punjab Long × NDBG 132 and Arka Bahar × Pusa Naveen for days to first opening female flower; three hybrids Punjab Long × DBG 5, Pusa Naveen × Samrat and NDBG 132 × Samrat for days to first opening male flower; one hybrid Punjab Long × Pusa Naveen for number of node bearing first female flower; two hybrids Pusa Naveen × Samrat and Punjab Long × NDBG 132 for number of node bearing first male flower; two hybrids Samrat × DBG 6 and ABG 1 × Punjab Long for vine length; one hybrid DBG 6 × Santosh for days to first picking; two hybrids Punjab Long × NDBG 132 and Punjab Long × Pusa Naveen for fruit length; three hybrids ABG 1 × Arka Bahar, Punjab Long × NDBG 132 and Arka Bahar × Pusa Naveen for fruit equatorial diameter; eight hybrids ABG 1 × Arka Bahar, Punjab Long × DBG 5, Samrat × DBG 6, DBG 6 × Santosh, Punjab Long × NDBG 132, ABG 1 × Punjab Long, NDBG 132 × Samrat and Punjab Long × Pusa Naveen for number of fruits per plant; eight hybrids ABG 1 × Arka Bahar, Punjab Long × DBG 5, Samrat × DBG 6, Pusa Naveen × Samrat, DBG 6 × Santosh, Punjab Long × NDBG 132, ABG 1 × Punjab Long and Arka Bahar × Pusa Naveen for average fruit weight per plant; and one hybrid Arka Bahar × Pusa Naveen for days to last picking manifested significant sca effects in desirable direction. Hence, it was found that, hybrids manifested high sca effects for fruit yield per plant also showed high and desirable sca effects for some of the important yield contributing characters. The best three hybrids, on the basis of the significant and positive sca effects over the environments for fruit yield per plant were ABG 1 × Arka Bahar (1.69), Punjab Long × DBG 5 (1.63) and Samrat × DBG 6 (1.10). Out of these hybrids, ABG 1 × Arka Bahar exhibited significant and desired sca effect for fruit equatorial diameter, number of fruits per plant and average fruit weight per plant; Punjab Long × DBG 5 for days to first opening male flower, number of fruits per plant and average fruit weight per plant; and Samrat × DBG 6 for vine length, number of fruits per plant and average fruit weight per plant. ABG 1 × Arka Bahar was the top ranked hybrid with respect to *per se* for fruit yield per plant across the environments, was also ranked first with respect to sca effect for fruit yield per plant. The second best top ranked hybrid with respect to *per se* for fruit yield per plant across the environments was Punjab Long x NDBG 132 also manifested the significant sca effect for fruit yield per plant, days to first opening female flower, number of node bearing first male flower, fruit length, fruit equatorial diameter, number of fruits per plant and average fruit weight per plant. The crosses showing significant sca effects are expected through-off transgressive segregants, and thu, such crosses could be exploited for the improvement of yield and specific yield contributing characters.

Table 3: Performance of top ten high yielding crosses for heterosis over better parent (BP) and standard check (ABG 1), their SCA effects for fruit yield per plant and component traits for which showing significant and desirable heterosis over standard check and better parent in pooled analysis

Sr. No.	Hybrids	Seed yield per plant (g)	Heterosis Over		SCA effects	Component characters showing significant and desirable heterosis over	
			BP	ABG 1		BP	ABG 1
1	ABG 1 × ArkaBahar	7.22	40.47**	43.82**	1.69**	-	FED, AFW
2	Punjab Long × NDBG 132	6.54	19.13	30.28*	0.88**	-	FED, AFW
3	NDBG 132 × ArkaBahar	6.41	16.76	27.69*	0.26	-	FED, AFW
4	Punjab Long × DBG 5	6.28	54.30**	25.10	1.63**	-	FED
5	ArkaBahar × Pusa Naveen	6.26	21.79	24.70	0.66**	-	FED, AFW
6	NDBG 132 × Samrat	6.23	13.48	24.10	0.75**	-	FED, AFW
7	ABG 1 × NDBG 132	6.17	12.39	22.91	0.24	-	FED
8	NDBG 132 × Pusa Naveen	6.17	12.39	22.91	0.17	-	FED, AFW
9	Pusa Naveen × Samrat	5.86	55.03**	16.73	0.93**	AFW	AFW
10	ABG 1 × Punjab Long	5.83	16.14	16.14	0.80**	-	-

*, ** Indicate significance at P = 0.05 and P = 0.01 levels, respectively

FED - Fruit equatorial diameter, AFW- Average fruit weight per plant

Table 4: Top ten crosses based on significant SCA effects for fruit yield per plant on pooled basis and its position to component traits with respect to sca effects in bottle gourd.

Sr. No.	Crosses	Fruit yield per plant (kg)	Days to first opening female flower	Days to first opening male flower	Number of node bearing first female flower	Number of node bearing first male flower	Vine length (m)
1	ABG 1 × ArkaBahar	1.69**	2.27**	0.20	0.04	0.57**	0.14
2	Punjab Long × DBG 5	1.63**	-0.87	-1.60*	-0.15	0.03	-0.10
3	Samrat × DBG 6	1.10**	1.92**	-0.15	0.28**	0.56**	0.35*
4	Pusa Naveen ×Samrat	0.93**	-0.20	-1.66*	0.18	-0.39**	-0.21
5	DBG 6 × Santosh	0.90**	-1.97**	-0.99	-0.11	0.35*	0.14
6.	Punjab Long × NDBG 132	0.88**	-2.28**	-0.88	0.09	-0.57**	0.24
7	ABG 1 × Punjab Long	0.80**	1.10	0.97	0.34**	0.11	0.38*
8	NDBG 132 ×Samrat	0.75**	-0.18	-1.38*	0.32**	-0.12	-0.06
9	Punjab Long ×Pusa Naveen	0.69**	-0.23	-1.18	-0.24*	0.18	0.21
10	ArkaBahar ×Pusa Naveen	0.66**	-2.11**	0.70	0.15	0.17	-0.33*

Contd….

Sr. No.	Crosses	Days to first picking	Fruit length (cm)	Fruit equatorial diameter (cm)	Number of fruits per plant	Average fruit weight per plant (kg)	Days to last picking
1	ABG 1 × ArkaBahar	-1.05	0.41	0.48**	0.99**	0.102**	2.16
2	Punjab Long × DBG 5	1.60	-2.23*	0.17	1.75**	0.054**	-1.70
3	Samrat × DBG 6	1.70*	-1.77	0.13	1.06**	0.058**	1.86
4	Pusa Naveen ×Samrat	-1.06	0.63	-0.58**	0.70	0.061**	-0.39
5	DBG 6 × Santosh	-1.76*	-1.81	0.17	0.65*	0.078**	-2.12
6.	Punjab Long × NDBG 132	-1.29	2.43*	0.37**	0.72*	0.053**	0.71
7	ABG 1 × Punjab Long	-0.60	-1.36	-0.02	0.72*	0.057**	-3.21*
8	NDBG 132 ×Samrat	0.42	-2.41*	0.12	1.03**	0.009	0.21
9	Punjab Long ×Pusa Naveen	0.70	4.37**	0.15	0.92**	0.029	2.04
10	ArkaBahar ×Pusa Naveen	0.76	0.71	0.23*	0.31	0.046**	3.57*

*, ** Indicates significance at P = 0.05 and P = 0.01 levels, respectively

A good agreement was exist between best performing parents and best general combining parents for fruit yield per plant and some important yield components (Table 5) indicates that, while choosing the parents for hybridization programme, *per se* performance of parents should also be given due weightage along with combining ability of parents. Such parallel behaviour of *per se* performance and general combining ability was also reported by Janaranjani *et al*., (2016) and Mishra *et al.,* (2019). A perusal of the data given in Table 5 further revealed that the three best *per se* hybrids for different characters possessed low to moderate preferred heterobeltiosis as well as standard heterosis and desired sca effects. It can be concluded that *per se* performance of parents was related with gca effects of parents, while *per se* performance of hybrids was related to heterotic response of the hybrids. The crosses manifested high *per se* performance, low to moderate heterosis and significant desirable sca effect for various traits involved either good x good or good x average or average x good or poor x poor combining parents (Table 5). Thus, the crosses exhibiting high sca effect did not always involve the parents with high gca effects, suggested that interallelic interactions were also important for characters studied.

The best three hybrids for fruit yield per plant on the basis of *per se* performance, *viz.*,ABG 1 × Arka Bahar (good x good), Punjab Long × NDBG 132 (average x good) and NDBG 132 × Arka Bahar (good x good) manifested significant and desirable standard heterosis. Of these three crosses, ABG 1 × Arka Bahar and Punjab Long × NDBG 132 possessed significant and desired sca effects and ABG 1 × Arka Bahar noted significant and desirable heterobeltiosis. These high yielding hybrids also possessed desirable sca effects, high heterosis as well as high *per se* performance for some of its important yield contributing characters. Significant and positive sca effects for fruit yield and its important yield component traits have also been reported by Dubey and Maurya, (2006), Rehana and Sharma (2007), Sirohi and Rana (2008), Wani *et al.,* (2009), Vegad *et al.,* (2011), Shaikh *et al*., (2012), Kumar *et al.* (2014), Adarsh *et al*., (2015), Ray *et al.* (2015), Shinde *et al*. (2016), Rani and Reddy (2017), Jayanth *et al.,* (2019), Quamruzzaman *et al.,* (2019), Khot *et al.,* (2021) and Patel and Mehta (2021).

Table 5: Summary of three best performing parents, best general combining parents and best performing hybrids along with their sca effects and per cent heterosis over better parent (BP) and standard check (SC) for various traits on pooled basis of bottle gourd.

Sr. No.	Characters	Best performing parents	Best general combiners	Best performing F_1	Sca effects	Best specific F_1 cross combination	sca effects	Heterosis of best performing cross combination over	
								BP	SC
1	Days to first opening female flower	Santosh	Santosh	Punjab Long × Santosh	-1.69*	ArkaBahar × Santosh	-4.30**	4.66	-3.34
		NDBG 132	NDBG 132	ArkaBahar x Santosh	-4.30**	ArkaBahar ×Samrat	-3.88**	-0.47	0.91
		-	DBG 5	DBG 6 x Santosh	-1.97**	Pusa Naveen × DBG 5	-2.43**	-5.05	-4.57
2	Days to first opening male flower	Santosh	Santosh	Punjab Long × Santosh	-0.85	ArkaBahar × Santosh	-2.81**	7.53	-0.39
		NDBG 132	NDBG 132	-	-	DBG 5 ×Samrat	-2.18**	-6.30	-3.84
		-	ABG 1	-	-	ArkaBahar ×Samrat	-1.90**	3.59	6.30
3	Number of node bearing first female flower	-	Santosh	-	-	Pusa Naveen × Santosh	-0.64**	-6.92	1.51
		-	ABG 1	-	-	Pusa Naveen × DBG 6	-0.54**	-7.14	32.45**
		-	DBG 5	-	-	Samrat× Santosh	-0.26*	5.54	15.09
4	Number of node bearing first male flower	Samrat	Santosh	-	-	Punjab Long × NDBG 132	-0.57**	-10.07	11.68
		-	ArkaBahar	-	-	Pusa Naveen × DBG 5	-0.53**	1.67	16.03
		-	DBG 5	-	-	DBG 5 × DBG 6	-0.46**	-5.00	8.42

Contd…..

Sr. No.	Characters	Best performing parents	Best general combiners	Best performing F_1	Sca Effects	Best specific F_1 cross combination	sca effects	Heterosis of best performing cross combination over	
								BP	SC
5	Vine length (m)	ArkaBahar	ArkaBahar	NDBG 132 ×ArkaBahar	0.49**	NDBG 132 ×ArkaBahar	0.49**	3.25	11.35
		-	ABG 1	ABG 1 × ArkaBahar	0.14	Pusa Naveen × DBG 6	0.42**	5.19	1.50
		-	Samrat	ABG 1 ×Samrat	0.26	Pusa Naveen × DBG 5	0.41**	2.08	-1.50
6	Days to first picking	Santosh	Santosh	DBG 6 × Santosh	-1.76*	Pusa Naveen × DBG 5	-3.61**	-5.03	-6.56
		NDBG 132	Samrat	Punjab Long × Santosh	-1.21	Pusa Naveen × Santosh	-2.59**	4.03	-8.49*
		Samrat	NDBG 132	Pusa Naveen × Santosh	-2.59**	NDBG 132 ×ArkaBahar	-2.35**	1.80	-5.32
7	Fruit length (cm)	-	ABG 1	ABG 1 × DBG 6	3.20**	Punjab Long ×Pusa Naveen	4.37**	27.38**	-8.07
		-	NDBG 132	-	-	DBG 5 × Santosh	3.71**	12.30	-10.12
		-	-	-	-	Samrat× Santosh	3.65**	8.92	-13.61*
8	Fruit equatorial diameter (cm)	ArkaBahar	ArkaBahar	ArkaBahar × Santosh	0.53**	ArkaBahar × Santosh	0.53**	4.33	57.31**
		Pusa Naveen	Santosh	ArkaBahar× DBG 6	0.33**	ABG 1 × ArkaBahar	0.48**	-6.55	40.91**
		Santosh	Pusa Naveen	ArkaBahar×Pusa Naveen	0.23*	DBG 5 ×Samrat	0.48**	3.41	25.89**

Contd…..

Sr. No.	Characters	Best performing parents	Best general combiners	Best performing F_1	sca effects	Best specific F_1 cross combination	sca effects	Heterosis of best performing cross combination over	
								BP	SC
9	Number of fruits per plant	-	NDBG 132	ABG 1 × NDBG 132	0.46	Punjab Long × DBG 5	1.75**	15.28	-0.21
		-	ABG 1	Punjab Long × NDBG 132	0.72*	Samrat × DBG 6	1.06**	13.52	-19.90*
		-	Pusa Naveen	ABG 1 × Punjab Long	0.72*	NDBG 132 ×Samrat	1.03**	7.13	3.28

10	**Average fruit weight per plant (kg)**	ArkaBahar	ArkaBahar	ABG 1 × ArkaBahar	0.102**	ABG 1 × ArkaBahar	0.102**	0.13	46.35**
		DBG 5	DBG 5	ArkaBahar × Pusa Naveen	0.046**	DBG 6 × Santosh	0.078**	17.29*	33.08**
		DBG 6	-	NDBG 132 × ArkaBahar	0.001	Pusa Naveen × Samrat	0.061**	25.00**	25.00**
11	**Days to last picking**	-	ArkaBahar	ArkaBahar × Pusa Naveen	3.57*	Punjab Long × DBG 6	6.80**	-0.94	5.37
		-	ABG 1	ABG 1 × ArkaBahar	2.16	DBG 5 × Santosh	3.98**	-2.28	0.73
		-	Pusa Naveen	ABG 1 × DBG 5	3.02*	ArkaBahar ×Pusa Naveen	3.57*	3.06	3.21
12	**Fruit yield per plant (kg)**	NDBG 132	NDBG 132	ABG 1 × ArkaBahar	1.69**	ABG 1 × ArkaBahar	1.69**	40.47**	43.82**
		ArkaBahar	ArkaBahar	Punjab Long × NDBG 132	0.88**	Punjab Long × DBG 5	1.63**	54.30**	25.10
		-	Pusa Naveen	NDBG 132 × ArkaBahar	0.26	Samrat × DBG 6	1.10**	44.41*	2.99

*, ** Indicates significance at P = 0.05 and P = 0.01 levels, respectively

CONCLUSION

From the results, it can be concluded that use of parents ABG 1, NDBG 132, Arka Bahar and Pusa Naveen in future breeding programme would be more useful in augmenting genes for high yield in bottle gourd. It was further noted that involvement of these parents in hybridization resulted into hybrids expressing useful heterosis for different traits. Hybrids ABG 1 × Arka Bahar and Punjab Long × NDBG 132 had high *per se* performance possessed desired sca effects as well significant and desirable standard heterosis for fruit yield per plant and some of its important component traits can be exploited in practical plant breeding.

Conflict of Interest. Nil.

REFERENCES

Adarsh, A., Kumar, R., Kumar, A., Chaurasiya, J., Singh, H. K., & Roy, C. (2015). Combining ability analysis in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] for earliness and fruit yield. *Green Farming*, *6*(5)**:** 988-990.

Anonymous (2018). Horticulture Statistics at a Glance 2018. Horticulture Statistics Division, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture &Farmers Welfare, Government of India. (http://agricoop.nic.in/sites/default/files/Horticulture%20Statistics%20at%20a%20Glance-2018.pdf) accessed on November 25, 2019.

Cutler, H. C., & Whitaker, T. W. (1961). History and distribution of the cultivated cucurbits in the Americas. *American Antiquity*, *26*(4): 469-485.

De Candolle, A. (1882). *Origin of Cultivated Species*. Hafner Publishing Co., London (Reprint 1967).

Dubey, S. K., & Maurya, I. B. (2006). Studies on combining ability in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.). *The Orissa Journal of Horticulture*, *34*(1): 59-73.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. *Australian Journal of Biological Sciences*, *9*(4):463-493.

Hayman, B. I. (1954). The analysis of variance of diallel tables. *Biometrics*, *10:* 235-244.

Janaranjani, K. G., Kanthaswamy, V., & Kumar, S. R. (2016). Heterosis, combining ability and character association in bottle gourd for yield attributes. *International Journal of Vegetable Science*, *22*(5): 490-515.

Jayanth, S., Makhan, L., Duhan, D. S., & Vidya, R. (2019). Estimation of heterosis and combining ability for earliness and vegetative traits in bottle gourd [*Lagenaria siceraria* (Molina.) Standl.]. *International Journal of Chemical Studies*, *7*(1): 20-25.

Khot, R. K.; Evoor, S., & Shwetha A. 2021. Combining ability studies in the advanced lines of bottle gourd [*Lagenaria siceraria* (Molina.) Standl.] for growth, earliness and yield parameters. *International Journal of Chemical Studies*, *9*(2): 1119-1122.

Kumar, A., Yadav, G. C., Pandey, V., & Patel, M. S. (2014). Studies on combining ability for yield and its related traits in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. *Annals of Agri-Bio Research*, *19*(1): 140-143.

Mishra, S., Pandey, S., Kumar, N., Pandey, V. P., & Singh, T. (2019). Studies on combining ability and gene action in *kharif* season bottle gourd [*Lagenaria siceraria* (Molina) Standl.]. *Journal of Pharmacognosy and Phytochemistry*, *8*(1): 11-18.

Patel, H. R., & Mehta, D. R. (2021). Combining ability for fruit yield and its component traits in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. *Biological Forum – An International Journal*, *13*(2): 187-200

Quamruzzaman, A. K. M., Salim, M. M. R., Akhter, L., Hasan, T., Mazed, K., & Chowdhury, M. A. Z. (2019). Genetic architecture of yield in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.). *Agricultural Sciences*, *10*(4): 567-576.

Rani, K. U., & Reddy, E. N. (2017). Combining ability analysis for yield and its components in bottle gourd. *International Journal of Pure and Applied Biosciences*, *5*(4): 809-817.

Ray, P. K., Yadav, G. C., Baranwal, D. K., & Singh, H. K. (2015). Genetic estimates and gene action for obtaining promising heterotic hybrids in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. *The Bioscan*, *10*(2): 801-806.

Rehana, N., & Sharma, S. P. (2007). Combining ability studies in bottle gourd. *Crop Research*, *32*(1-3):148-151.

Schmidt, J. (1919). La valeur de Tindividu a titre de generateurapprecifesuivant la method du croisementdialldle. *Revel. Lab. Carlsberg*., *14*: 633.

Shaikh, J. A., Kathriria, K. B., Acharya, R. R., & Varpe, B. (2012). Combining ability studies in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] over environments. *Research on Crops*, *13*(2): 731-736.

Shinde, S., Supe V. S., & Gaikwad S. S. (2016). Combining ability studies for earliness and yield in bottle gourd (*Lagenaria siceraria* L. (Molina) Standl.) in *kharif* season. *Asian Journal of Science and Technology*, *7*(5): 2846- 2849.

Sirohi, S., & Rana, S. C. (2008). Heterosis studies in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.). *Haryana Journal of Horticultural Sciences, 36*(3/4): 363-364.

Vegad, P. M., Vaddoria, M. A., Mehta, D. R., & Naghera, Y. V. (2011). Combining ability analysis in bottle gourd. *Crop Improvement, 38*(1): 13-17.

Wani, K. P., Ahmed, N., Afroza, B., & Hussain, K. (2009). Line x tester analysis for combining ability in bottle gourd under temperate conditions of Kashmir valley. *Indian Journal of Horticulture, 66*(4): 476-482.

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