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A study was conducted in bottle gourd to estimate the combining ability for yield and its ten yield-related components. Twenty-one bottle gourd hybrids generated from 7 × 7 diallel cross (excluding reciprocals) along with their seven parents evaluated in a Randomized Block Design with three replication at the Olericulture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh during 2018-19. Analysis of variance revealed highly significant differences among all the F1 hybrid means and their respective seven parental values for all the traits examined. The mean squares of general combining ability (GCA), the specific combining ability (SCA) were also highly significant. SCA genetic variances were greater than GCA. In the present study, high GCA values were found in parents P2, P4, P5 (days to 1st harvest); P1, P2, P7 (fruit length); P3, P6 (fruit diameter); P3, P6 (exocarp thickness); P6, P1 (TSS); P1, P3 (branches per plant); P3, P6 (vine length); P1, P6 (fruits number per plant); P2, P6, P7 (average fruit weight); P1, P2, P6, P7 (yield per plant), which were selected for good combiner for yield and yield contributing characters.

Keywords: bottle gourd, combining ability, sca, gca, hybrids, additive, and non-additive gene action.

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ABSTRACT

A study was conducted in bottle gourd to estimate the combining ability for yield and its ten yield-related components. Twenty-one bottle gourd hybrids generated from 7 × 7 diallel cross (excluding reciprocals) along with their seven parents evaluated in a Randomized Block Design with three replication at the Olericulture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh during 2018-19. Analysis of variance revealed highly significant differences among all the F1 hybrid means and their respective seven parental values for all the traits examined. The mean squares of general combining ability (GCA), the specific combining ability (SCA) were also highly significant. SCA genetic variances were greater than GCA. In the present study, high GCA values were found in parents P2, P4, P5 (days to 1st harvest); P1, P2, P7 (fruit length); P3, P6 (fruit diameter); P3, P6 (exocarp thickness); P6, P1 (TSS); P1, P3 (branches per plant); P3, P6 (vine length); P1, P6 (fruits number per plant); P2, P6, P7 (average fruit weight); P1, P2, P6, P7 (yield per plant), which were selected for good combiner for yield and yield contributing characters. Higher SCA values were obtained from cross combinations P2xP7, P4xP7 (days to 1st harvest); P4xP5, P3xP5 (fruit length); P3xP6, P2xP4 (fruit diameter); P1xP6, P1xP7 (fruits number per plant); P6xP7, P4xP7 (average fruit weight) and P3xP4, P3xP5, P4xP5, P4xP7 (yield per plant) which may be selected for better commercial hybrids. The predominance of non-additive gene action was recorded in almost all the traits under study. Therefore, the yield and quality traits of bottle gourd can be improved by heterosis breeding by selecting which parents have good specific combining ability for the target trait(s).

Keywords: bottle gourd, combining ability, sca, gca, hybrids, additive, and non-additive gene action.

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I. INTRODUCTION

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is an important winter vegetable crop but it is cultivating year round now a days. But there exists a considerable variability of this crop in Bangladesh, possibilities to develop high yielding varieties through breeding approaches like selection or hybridization. A sound-breeding programme provides the opportunity to produce high yielding varieties of a crop with superior quality. However, the development of a meaningful breeding programme needs information on the nature of gene actions controlling the economic characters and other characters of importance. Knowledge of genetic architecture of the characters under the genetic improvement is essential for adopting appropriate breeding procedure. Such knowledge leads the plant breeder to develop new commercial varieties of the crop. Gardner (1963) stressed that information on variation attributable to genetic differences and also on the relationship among various quantitative traits is fundamentally significant in a crop improvement programme.

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Combining ability studies are more reliable as they provide useful information for the selection of parents in terms of performance of the hybrids and elucidate the nature and magnitude of various types of gene actions involved in the expression of quantitative traits. Diallel cross analysis provides the estimates of genetic parameters regarding combining ability as well as a rapid overall picture of the dominance relationship of the parents studied using the first filial generations (F1) with or without reciprocals. Diallel analysis involving parents give the additional information as presence or absence of epistasis, average degree of dominance, distribution of dominant and recessive genes in the parents. Application of diallel technique in a self-pollinated crop like bottle gourd for this purpose may be appropriate. Genetic information regarding combining ability studies of bottle gourd in Bangladesh is limited. Therefore, the present study was undertaken with the following objectives: to generate information for identification of good general and specific combiners for the improvement of yield and its attributes.

II. MATERIALS AND METHODS

2.1 Experimental site

The experiment was conducted at the Olericulture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) during 2018-19. The experimental field was at 23.9920° N Latitude and 90.4125° E Longitudes having an elevation of 8.2 m from sea level, having agro-ecological zone (AEZ) 28 (Anon., 1995). The experimental site is situated in the sub-tropical climatic zone and characterized by scanty rainfall during the experimental time. The average minimum and maximum temperature were18.37°C and 29.37°C and the average relative humidity varied from 55.55 to 75.70 %. The soil of the experimental field was sandy clay loam in texture having a pH range around 6.0.

2.2 Plant materials

Twenty one cross combinations viz., P1xP2, P1xP3, P1xP4, P1xP5, P1xP6, P1xP7, P2xP3, P2xP4, P2xP5, P2xP6, P2xP7, P3xP4, P3xP5, P3xP6, P3xP7, P4xP5, P4xP6, P4xP7, P5xP6, P5xP7 and P6xP7 along with seven parents viz., P1[code LS14], P2[code LS01], P3 [code LS02], P4[code LS03], P5 [code LS04], [P6 code LS07], P7 [code LS09] of bottle gourd were used in this study. The seeds of these germplasm were sown on the seedbed on 05October, 2018. Twenty days old seedlings were transplanted in the main field on 25October, 2018.

2.3 Experimental design and layout

The experiment was laid out in a Randomized Complete Block design with three replications. The unit plot size was 10.0 x 2.0m maintaining 2.0 x 2.5m spacing and 0.5m drain.

2.4 Land, pit preparation and fertilization

The land was fertilized with organic manure, N, P, K, S, B and Zn @ 3000, 80, 45, 88, 25, 1.8 and 4.5 kg/ha, respectively. Half of organic manure and all of S, Zn and B each of P and K @ 30 kg/ha were applied during final land preparation. Rest of cowdung and P and K @ 15 kg/ha were applied as basal in the pit. Rest of N and K were applied after 20 days of transplanting in 4 equal installments at 20 days interval starting.

2.5 Intercultural operation and plant protection

The soil around the base of each seedling was pulverized after the establishment of seedlings. Necessary intercultural operations were done to ensure normal growth and development of the plants. GI steel sticks were used to support the growing plants and allowed them to grow along string netting along with irrigation was applied to the plants in pits as and when required. Adult red pumpkin beetle was controlled by hand removal daily, whereas fruit fly was controlled at the fruiting stage using poison bait.

2.6 Data recorded

Data were recorded on the following parameters viz., days to 1st harvest, fruit length, fruit diameter, exocarp thickness, TSS, branches per plant, vine length, fruits number per plant, average fruit weight and yield per plant.

2.7 Statistical analysis

Analysis of variance (ANOVA)

All the quantitative data taken were subjected to ANOVA. The total variances of each character were partitioned into block, genotype and error differences. The differences within the classes of effects were tested by F-test, and combining ability analysis of the traits with significant genotypic differences was done according to the Model 1 and Method 2 of Griffing (1956a, b). The fixed effect model was more appropriate in the present case since the parents selected were cross-pollinated lines and the parents, and F_1s were the populations considered. This analysis partitioned the variation due to genotypic differences into general combining ability (GCA) and specific combining ability (SCA) effects.

The mathematical model used in this analysis was as follows:

Yij = m + gi + gj + Sij +

Where,

Yij = is the mean of i x jth genotype over k and l.

ij = l, ...p

k = l, ...b

l = l, ... c

m = population mean

gi = GCA effects of the ith parent.

gj = GCA effect of the jth parent.

eijkl = environmental effects

The significant differences within each of the component effects were tested by F-test. Diallel tables were prepared by computing the averages over the 3 replications of all the parents and F_1s in the appropriate cells. The row sums, column sums, the sum squares of GCA, SCA were all computed from this table.

Analysis of variance of combining ability and expectation of mean squares using Griffing`s (1956) Model I Method 2.

The general combining ability form of ANOVA was as follows:

Source of variation	df	Sum squares	Mean sum squares	F-test	Expected mean squares
GCA	6	SSg	MSg	MSg/Mse	$\sigma^2 e + \frac{(P+2)}{(P-1)} \sum gi^2$
SCA	21	SSs	MSs	MSs/MSe	$\sigma^2 e + \frac{2}{P(p-1)} \sum_I \sum_j Sij^2$
Error	54	Sse	Mse		$\sum^2 e$

GCA and SCA effects

The GCA and SCA effects were estimated according to Sharma et. al. (2002) by the following formula:

$$\text{GCA effects (gi)} = \frac{1}{n+2} \sum_{n} [(Yi. + Yii) - \frac{2}{n} (Y..)] \quad \text{Restricted to } \sum_{i}^{n} gi = 0$$

$$\text{SCA effects (Sij)} = Yij - \frac{1}{n+2}[Yi. - Yii + Yj. + Yjj)] + \left[\frac{2}{(n+1)(n+2)} Yii\right] (i < j)$$

III. RESULTS AND DISCUSSION

The analysis of variance for combining ability (general and specific combining ability) were found highly significant for maximum characters studied except exocarp thickness, TSS, vine length, average fruit weight (Table 1) indicating that both additive and non-additive gene actions played a significant role for the expression of these characters. Dubey and Maurya (2006), Pal *et al.* (2004), Rehana and Sharma (2007), Singh *et al.* (2006) also reported similar result for bottle gourd while Yadav *et al.* (2008), Mohanty (2000), Srivastava *et al.* (2008) reported for bitter gourd, pumpkin, and okra, respectively. GCA variances were higher in magnitude than the SCA variances for all the characters studied, indicating the predominance of the additive gene effects for the characters. Similar findings were reported by Sirohi and Chowdhury (1980), Janakiram and Sirohi (1988), and Choudhury and Kale (1991). Dubey and Maurya (2006), Pal *et al.* (2004) also reported that non-additive gene effects appeared more important than additive gene effects for days to 1st harvest, fruit length, fruits number per plant, yield per plant, days to edible fruit maturity, vine length, Average fruit weight while Rahman (2006) reported similar findings for exocarp thickness, fruits number per plant, average fruit weight, yield per plant in pumpkin.

Table 1: Analysis of variance for combining ability of bottle gourd in bottle gourd

Source of variation	df	Mean sum of square									
		Days to 1st harvest	Fruit length	Fruit diameter	Exocarp thickness	TSS	Branches per plant	Vine length	Fruits number per plant	Average fruit weight	Yield per plant
GCA	6	6.07**	240.00**	13.13**	0.07	0.16	27.47**	1.90	1.71	0.08	23.75**
SCA	21	4.05**	20.20**	1.22	0.03	0.04	27.18**	1.65	2.66**	0.07	20.62**
Error	54	0.72	1.17	0.12	0.01	0.01	0.04	0.00	0.27	0.01	2.20

* *Significant at 1% level of probability;* * *Significant at 5% level of probability*

3.1 General Combining Ability (GCA) Effects

The GCA component is primarily a function of the additive genetic variance. The GCA and SCA variances with each parent play a significant role in the choice of parents. The analysis of variance for combining ability (Table 1) indicated that mean square due to GCA and SCA were highly significant for all the traits. This indicated variation in parents and crosses and significant combination of additive and non additive effects in the expression of the characters. Sit and Sirohi (2002), Dubey and Maurya (2007), and Pandey et al. (2004) had also observed similar findings. A parent with higher positive significant GCA effects is considered as a good general combiner. The magnitude and direction of the significant effects for the seven parents provide meaningful comparisons and would give indications to the future breeding programme. The results of GCA effects for 10 different characters are presented in the Table 2.

In the present study, parent P4 (-0.90**) appeared as the best general combiner followed by P2 (-0.83**) and P5 (-0.62*) for days to 1st harvest as they showed negative significant GCA values (Table 2). Dubey and Maurya (2006) reported a highly significant negative GCA effect for days to 1st harvest under the summer in bottle gourd. Pal *et al.* (2004) also found such effect (-1.80) in bottle gourd. The parent P2 (4.84**) exhibited the highest GCA effect for fruit length,

followed by P1 (4.66**) and P7 (3.40**). Parent P6 showed the highest GCA for fruit diameter (2.32**), followed by P3 (0.94**). Dubey and Maurya (2006), Sharma *et al.* (2002), and Pal *et al.* (2004) reported a significant positive effect in bottle gourd for fruit length and fruit diameter. Yadav *et al.* (2008) reported a significant positive effect (2.59) in bitter gourd. Incase of exocarp thickness highest GCA value was obtained by also P3 (0.14**). Mohanty (2000) mentioned a significant positive GCA effect obtained by PusaVishwas followed by Cuttack Local in bitter gourd. Thus parent P3 was the best general combiner followed by P6 to use in crosses for the improvement of exocarp thickness as indicated by their significant and higher GCA effects. Parent P6 (0.18**) exhibited the highest GCA effect for TSS followed by P1 (0.12**), while parent P1 (2.39**) also exhibited the highest GCA effect for branches per plant followed by P3 (2.28**). The parent PusaSamridhi was reported to have the significant GCA effects for vine length and the number of primary branches by Shinde et al. (2016) in bottle gourd. Dubey and Maurya (2006), Sharma *et al.* (2002), and Pal *et al.* (2004) reported a significant positive effect in bottle gourd. In the case of vine length, the parent P3 (0.78**) showed the highest significant highest value, followed by P6 (0.32**). The one of the most important parameter is fruits number per plant, in which the highest GCA value was obtained by P6 (0.70**) followed by P1 (0.36**), while the parent P6 exhibited the highest positive significant GCA value (0.10**) for average fruit weight followed by P7 (0.09**), P2 (0.06**). P6 showed the highest significant GCA value 1.75**) followed by P1 (1.07**), P2 and P7 (1.06**) for yield per plant. The parent P4 (-2.74**) was however, however a poor combiner for yield per plant. Dubey and Maurya (2006), Quamruzzaman *et al.* (2009) and Pal *et al.* (2004) reported that significant positive GCA effect obtained in summer while Kumar *et al.* (1998) got best GCA effect in bottle gourd for fruits number per plant, average fruit weight and yield per plant. Almost similar trends of additive and non-additive gene actions have been reported previously by other research groups like Gill *et al.* (1984) and Shamanin *et al* (1985).

Table 2: Estimates of general combining ability (GCA) effect and mean of seven bottle gourd parents

Parents	Days to 1st harvest	Fruit length	Fruit diameter	Exocarp thickness	TSS	Branches per plant	Vine length	Fruits number per plant	Average fruit weight	Yield per plant
P1	-0.16 (62.00)	4.66** (41.00)	-0.23 (12.00)	0.01 (2.00)	0.12** (3.50)	2. 39** (29.30)	0.13** (6.90)	0.36** (12.30)	-0.06** (2.35)	1.07* (28.70)
P2	-0.83** (58.30)	4.84** (43.50)	-1.00** (10.80)	-0.13** (2.00)	-0.17** (2.60)	-0.21** (25.50)	0.05** (8.90)	-0.50** (13.00)	0.06** (2.25)	1.06* (29.00)
P3	0.91** (61.00)	-5.18** (20.25)	0.94** (15.80)	0.14** (2.40)	0.02 (3.00)	2.28** (32.70)	0.78** (7.20)	-0.30 (13.50)	0.02 (2.00)	-1.12 (26.50)
P4	-0.90** (57.70)	-0.35 (31.50)	-0.68** (11.30)	-0.03** (2.00)	-0.17** (2.50)	-1.58** (19.00)	-0.27** (7.10)	0.14 (13.00)	-0.28** (1.90)	-2.74** (24.00)
P5	-0.62* (58.00)	1.28** (31.50)	-0.85** (10.70)	-0.05** (2.00)	0.01 (2.70)	-1.80** (32.70)	-0.56** (7.50)	0.25 (13.50)	-0.06** (2.00)	-1.12* (26.50)
P6	0.70* (60.00)	-8.65** (19.50)	2.32** (17.40)	0.07** (2.20)	0.18** (2.50)	0.20** (27.50)	0.32** (7.50)	0.70** (14.00)	0.10** (2.40)	1.75** (34.00)
P7	0.90** (63.00)	3.40** (39.00)	-0.49** (11.70)	0.01 (2.00)	0.02 (3.00)	-1.28** (29.00)	-0.42** (7.20)	-0.13 (13.00)	0.09** (2.20)	1.06* (29.00)
SE (gi)	0.26	0.33	0.11	0.01	0.02	0.06	0.01	0.16	0.02	0.46
SE (gi-gj)	0.40	0.51	0.17	0.02	0.03	0.09	0.01	0.25	0.03	0.70
C.D Value (0.05)	0.59	0.75	0.25	0.02	0.05	0.14	0.02	0.36	0.05	1.04
C.D Value (0.01)	0.82	1.04	0.35	0.03	0.06	0.19	0.03	0.50	0.06	1.45

Figures in the parenthesis are the mean values

* *Significant at 5% level of probability; ** Significant at 1% level of probability*

3.2 Specific Combining Ability (SCA) Effects

The SCA effects signify the role of non-additive gene action in the expression of the characters. It indicates the highly specific combining ability leading to the highest performance of some specific cross combinations. That is why it is related to a particular cross. High SCA effects may arise not only in crosses involving high combiners but also in those involving low combiners. Thus in practice, some of the low combiners should also be accommodated in the hybridization programme. Estimates on SCA effects of the crosses in F1 generation showed that there were a good number of crosses having significant positive or negative SCA effect for different important characters of bottle gourd. None of the hybrids indicated significant positive SCA effects for all the characters. Ram *et al.* (1999), Sharma *et al.* (2001) reported similar results in the case of cucumber and bitter gourd, respectively. The SCA effects of 21 F1 crosses for ten different characters studied are presented in the Table 3.

3.2.1 Days to 1st harvest

Negative SCA effect is preferable for days to 1st harvest. Of the twenty one F1s, thirteen showed negative SCA values (Table 3), indicating that there was considerable heterosis for this character. Out of these crosses, eight crosses showed significant negative SCA values with the larger negative values in crosses P2 x P7 (-3.64**), P4 x P7 (-2.24**), P3 x P5 (-2.20**), P3 x P6 (-2.20**) and P1 x P7 (-2.14**) and was the best specific combiner for the early harvest. The significant SCA effects for days to first harvesting was also reported by Singh et al. (2012) in bottle gourd. Dubey and Maurya (2006), Pal *et al.* (2004), Jayanth et al. (2019), Sharmila et al. (2016) also reported significant SCA effect was obtained for an early harvest in bottle gourd, while Yadav *et al.* (2008) and Quamruzzaman *et al.* (2007) reported similar findings in bitter gourd and eggplant, respectively which were in agreement with the present findings.

3.2.2 Fruit length

More than 50% of the F1s (16 crosses) showed positive SCA values indicating that these hybrids had increasing in fruit length, while the significant positive SCA values were P4 x P5 (6.56**), P1 x P2 (4.91**), P1 x P3 (3.25**), P1 x P7 (3.03**), P4 x P6 (2.44**), P2 x P5 (2.12**) and P2 x P7 (2.00**). Thus these seven combinations showed as the best specific combiner to increase the fruit length. Similar findings were obtained by Janaranjani (2016), Dubey and Maurya (2006); Pal *et al.* (2004); Rani et al. (2017); Sharmila et al. (2016) in bottle gourd and Yadav *et al.* (2008), Mohanty (2000) in bitter gourd and Quamruzzaman et al. (2007) in eggplant.

3.2.3 Fruit diameter

F1s in general had the positive SCA values for fruit diameter while the range was 0.03 to 2.36. Of the F1s, six showed significant positive SCA values indicating that these F1s produced more wider fruits than the means of their parents. The highest SCA value was obtained by P3 x P6 (2.36**) followed by P2 x P4 (0.97**), P1 x P6 (0.86**), P1 x P7 (0.67**), P4 x P7 (0.56*). These combinations may be considered as the best specific combiner to increase the diameter of fruits. Similar findings were reported by Janaranjani (2016), Pal *et al.* (2004); Rani et al. (2017); Sharmila et al. (2016) in bottle gourd, and Yadav *et al.* (2008) in bitter gourd.

3.2.4 Exocarp thickness

Ten F1s showed positive SCA values for the trait (Table 3). This indicates that these F1s produced thicker rind compared to the mean of their parents. Out of these combinations, nine F1's viz., P1 x P5 (0.37**), P3 x P5 (0.26**), P5 x P6 (0.25**), P3 x P4 (0.23**), P3 x P7 (0.19**), P4 x P7 (0.19**), P1 x P2 (0.13**), P3 x P6 (0.13**) showed significant values, which may be the best specific combiner for the improvement of the trait. Similar result was obtained by Janaranjani (2016), while significant positive SCA effect (7.41) was obtained by F1 (1x8) in pumpkin (Mohanty, 2000).

3.2.5 TSS

The range of positive SCA effect was 0.01 to 0.43 for this trait while the significant positive cross combinations were P5 x P7 (0.43**), P2 x P4 (0.34**), P3 x P6 (0.32**), P4 x P7 (0.14**), P3 x P5 (0.13**), P2 x P7 (0.12**), P4 x P5 (0.09**) (Table 3).

3.2.6 Branches per plant

Among the cross combinations, about 11 combinations were significant positive SCA effect while five combinations also showed higher significant positive effect viz., P4 x P6 (6.02**), P2 x P4 (4.01**), P3 x P4 (3.94**), P3 x P6 (2.83**), P6 x P7 (2.72**) play a maximum role to increase branches per plant. The highest SCA effects for a number of branches was also reported by Dubey and Maurya (2006) in bottle gourd. Dubey and Maurya (2006); Sharmila et al. (2016) and Jayanth et al. (2019) reported significant positive effect with the best effect in bottle gourd, while Yadav *et al.* (2008) and Quamruzzaman *et al.* (2007) reported similar findings in bitter gourd and eggplant, respectively which were in agreement with the present findings.

3.2.7 Vine length

The range of significant positive SCA effect was 0.31 to 2.21, while higher values were obtained by P3 x P5 (2.21**), P3 x P4 (1.46**), P6 x P7 (1.04**) P4 x P6 (0.90**), P1 x P3 (0.89**), P3 x P6 (0.86**) indicate that these combinations were very significant in specific combining ability for the improvement of vine length. The highest SCA effects for vine length was also reported by Dubey and Maurya (2006) in bottle gourd. For vine length, the highest positive heterosis was reported in the cross Pusa Naveen×Punjab Komal by Janaranjani et al. (2016) in bottle gourd. Dubey and Maurya (2006) reported similar report with 8 significant SCA effect in the summer while Pal *et al.* (2004); Sharmila et al. (2016) and Jayanth et al. (2019) also reported the best combiner in bottle gourd. In other cucurbitaceous crops like bitter gourd, a similar effect was obtained by Yadav *et al.* (2008) and Mohanty (2000).

3.2.8 Fruits number per plant

Maximum F1s in general had the positive SCA values for fruits number per plant (Table 3). Of the F1s, 7 showed significant positive SCA values indicating that these F1s produced more fruits number per plant than the means of their parents. Seven combinations showing highly significant positive SCA values were P1 x P6 (3.17**), P4 x P6 (3.13**), P1 x P7 (2.62**), P1 x P5 (1.62**), P3 x P4 (1.13**), P2 x P5 (0.86*), P2 x P7 (0.86*). These combinations may be considered as the best specific combiner to increase the fruits number per plant. Similar findings were obtained by Dubey and Maurya (2006) with 8 significant positive SCA values in summer season in bottle gourd while Janaranjani (2016), Moradipour et al (2017), Pal *et al.* (2004); Sharmila et al. (2016) and Rani et al. (2017) reported the same trend in bottle gourd. Similar findings were reported by Yadav *et al.* (2008), Singh *et al.* (2004) in bitter gourd.

3.2.9 Average fruit weight

Among the cross combinations, about 50% F1s showed positive SCA values, of which nine had significant positive values for average fruit weight, and the range was 0.01 to 0.39** (Table 3). This indicates that these F1s produced larger average fruit weight compared to the mean of their parents. Highest significantly positive SCA values was obtained by P6 x P7 (0.39**) followed by P3 x P5 (0.38**), P4 x P7 (0.33**), P3 x P4 (0.30**), P3 x P6 (0.22**), P4 x P5 (0.20**), P2 x P6 (0.10*), P5 x P6 (0.10*) and P2 x P7 (0.09*). The result also in agreement with the findings of Dubey and Maurya (2006), Pal *et al.* (2004); Sharmila et al. (2016) and Rani et al. (2017) in bottle gourd while Yadav *et al.* (2008) and Quamruzzaman *et al.* (2007) reported similar findings in bitter gourd and eggplant, respectively which were in agreement with the present findings.

3.2.10 Yield per plant

Twelve F1s in general had the positive significant SCA values for this trait (Table 37), while highest SCA value was obtained by P3 x P4 (6.90**) followed by other higher SCA values P3 x P5 (5.12**), P4 x P5 (4.22**), P4 x P7 (3.57**), P1 x P7 (3.52**), P1 x P6 (3.40**), P3 x P6 (3.30**), P2 x P7 (3.25**), P2 x P5 (3.21**), P6 x P7 (3.17**), P4 x P6 (2.11*), P2x P3 (1.99*). These combinations may be considered as the best specific combiner to increase the yield per plant. These results were confirming with the result of Janaranjani (2016), Moradipour et al (2017), Sharmila et al. (2016), while Dubey and Maurya (2006) reported best SCA effect was obtained by 7 crosses in summer and Pal *et al.* (2004) reported best combiner was IC-92362 x Pusa Naveen in bottle gourd while Yadav *et al.* (2008) and Quamruzzaman *et al.* (2007) reported similar findings in bitter gourd and eggplant, respectively which were in agreement with the present findings.

Table 3: Estimates of specific combining ability (SCA) effect of 21 crosses for ten characters in bottle gourd

Crosses	Days to 1st harvest	Fruit length	Fruit diameter	Exocarp thickness	TSS	Branches per plant	Vine length	Fruits No. per plant	Av. fruit weight	Yield per plant
P1 x P2	-0.07	4.91**	0.19	0.13**	-0.05	1.80**	-0.17**	-0.50	0.03	-0.56
P1 x P3	-1.83**	3.25**	-1.76**	-0.11**	-0.12**	1.98**	0.89**	-1.33**	-0.01	-2.60**
P1 x P4	-1.18*	1.1	-0.14	-0.04	-0.02	0.83**	-0.74**	-0.77	-0.03	-1.89
P1 x P5	-0.63	1.14	0.03	0.37**	-0.03	0.06	0.65**	1.62**	-0.26**	-0.68
P1 x P6	-1.63**	-2.27**	0.86**	-0.07**	-0.07	-3.94**	-0.24**	3.17**	-0.21**	3.40**
P1 x P7	-2.14**	3.03**	0.67**	-0.01	-0.08*	2.20**	0.70**	2.62**	-0.17**	3.52**
P2 x P3	1.34*	4.07**	-1.14**	-0.17**	-0.06	-5.43**	-1.70**	0.91**	-0.01	1.99*
P2 x P4	0.16	-5.25**	0.97**	-0.01	0.34**	4.01**	-0.47**	-0.03	0.08	0.99
P2 x P5	-1.13	2.12**	-0.03	0.01	0.06	-0.35**	-0.54**	0.86*	0.07	3.21**
P2 x P6	0.54	-0.96	-1.20**	-0.10**	-0.15**	-2.35**	-0.66**	-1.59**	0.10*	-2.56**
P2 x P7	-3.64**	2.00**	0.28	-0.07**	0.12**	2.13**	0.31**	0.86*	0.09*	3.25**
P3 x P4	1.75**	3.27**	-0.31	0.23**	0.01	3.94**	1.46**	1.13**	0.30**	6.90**
P3 x P5	-2.20**	5.64**	-0.97**	0.26**	0.13**	1.83**	2.21**	0.03	0.38**	5.12**
P3 x P6	-2.20**	-1.94**	2.36**	0.13**	0.32**	2.83**	0.86**	0.08	0.22**	3.30**
P3 x P7	1.95**	-0.98	-1.33**	0.19**	-0.09**	-9.35**	-0.70**	0.03	-0.07	-1.19
P4 x P5	0.45	6.56**	0.48*	-0.09**	0.09**	-5.98**	-1.65**	0.58	0.20**	4.22**
P4 x P6	-0.72	2.24**	-2.19**	-0.20**	-0.02	6.02**	0.90**	3.13**	-0.28**	2.11*
P4 x P7	-2.24**	2.20**	0.56*	0.19**	0.14**	-1.17**	-0.60**	-0.42	0.33**	3.57**
P5 x P6	2.67**	0.61	0.32	0.25**	0.03	-7.76**	-1.24**	0.02	0.10*	1.57
P5 x P7	-0.51	0.57	0.13	-0.13**	0.43**	-8.28**	-2.30**	-0.03	0.01	-0.02
P6 x P7	1.32*	3.25**	-0.84**	0.06*	-0.28**	2.72**	1.04**	-0.98*	0.39**	3.17**
SE (sij)	0.65	0.83	0.27	0.03	0.04	0.15	0.01	0.40	0.05	1.13
SE (sii-sjj)	-0.89	1.14	0.37	0.04	0.06	0.20	0.02	0.54	0.06	1.56
CD Value (0.05)	1.14	1.45	0.47	0.05	0.07	0.26	0.04	0.70	0.09	1.98
CD Value (0.01)	1.43	1.83	0.59	0.07	0.09	0.33	0.04	0.88	0.11	2.49

* *Significant at 5% level of probability;* ** *Significant at 1% level of probability*

It is evident that SCA effects of certain crosses were related with the GCA of their parents as the best cross combination for most of the characters involved at least one parent with high or average GCA effects for particular traits. Similar results have been reported by Dubey and Maurya (2006), Maurya *et al.* (1993) in bottle gourd and Mishra *et al.* (1994) in bitter gourd. Sivakami *et al.* (1987), Mishra *et al.* (1994) reported that both additive and non-additive genetic variances were important in the inheritance of total yield. However, Sirohi and Chowdhury (1980), Janakiram and Sirohi (1988), Choudhury and Kale (1991) observed that GCA were dominant over SCA effect for most of the yield related characters. But Dubey and Maurya (2006), Pal *et al.* (2004) reported additive genetic variance was more important than non-additive genetic variance. These differences may be due to the differences in the genetic material studied. Results of the present study were in agreement with those of Sirohi *et al.* (1988). Heterosis (high

SCA) in diallel crosses involving good x good GCA might be due to additive x additive type of interaction which is partially fixable (Pal *et al.* 2004). High SCA effects in the crosses involving poor x poor combining parents were possibly due to intra- and inter allelic interaction.

IV. CONCLUSION

In the present study, high GCA values were found in parents P2 , P4 , P5 (days to 1st harvest); P1, P2, P7 (fruit length); P3, P6 (fruit diameter); P3, P6 (exocarp thickness); P6 , P1 (TSS); P1 , P3 (branches per plant); P3 , P6 (vine length); P1, P6 (fruits number per plant); P2, P6, P7 (average fruit weight); P1, P2, P6, P7 (yield per plant), which are good general combiner for yield and yield contributing characters. Since the yield being the main considerations in the heterosis breeding. So, it is thus concluded that the crosses P2x P7, P4xP7 (days to 1st harvest), P4xP5, P3xP5 (fruit length), P3xP6, P2xP4 (fruit diameter), P3xP5, P5xP6 (fruit exocarp thickness), P2xP4, P3xP6 (TSS), P4xP6, P2xP4 (branches per plant), P3xP5, P3xP4 (vine length), P1xP6, P1xP7 (fruits number per plant), P6xP7, P4xP7 (average fruit weight), P3xP4, P3xP5, P4xP5, P4xP7 (yield per plant) showing high SCA effects for yield and other character could be exploited for hybrid vigor. However, before selecting these combinations for exploitation on a large scale, it requires their further testing. Recurrent and reciprocal recurrent selection procedures should be exploited for the improvement of those characters, where both additives as well as non-additive variances are present.

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