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Combining Ability Analysis for Fruit Yield in Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl]

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Present investigation was carried out during *Zaid* season 2019-2020 in (Y_1) and *Zaid* 2020-2021 in (Y_2) at the Main Experimental Station (MES), Department of Vegetable Science, Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P) with 21 genotypes with six parental line and their fifteen F_1 hybrids of bottle gourd by using diallel (excluding reciprocal) mating fashion. Experiment was laid out in RBD include three replication having each experimental unit with rows space at 3 (m) apart with a plant to plant spacing of 0.50 (m). Significant variances over seasons were found for general as well as sca for all the 17 traits studied during over season pooled which suggested that both additive and non-additive gene action were most important in the expression of all the traits. Pooled combining ability analysis revealed that parents *viz.*, P_4, P_6 and P_2 were good general combiner for fruit yield per plant. An attempt to identify desirable parents based on gca effect as well *per se* performance of the most of the character studied. Among the 15 F_1 crosses P_3 x P_4, P_2 x P_6 and P_2 x P_5 have found good specific combiners for total fruit yield per plant along with most of the other yield contributing characters follow days to first staminate flower anthesis, days to first pistillate flower anthesis, fruit length and average fruit weight.

Keywords: Bottle gourd; combining ability; GCA; SCA.

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1. INTRODUCTION

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl., 2n = 2x = 22) is an important bottle-like crop grown annually throughout the country. As a vegetable crop for the warm season, it grows well in hot and humid climates. But now, off-season cultivation is gradually expanding year-round in the plains of northern India. Bottle is found in the wilds of South Africa and India as a vegetable in the rainy and summer months. It grows widely in warm regions of Africa, Ethiopia, Central America and other parts of the world. The total area of amber in India is 0.189 million hectares with a yield of 31.06 million tons and a yield of 16434 tons/ha [1].

As per De Candolle (1882), bottle gourd was found in wild form in South Africa and India. However, Cutler and Whitaker [2] are of the view that probably it is indigenous to tropical Africa on the basis of variability in seeds and fruits of bottle gourd. The wild species are orginate to the northern part of Africa. The *L. breviflora* (Benth.) Naud. and *L. Siceraria* (Sond.) G. Roberty are observed in South Africa and Zimbabwe, respectively, [3].

Total of six species has been recognized from the member of genus *Lagenaria*, of which only *L. sicerariais* the domesticated annual with monoecious sex form while the other five are wild congeners, perennial and dioecious (Bisognin, 2002).

Bottle gourd is a cross-pollinated crop. It is popular with many people. It is easily absorbed is widely used as a vegetable. Due to their delicate and nutty aroma, Bottle gourd are widely used in many delicious recipes. The fruit is mainly used in desserts, pickles, petha, halva, capokand, paratha, koftah and rayat. Bottle gourd are a rich source of minerals and vitamins. Contains dietary fiber, vitamin A, vitamin C, vitamin E, vitamin K, vitamin B_6, folic acid, manganese, potassium, protein, thiamine, riboblavin, pantothenic acid, calcium, iron, magnesium, phosphorus and selenium. It also contains many nutrients, such as calories - 22 Kcal, carbohydrates - 5.4 g, protein - 0.9 g and sodium - 347 mg [4]. The fruit was rich in pectin, which provided a great opportunity to make jelly. A decoction of leaves is an excellent remedy for jaundice. The fruit has a cooling effect and has heart-strengthening and diuretic properties, so it is good for biliary diseases and for recovery to restore health after illness. Cellulose is excellent for overcoming constipation, coughing, blindness and as an antidote to some toxins. The bottle gourd was one of the first domesticated plants for human use, providing food, medicine and various utensils and musical instruments from large, hard, peeled and ripe fruits. Dried fruit peels have been used to create a variety of universal products, including bowls, mesh bottle gourd and musical instruments. (Wikipedia, 2018).

The combining ability analysis helps in the judging of inbreds in terms of genetic value and in the selection of superior parent for hybridization. The superior sca combinations are also identified by this most technique.

2. MATERIALS AND METHODS

Present investigation was carried out during *Zaid* season 2019-2020 in (Y_1) and *Zaid* 2020-2021 in (Y_2) at the Main Experimental Station (MES), Department of Vegetable Science, Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P). Twenty one diverse genotypes of bottle gourd include six parents and fifteen F_1 hybrids created from these parents were used as a plant material for study. The selected parental lines *i.e*. Narendra Pooja (P_1), Narendra Rashmi (P_2), Pusa Naveen (P_3), Narendra Prabha (P_4), NDBG-28 (P_5) and Narendra Jyoti (P_6), were crosses in all the possible combinations, excluding reciprocals. The F_1 hybrids and parents were evaluated in RCBD with three replication for seventeen total fruit yield and yield component traits *viz*. days to first staminate flower anthesis, days to first pistillate flower anthesis, node number to first staminate flower appearance, node number to first pistillate flower appearance, days to first fruit harvest, vine length (meter), number of primary branches per plant, fruit length (cm), fruit circumference (cm), average fruit weight (kg), number of fruit per plant (kg), fruit yield per plant (kg), TSS, dry matter content (g), reducing sugars (%), non-reducing sugar (%) and total sugars (%).

The seeds of the above said parents (6 parental line) were sown in field separately in crossing blocks. Healthy and normal flower buds in a raceme preferably of the first flush, which were expected to open a day in afternoon (1.30pm–3pm). Pollination was done in just afternoon. After pollination crossed flower buds were covered with cotton the fruits set tagged. Simultaneously flower buds of parents were also selfed and it was ensured by covering flower buds with cotton just after pollination. Seeds were extracted from red hard shelled fruits by hand dried packed with appropriate label.

Rows were set 3.0 inches apart plan to plant spacing of 0.5 meter. Sowing was done on 20 March, 2019-20 and 22 April 2020-2021 for *Zaid* crops respectively. To develop excellent crops, the entire suggested agronomic package of procedures and protection measures were implemented. It was done to analyse each traits for combining ability analysis different characters was carried out by following the method 2 model 1 of Griffing [5], where parents and F_1's were included but not the reciprocals.

3. RESULT AND DISCUSSION

Perusal of Table-1 revealed that mean square due to evidence that the mean square due to environment was observed significant for all the traits except fruit length, fruit circumference and total soluble solids. The mean square due to interaction effects of GCA *vs*. environments and SCA *vs*. environment was observed significant for the trait except days to first staminate and pistillate flower anthesis and days to first fruit harvest, fruit circumference, fruit length and non-reducing sugar. Similar finding had also been reported by Singh *et al.* (2005), Gayakawade*et al.* [6] and Adarsh *et al.* [7] in bottle gourd. Variations in the gca and sca variantions, magnitudes were also noted which may have been influenced by the environment.

3.1 GCA Effects

GCA studies helps in making the selection of the parents and also helps in the isolation of appropriate germplasm for additional improvement. General combining ability (GCA) is mostly a function of additive and additive × additive gene action.

Perusal of Table-2 showed that each traits gca impacts changed over the line of the season. Additionlly, variation in gca effects had been noted by Singh *et al.* [8] and Yadav and Kumar [9]. Parent, P_1 considered desirable for days to 50% flowering, days to first pistillate flower anthesis and days to first fruit harvest. The earlier is desirable traits therefore, negative gca effecst is desirable to days to 50% flowering. Parents, P_2, P_6 and P_5 exhibited best gca for number of fruit per plant while, the parents, P_4, P_6 and P_2 exhibited good general combiner for total fruit yield per plant. In attempt to identified most desirable parents based on the gca effects as well as *per se* performance the three superior parents were considered for the characters Table- 2. This indicated positive involvement between the two parameter (gca effects and *per se* performance). Thus, in parents P_1 was identified the good general combiner for earlier, node number to first staminate and pistillate flower appearance and days to first fruit harvest, P_6 exhibited superior general combiner for average fruit weight, no. of fruit per plant and total fruit yield per plant. Similar results have also Sreevani [10], Yadav and Kumar [9], Shinde *et al.* [11], Mishra *et al.* [12]. The gca includes both additive, additive × additive type of gene action [13] which is fixable in character. Practical important is given to additive parental effects as measured by the genotypes for the different traits were depicted in table.

3.2 Specific Combining Ability Effects

The sca effects of the crosses showing significant sca effects for total fruit yield and their association with other yield components. Specific combining ability effectfor all the 15 F_1 hybrids pertaining to different traits are given in Table-3 that indicating that predominance of non-additive gene action which is non-fixable and it is a main component that may utilize in heterosis breeding. Sca effect represents dominance variance and additive × dominance and dominance ×dominance types of epistasis.

The three superior hybrids F_1 showing the maximum and significant desirable sca effects for total fruit yield per plant in order of merit were P_3 x P_4, P_2 x P_5 and P_2 x P_6 in over the season pooled. The top three crosses observed for highest sca effect for total fruit yield per plant also showed significant sca effects for some other component traits as well. The hybrids were and P_1 x P_2, P_3 x P_6 and P_1 x P_5 in pooled possessed highest negative sca effects for fruit yield per plant. The crosses with better *per se* performance and sca effects involved in general low x low, low x high and high x high combiners. Similar results reported have also been reported by Singh *et al.* [14], Jayanth *et al*. [15].

The evaluation of hybrids on the beginning for sca effect is second most important criteria because sca of hybrids have been attributed to the combination of positive favourable gene from different parents due to the presence of linkage in repulsion phase [16]. The three promising hybrids are P_3 x P_4, P_2 x P_5 and P_2 x P_6 could be including for development of hybrid vigor in bottle gourd. However, its need further testing before recommendation these combinations for exploitation on the large scale.

Table 1. Analysis of variance (mean squares) for combining ability in 6 x 6 diallel cross of bottle gourd over seasons (pooled)

Source of Variation	d.f.	Days to first staminate flower anthesis	Days to first pistillate flower anthesis	Node number to first staminate flower appearance	Node number to first pistillate flower appearance	Days to first fruit harvest	Vine length	Number of primary branches per plant	Fruit length	Fruit circumference
GCA	5	15.10**	19.07**	1.20*	0.98*	16.56**	0.83**	0.94*	24.28**	6.22**
SCA	15	3.23*	2.86*	0.97**	0.79**	3.14*	0.53**	2.62**	21.94**	3.38**
Environmets	1	13.81**	20.57**	4.91**	31.92**	44.58**	1.56**	76.45**	0.39	0.39
GCA×Environments	5	0.69	1.58	1.35*	1.20**	1.04	0.72**	3.10**	1.01	0.17
SCA×Environments	15	0.53	1.07	0.65*	0.72**	1.10	0.54**	1.90**	0.85	0.50
Error	80	1.12	1.38	0.29	0.22	1.36	0.04	0.26	0.62	0.49

Source of Variation	d.f.	Average fruit weight	Number of fruits per plant	Fruit yield per plant	Total soluble solid (T.S.S.)	Dry matter content	Sugars		
							Reducing sugars	Non-reducing sugar	Total sugars
GCA	5	0.03**	0.97**	0.79**	0.04**	0.07**	0.16**	0.02**	0.08**
SCA	15	0.02**	0.84**	0.89**	0.05**	0.28**	0.16**	0.01**	0.12**
Environmets	1	0.02**	4.01**	0.93**	0.006	1.29**	0.08**	0.002**	0.15**
GCA×Environments	5	0.009**	0.03	0.06*	0.03*	0.05*	0.004*	0.0003	0.002*
SCA×Environments	15	0.004**	0.22**	0.08**	0.02**	0.10**	0.01**	0.0002	0.01**
Error	80	0.001	0.03	0.02	0.006	0.01	0.001	0.0001	0.0008

**, ** Significant at 5 per cent and 1 per cent probability levels, respectively*

Table 2. Estimates of G.C.A. effects of parents in 6 x 6 diallel cross of bottle gourd during two seasons (Y_1, Y_2) and over seasons (pooled)

Traits / Parents	Days to first staminate flower anthesis			Days to first pistillate flower anthesis			Node number to first staminate flower appearance			Node number to first pistillate flower appearance			Days to first fruit harvest		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
P_1	-1.97**	-1.61**	-1.79**	-2.13**	-1.43**	-1.78**	-0.55*	-0.26	-0.40*	-0.27	-0.25	-0.26*	-1.88**	-1.54**	-1.71**
P_2	-0.097	-0.27	-0.18	-0.51	-0.68	-0.59*	0.40*	-0.32	0.04	0.08	-0.39*	-0.15	-0.38	-0.58	-0.48
P_3	0.52	0.68	0.60*	0.73	0.86*	0.79*	0.03	0.82**	0.43**	0.07	0.65**	0.36*	0.61	0.75*	0.68*
P_4	0.44	0.43	0.43	0.31	0.73	0.52	-0.09	0.21	0.061	0.019	0.16	0.09	0.15	0.70	0.43
P_5	-0.22	0.18	-0.02	-0.18	-0.13	-0.16	-0.11	-0.15	-0.13	0.19	-0.60**	-0.20	-0.09	-0.04	-0.06
P_6	1.31**	0.59	0.95**	1.77**	0.65	1.21**	0.31	-0.29	0.00	-0.09	0.43*	0.16	1.61**	0.70	1.16**
SE (g_i)	0.33	0.35	0.24	0.38	0.37	0.26	0.16	0.18	0.12	0.13	0.16	0.10	0.39	0.36	0.26
SE (g_i-g_j)	0.51	0.54	0.37	0.59	0.58	0.41	0.25	0.28	0.19	0.21	0.25	0.16	0.60	0.56	0.41

**, ** Significant at 5 per cent and 1 per cent probability levels, respectively*

Table-2. Contd…

Traits / Parents	Vine length			Number of primary branches per plant			Fruit length			Fruit circumference			Average fruit weight		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
P_1	0.26**	-0.05	0.10*	0.80**	-0.24	0.28*	-1.52**	-2.26**	-1.89**	-1.01**	-0.66*	-0.84**	-0.01	-0.03**	-0.02**
P_2	-0.44**	-0.20*	-0.32**	0.09	-0.05	0.02	-0.65*	-0.80*	-0.72**	-0.59*	-0.54*	-0.56**	-0.07**	-0.04**	-0.05**
P_3	0.62**	-0.02	0.30**	-0.31	-0.05	-0.18	-0.27	-0.47*	-0.37*	0.44*	0.45	0.45*	0.01	0.01	0.01
P_4	-0.18*	-0.25**	-0.22**	0.74**	-0.18	0.28*	0.34	0.94**	0.64**	0.73**	0.75*	0.74**	0.09**	0.007	0.05**
P_5	-0.17*	0.31**	0.06	-0.67**	0.48*	-0.09	0.63*	1.19**	0.91**	-0.05	-0.25	-0.15	-0.04*	-0.009	-0.02*
P_6	-0.08	0.21*	0.06	-0.65**	0.04	-0.30*	1.47**	1.40**	1.43**	0.48*	0.25	0.36*	0.02*	0.06**	0.04**
SE (g_i)	0.06	0.06	0.04	0.16	0.16	0.11	0.27	0.23	0.18	0.20	0.24	0.16	0.01	0.009	0.001
SE (g_i-g_j)	0.10	0.10	0.07	0.26	0.25	0.18	0.42	0.36	0.28	0.31	0.38	0.24	0.01	0.01	0.01

**, ** Significant at 5 per cent and 1 per cent probability levels, respectively*

Table 2.Contd..

Parents \ Traits	Number of fruits per plant			Fruit yield per plant			Total soluble solid (T.S.S.)			Dry matter content		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
P_1	-0.31**	-0.41**	-0.36**	-0.28**	-0.48**	-0.38**	0.03	-0.02	0.01	-0.16**	-0.01	-0.09*
P_2	0.26**	0.16*	0.21**	0.11*	0.04	0.08*	-0.03	-0.05*	-0.04*	0.09*	-0.06	0.01
P_3	-0.21*	-0.21**	-0.21**	-0.17*	-0.11*	-0.14**	-0.03	-0.05*	-0.04*	-0.01	-0.01	-0.01
P_4	-0.11	0.04	-0.03	0.17*	0.14*	0.16**	-0.06*	0.01	-0.03	0.10*	-0.00	0.04
P_5	0.17*	0.16*	0.17**	0.02	0.16**	0.09*	-0.04	0.08**	0.02	0.08*	0.10*	0.09**
P_6	0.19*	0.26**	0.22**	0.14*	0.24**	0.19**	0.14**	0.02	0.08**	-0.10*	0.01	-0.05
SE (g_i)	0.06	0.04	0.04	0.05	0.04	0.03	0.03	0.02	0.01	0.03	0.04	0.02
SE (g_i-g_j)	0.09	0.07	0.06	0.07	0.07	0.05	0.04	0.03	0.02	0.04	0.06	0.04

**, ** Significant at 5 per cent and 1 per cent probability levels, respectively*

Table 2.Contd..

Parents \ Traits	Reducing sugars			Non-reducing sugar			Total Sugars		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
P_1	0.008	-0.005	0.002	-0.02	-0.008	-0.006*	-0.01*	-0.01	-0.01*
P_2	-0.11**	-0.09**	-0.10**	0.01**	0.02**	0.02**	-0.08**	-0.07**	-0.08**
P_3	-0.05*	-0.05**	-0.05**	0.02**	0.003	0.01**	-0.02*	-0.03*	-0.02**
P_4	0.09**	0.14**	0.12**	0.03	0.003	0.01	0.10**	0.14**	0.12**
P_5	-0.07**	-0.09**	-0.08**	0.03**	0.04**	0.03**	-0.03**	-0.04**	-0.04**
P_6	0.13**	0.10**	0.12**	-0.06**	-0.07**	-0.07**	0.05**	0.02*	0.04**
SE (g_i)	0.01	0.006	0.008	0.003	0.004	0.003	0.007	0.01	0.006
SE (g_i-g_j)	0.02	0.01	0.01	0.005	0.007	0.004	0.01	0.01	0.01

**, ** Significant at 5 per cent and 1 per cent probability levels, respectively*

Table 3. Estimates of SCA effects of F_1 hybrids in 6 x 6 diallel cross of bottle gourd over two seasons (Y_1, Y_2) and pooled

Traits / Crosses	Days to first staminate flower anthesis			Days to first pistillate flower anthesis			Node number to first staminate flower appearance			Node number to first pistillate flower appearance			Days to first fruit harvest		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
$P_1 \times P_2$	-0.75	-1.33	-1.04	1.16	-0.57	0.29	-0.04	-0.30	-0.17	0.47	0.51	0.49	1.54	0.07	0.81
$P_1 \times P_3$	-0.04	-0.62	-0.33	-1.42	-0.78	-1.10	-0.48	-1.04	-0.76*	0.92*	-1.37*	-0.22	-2.11	-0.92	-1.52*
$P_1 \times P_4$	1.03	0.95	0.99	-0.67	0.67	0.003	-0.21	-0.96	-0.59	0.34	-0.28	0.03	-1.66	0.45	-0.60
$P_1 \times P_5$	1.03	-0.12	0.45	0.49	-0.44	0.02	0.20	0.90	0.55	1.64**	0.62	1.13**	-0.07	-0.46	-0.27
$P_1 \times P_6$	1.16	1.79	1.47*	0.86	2.09	1.48*	0.37	0.53	0.45	-0.94*	0.02	-0.46	1.54	2.11	1.83*
$P_2 \times P_3$	2.74*	1.37	2.06*	0.95	2.80*	1.87*	-0.70	0.57	-0.06	-1.33*	0.20	-0.56	0.04	2.45*	1.25
$P_2 \times P_4$	-0.17	1.29	0.56	0.03	0.59	0.31	-0.30	-1.34*	-0.82*	-0.25	1.12*	0.43	0.83	0.49	0.66
$P_2 \times P_5$	-0.83	-0.45	-0.64	-1.46	0.13	-0.66	0.71	0.96	0.83*	0.67	-0.26	0.20	-0.91	0.24	-0.33
$P_2 \times P_6$	0.28	-0.87	-0.29	-0.42	0.34	-0.03	0.28	-0.66	-0.19	0.12	-0.43	-0.15	-0.95	0.49	-0.22
$P_3 \times P_4$	0.86	0.00	0.43	1.11	0.72	0.92	0.32	0.21	0.26	-1.00*	0.70	-0.14	1.50	0.82	1.16
$P_3 \times P_5$	-0.79	-0.41	-0.60	1.28	-0.73	0.27	1.14*	0.54	0.84*	0.65	1.08*	0.86*	1.75	-0.75	0.50
$P_3 \times P_6$	-0.33	0.83	0.24	-1.33	0.13	-0.60	0.45	-1.41*	-0.48	0.00	-0.05	-0.02	-1.28	-0.50	-0.89
$P_4 \times P_5$	2.28*	2.16*	2.22*	2.03	2.72*	2.37*	1.04*	0.42	0.73*	0.17	0.20	0.19	1.88	2.28*	2.08*
$P_4 \times P_6$	0.74	-0.25	0.24	1.07	-1.07	0.003	0.51	-0.63	-0.06	0.56	0.13	0.34	0.83	-0.46	0.18
$P_5 \times P_6$	-0.25	1.33	0.53	-0.08	1.13	0.52	-1.99**	-0.29	-1.14*	-0.04	0.87	0.41	0.42	1.28	0.85
SE (s_{ij})	0.91	0.96	0.54	1.05	1.03	0.60	0.46	0.50	0.28	0.37	0.45	0.24	1.07	0.99	0.60
SE (s_{ij}-s_{ik})	1.35	1.44	0.99	1.57	1.54	1.10	0.68	0.75	0.50	0.56	0.68	0.44	1.59	1.48	1.09

**, ** Significant at 5 per cent and 1 per cent probability levels, respectively*

Table-3. Cont….

Traits / Crosses	Vine length			Number of primary branches per plant			Fruit length			Fruit circumference			Average fruit weight		
	Y_1	**Y_2**	**Pooled**	**Y_1**	**Y_2**	**Pooled**	**Y_1**	**Y_2**	**Pooled**	**Y_1**	**Y_2**	**Pooled**	**Y_1**	**Y_2**	**Pooled**
$P_1 \times P_2$	-0.19	-0.43*	-0.31*	-0.80	-0.98*	-0.89*	-1.61	-3.23**	-2.42**	0.69	-0.55	0.06	-0.10*	-0.08*	-0.09**
$P_1 \times P_3$	-0.61*	0.03	-0.29*	1.03*	-0.25	0.39	-1.65*	-2.23*	-1.94**	0.64	0.44	0.54	-0.08*	-0.04	-0.06*
$P_1 \times P_4$	-0.22	-0.15	-0.19	-1.12*	-1.05*	-1.08*	-1.28	-0.98	-1.13*	-0.64	-0.17	-0.41	-0.15**	-0.02	-0.09**
$P_1 \times P_5$	0.15	2.00**	1.07**	1.13*	2.87**	2.00**	-2.23*	-2.56*	-2.40**	-0.18	-0.51	-0.34	-0.11*	-0.05*	-0.08**
$P_1 \times P_6$	-0.17	-0.47*	-0.32*	-1.22*	-1.01*	-1.11**	1.59	1.89*	1.74**	-0.72	-0.34	-0.53	-0.03	0.01	-0.007
$P_2 \times P_3$	-0.87**	0.88**	0.005	0.41	2.96**	1.68**	3.47**	4.31**	3.89**	0.56	1.32	0.94*	0.00	0.02	0.01
$P_2 \times P_4$	-0.52*	-1.01**	-0.76**	0.08	-0.23	-0.07	2.84*	2.89**	2.86**	-2.06*	-1.30	-1.68**	-0.07*	0.01	-0.02
$P_2 \times P_5$	0.50*	-0.53*	-0.01	-0.42	-1.27*	-0.85*	1.88*	2.64**	2.26**	-1.93*	-0.97	-1.45*	0.03	0.02	0.02
$P_2 \times P_6$	-0.02	-0.55*	-0.29*	-2.07**	1.20*	-0.43	-4.94**	-5.89**	-5.42**	1.52*	-1.13	0.19	-0.007	-0.05*	-0.03
$P_3 \times P_4$	-0.77**	-0.04	-0.41*	-0.70	0.42	-0.14	4.13**	2.89**	3.51**	-1.76*	-2.30*	-2.03**	0.12*	0.20**	0.16**
$P_3 \times P_5$	-0.29	-0.45*	-0.37*	0.14	-2.11**	-0.98*	1.51	1.31	1.41*	-1.31*	-0.97	-1.14*	0.005	0.01	0.008
$P_3 \times P_6$	0.001	0.22	0.11	-1.67*	1.59*	-0.03	-3.65**	-4.89**	-4.27**	-0.51	-0.47	-0.49	-0.16**	-0.16**	-0.16**
$P_4 \times P_5$	-0.02	-0.56*	-0.29*	-1.31*	-1.48*	-1.39**	1.22	4.22**	2.72**	-0.93	-0.92	-0.93*	-0.11*	-0.003	-0.05*
$P_4 \times P_6$	0.64*	-0.34	0.14	0.63	-0.56	0.03	0.05	0.68	0.36	0.85	1.23	1.04*	-0.15**	-0.10*	-0.12**
$P_5 \times P_6$	0.16	-0.47*	-0.15	-0.67	-1.10*	-0.89*	1.09	0.43	0.76	1.98*	1.23	1.61**	-0.04	-0.09*	-0.07*
SE (s_{ij})	0.18	0.18	0.10	0.46	0.45	0.26	0.76	0.63	0.41	0.55	0.68	0.36	0.03	0.02	0.01
SE (s_{ij}-s_{ik})	0.27	0.27	0.19	0.69	0.68	0.48	1.13	0.95	0.74	0.82	1.01	0.65	0.05	0.03	0.03

**, ** Significant at 5 per cent and 1 per cent probability levels, respectively*

Table -3: Cont…

Traits / Crosses	Number of fruits per plant			Fruit yield per plant			Total soluble solid (T.S.S.)			Dry matter content		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
$P_1 \times P_2$	-0.02	-0.13	-0.08	-0.64**	-0.52**	-0.58**	0.14	0.03	0.09	-0.51**	-0.42*	-0.46**
$P_1 \times P_3$	0.38*	-0.18	0.09	-0.10	-0.35*	-0.23*	0.06	0.04	0.05	-0.41**	-0.39*	-0.40**
$P_1 \times P_4$	0.11	0.15	0.13	-0.48*	-0.04	-0.26*	0.11	-0.02	0.04	-0.46**	-0.25*	-0.36**
$P_1 \times P_5$	0.39*	-0.13	0.12	-0.24	-0.38*	-0.31*	0.07	-0.09	-0.007	0.49**	-0.10	0.19*
$P_1 \times P_6$	0.95**	0.03	0.49**	0.76**	0.34*	0.55**	0.04	-0.09	-0.02	0.64**	0.56**	0.60**
$P_2 \times P_3$	0.42*	0.27	0.35*	0.25	0.27*	0.26*	-0.08	-0.12	-0.10*	-0.48**	0.25*	-0.11
$P_2 \times P_4$	0.42*	0.61**	0.52**	0.02	0.48*	0.25*	-0.27*	0.02	-0.12*	-0.43**	-0.11	-0.27**
$P_2 \times P_5$	0.54*	0.75**	0.65**	0.65**	0.65**	0.65**	-0.001	0.25*	0.12*	-0.52**	0.07	-0.22*
$P_2 \times P_6$	0.52*	0.62**	0.57**	0.72**	0.58**	0.65**	0.37**	-0.04	0.16*	0.65**	-0.10	0.27**
$P_3 \times P_4$	1.00**	0.69**	0.85**	1.63**	1.59**	1.61**	0.13	0.14*	0.14*	0.54**	0.42*	0.48**
$P_3 \times P_5$	0.12	-0.16	-0.02	0.34*	-0.15	0.09	-0.15	-0.22*	-0.19**	-0.47**	-0.07	-0.27**
$P_3 \times P_6$	0.30	-0.19	0.05	-0.25	-0.56**	-0.41**	0.01	0.09	0.05	-0.27*	-0.11	-0.19*
$P_4 \times P_5$	-0.01	-0.12	-0.06	-0.43*	-0.20	-0.31*	0.45**	0.28**	0.37**	-0.12	-0.10	-0.11
$P_4 \times P_6$	0.90**	-0.08	0.41**	0.43*	-0.25	0.09	-0.36**	-0.20*	-0.28**	-0.36**	-0.33*	-0.34**
$P_5 \times P_6$	0.48*	0.42*	0.45**	0.32*	0.26	0.29*	-0.14	0.17*	0.01	-0.29*	-0.22	-0.25**
SE (s_{ij})	0.17	0.13	0.09	0.13	0.12	0.07	0.08	0.06	0.04	0.08	0.11	0.06
SE (s_{ij}-s_{ik})	0.26	0.20	0.16	0.20	0.18	0.13	0.12	0.09	0.07	0.12	0.17	0.10

**, ** Significant at 5 per cent and 1 per cent probability levels, respectively*

Table -3: Cont….

Traits / Crosses	Reducing sugars			Non-reducing sugar			Total Sugars		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
$P_1 \times P_2$	-0.31**	-0.19**	-0.25**	0.002	0.004	0.003	-0.29**	-0.19**	-0.24**
$P_1 \times P_3$	0.34**	0.43**	0.39**	-0.14**	-0.12**	-0.13**	0.21**	0.28**	0.25**
$P_1 \times P_4$	-0.20**	-0.22**	-0.21**	0.06**	0.06**	0.06**	-0.11**	-0.13**	-0.12**
$P_1 \times P_5$	-0.11*	0.05*	-0.02	0.002	0.03*	0.01*	-0.09**	0.07*	-0.01
$P_1 \times P_6$	0.39**	0.17**	0.28**	-0.05**	-0.07**	-0.06**	0.17**	0.09*	0.13**
$P_2 \times P_3$	-0.15*	-0.16**	-0.15**	-0.05**	-0.04*	-0.04**	-0.21**	-0.21**	-0.21**
$P_2 \times P_4$	0.31**	0.28**	0.30**	-0.02*	-0.04*	-0.03**	0.29**	0.23**	0.26**
$P_2 \times P_5$	0.01	0.21**	0.11**	0.04*	0.01	0.03**	0.05*	0.19**	0.12**
$P_2 \times P_6$	0.30**	0.36**	0.33**	0.05**	0.05*	0.05**	0.37**	0.45**	0.41**
$P_3 \times P_4$	0.29**	0.26**	0.27**	-0.004	0.01	0.007	0.28**	0.26**	0.27**
$P_3 \times P_5$	-0.21**	-0.16**	-0.19**	-0.05**	-0.05**	-0.05**	-0.28**	-0.15**	-0.21**
$P_3 \times P_6$	-0.45**	-0.45**	-0.45**	0.07**	0.10**	0.09**	-0.35**	-0.35**	-0.35**
$P_4 \times P_5$	0.27**	0.16**	0.22**	0.04*	0.03*	0.03**	0.31**	0.20**	0.25**
$P_4 \times P_6$	-0.13*	0.32**	0.09**	-0.10**	-0.08**	-0.09**	-0.22**	0.21**	-0.003
$P_5 \times P_6$	0.34**	0.02	0.18**	-0.12**	-0.12**	-0.12**	0.24**	-0.10*	0.07**
SE (s_{ij})	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01
SE (s_{ij}-s_{ik})	0.06	0.02	0.03	0.01	0.01	0.01	0.02	0.04	0.02

**, ** Significant at 5 per cent and 1 per cent probability levels, respectively*

4. CONCLUSION

Based on the above findings it may be safely concluded that the parents P_1 followed by P_2, P_6 and P_5 were found superior general combiner among six parental lines as it showed desirable effects of gca for most for the fruit yield and crosses P_3 x P_4, P_2 x P_5 and P_2 x P_6 showed significant sca effect for total fruit yield per plant of bottle gourd. Therefore, these genotypes could be used broadly in hybrid breeding programme with analysis to increase yield of bottle gourd. For varietal improvement these crosses could be utilized for exploiting promising recombinant after multi position testing.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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