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Studies on *per se* Performance and Combining Ability Analysis in Sponge Gourd (*Luffa cylindrica* (L.) Roem.)

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ABSTRACT: To study the *per se* performance and combining ability of 30 crosses evolved through diallel mating system using six diverse genotypes. This experiment was conducted at Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal during 2023. Analysis of variances for diallel mating design revealed that variance due to treatments were highly significant for all the traits. Among 30 crosses, Pusa Sneha × Kashi Shreya recorded the highest mean value for fruit yield. Combining ability studies revealed that mean square due to GCA and SCA were significant indicated that both additive and non-additive type of gene effects played an important role in the inheritance of all these traits under study with preponderance of non-additive gene action for all the traits except number of primary branches vine^{-1}, number of nodes vine^{-1}, sex ratio, days to first fruit harvest and crude fibre. The parents Kashi Shreya (P_4), Pusa Sneha (P_2) and Kashi Rakshita (P_5) were the best general combiners for fruit yield and some of the yield contributing characters. The three cross combinations *viz.*, Pusa Sneha × Pusa Supriya, Kashi Shreya× Pusa Supriya and Pusa Chikni × Kashi Rakshita were found to be good specific combiners for fruit yield per vine.

Key words: *Per se*, diallel, sponge gourd, general combining ability, specific combining ability.

INTRODUCTION

Sponge gourd (*Luffa cylindrica* Roem (L.)) is one of the most important cucurbitaceous vegetable, which is grown in both rainy and summer season throughout the country and world. It's origin place is subtropical Asian region particularly India and it is a domesticated species (Kaloo, 1993). It belongs to the family Cucurbitaceae with diploid chromosome number 2n = 26. It is a monoecious and highly cross pollinated crop in which a large amount of variations are observed for most of the economically important traits. Variability found in shape, size and colour of fruits is most conspicuous. The tender fruits are rich in vitamin A, vitamin C and iron (Yawalkar, 2004). The main goal of research on cucurbitaceous vegetables in India is to improve productivity on sustainable basis through developing biotic and abiotic stress resistant variety/hybrid coupled with quality attributes. Sprague and Tatum (1942) proposed combining ability, which is a powerful tool for discriminating between good and poor combiners and for choosing suitable parents for breeding programs. Combining ability analysis is an important tool in the hands of the plant breeders to identify good parents in their breeding material and further to select promising hybrid combinations to develop suitable hybrids from them. The *sca* effects of hybrids have been attributed to the combination of positive favourable genes from different parents or might be due to the presence of linkage in repulsion phase (Sarsar *et al*., 1986). Specific combining ability is the deviation from the performance predicted (Allard, 1960) and it is due to non-additive gene action (Sprague and Tatum 1942). The relative amount of general combining ability (GCA) and specific combining ability (SCA) effects play a vital role in planning the appropriate and sound breeding programme. Therefore, the present investigation was carried out to estimate GCA and SCA effects and to know the type of gene action governing fruit yield and its component traits of six diverse sponge gourd genotypes and their combinations. Not much work has been done to exploit the hybrid vigour in this crop.

Hence, there is a major scope for production of hybrid seeds to achieve high fruit yield, uniformity and high quality fruits.

MATERIALS AND METHODS

The experimental material comprised of parents and their F_1's derived by crossing six different genotypes of sponge gourd *viz.*, Phule Prajaktha (P_1), Pusa Sneha (P_2), Pusa Chikni (P_3), Kashi Shreya (P_4), Kashi Rakshita (P_5) and Pusa Supriya (P_6) in a diallel fashion excluding reciprocals. The experiment was laid out in a randomized block design with two replications in the year 2023 at Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal. The plants were spaced at a distance of 3.0 m between rows and 1.5 m within a row. Observations were recorded on five plants of each parents and F_1 hybrids were selected randomly for data recording of twelve characters *viz.*, vine length (m), number of primary branches per vine, number of nodes per vine, sex ratio, days to first fruit harvest, fruit length (cm), fruit girth (cm), fruit weight (g), number of fruits per plant, fruit yield per vine, TSS (^{o} Brix) and crude fibre (g). Analysis of variance was carried out as suggested by Panse and Sukhatme (1967). The formula used to estimate combining ability analysis was carried out according to Model-I, Method-2 of Griffing (1956).

RESULTS AND DISCUSSION

The analysis of variance showed highly significant differences among the hybrids and parents for all the traits studied (Table 1). Thus, suggested the existence of inherent differences between the genotypes studied. Among the parents, Kashi Shreya (P_4) was the best parent as it recorded the highest *per se* values for the traits *viz.*, number of primary branches per vine, days to first fruit harvest, fruit weight and fruit yield per vine. Among parents, Kashi Shreya (7.20) recorded the highest fruit yield per vine. The parent Pusa Sneha (P_2) recorded superior mean performance for the traits sex ratio, fruit length. Similarly, the parent Kashi Rakshitha (P_5) recorded superior mean performance for the quality traits TSS and crude fibre (Table 2 and 3). It was observed that among various traits, vine length, fruit length, fruit girth, fruit weight, number of fruits per vine, fruit yield per vine and TSS had more of non-additive gene action.

The parent Kashi Shreya (P_4) having the highest *per se* performance for fruit yield per vine had the highest *per se* value for fruit weight. This is in confirmation with the findings of Srikanth *et al.* (2020); Saravanan (2013) in ridge gourd; Sivasubramanian (2016) in snake gourd; Preethi *et al.* (2019) in cucumber. The parent Kashi Shreya (P_4) with the highest *per se* value in fruit yield per vine did not have the highest *per se* value in sex ratio. Similar findings were reported by Reddy *et al.* (2019) in sponge gourd; Krishnamoorthy (2019) in ridge gourd. Based on the mean performance of the 12 characters studied, it was concluded that the parents Kashi Shreya (P_4) and Pusa Sneha (P_2) were considered as best for yield and yield contributing characters. Hence these parents may be considered as a desirable parents for improvement in the breeding programme based on the *per se* performance.

Among 30 hybrids, the highest fruit yield was recorded by the hybrid Pusa Sneha × Kashi Shreya (13.25) and Kashi Rakshita × Pusa Chikni (1.78) recorded the lowest yield, 14 hybrids (Phule Prajaktha × Pusa Sneha, Phule Prajaktha × Kashi Shreya, Pusa Sneha × Phule Prajakta, Pusa Sneha × Kashi Shreya, Pusa Sneha × Kashi Rakshita, Pusa Sneha × Pusa Supriya, Pusa Chikni × Kashi Shreya, Kashi Shreya × Pusa Sneha, Kashi Shreya × Pusa Chikni, Kashi Shreya × Kashi Rakshita, Kashi Shreya × Pusa Supriya, Kashi Rakshita × Kashi shreya, Pusa Supriya × Pusa Sneha, Pusa Supriya × Kashi Shreya) recorded significantly higher values than mean of the hybrids (7.24). The hybrids *viz.*, Pusa Sneha × Kashi Shreya, Pusa Supriya × Pusa Sneha and Pusa Supriya × Kashi Shreya were found to be superior for the yield and yield contributing traits like fruit length, fruit girth, fruit weight and number of fruits per vine (Table 2 and 3). Hence these hybrids can be utilized for exploitation of heterosis breeding.

Specific combining ability effects for crosses pertaining to different traits are given in the Table 7 and 8. From the analysis of combining ability estimates (Table 4 and 5), it was observed that among various traits, vine length, fruit length, fruit girth, fruit weight, number of fruits per vine, fruit yield per vine and TSS had more of non-additive gene action while all other traits had more of additive gene action (Table 4 and 5). Ray *et al.* (2015); Shinde *et al.* (2016); Mishra *et al.* (2019); Khot *et al.* (2021); Patel and Mehta (2021); Patel *et al.* (2023) in bottle gourd who found that the presence of both additive and non-additive gene action for almost all characters.

For vine length, among the six parents, Kashi Rakshita (P_5) and Pusa Supriya (P_6) showed significant positive *gca* effects of 6.83 and 41.55 respectively (Table 6). The *sca* effect of thirty crosses ranges from -56.79 to 70.00 in the hybrid Kashi Rakshita × Pusa Supriya to Pusa Sneha × Pusa Supriya. Among 30 crosses, 11 crosses showed significantly positive *sca* effects. Significant effects for this trait were also reported by Singh *et al*. (2018); Chauhan *et al.* (2019) in sponge gourd.

For number of primary branches per vine, among six parents, the *gca* effect was varied from -0.69 to 0.94 in Pusa Supriya (P_6) and Kashi Shreya (P_4). The *gca* effect was significantly positive (0.24, 0.94, 0.36) in Pusa Sneha (P_2), Kashi Shreya (P_4) and Kashi Rakshita (P_5) respectively. In the thirty crosses, the *sca* effect was ranged from -0.84 to 0.77. The *sca* effect was significantly positive (0.26, 0.57, 0.23, 0.77) in the cross combinations *viz.*, Phule Prajaktha × Pusa Sneha, Pusa Sneha × Pusa Chikni, Kashi Shreya × Kashi Rakshita, Kashi Shreya × Pusa Supriya. Significant effects for this trait were also reported by Ray *et al.* (2015); Dubey and Maurya (2007); Maurya *et al.* (2004) in bottle gourd. For number of nodes per vine, the range of *gca* effect was varied from -2.20 to 4.59 in the parents Kashi Shreya (P_4) and Pusa Supriya (P_6). The *gca* effect was significantly positive (2.19 and 4.59) in Pusa Sneha (P_2) and Pusa Supriya (P_6). Among 30 crosses, the range of *sca* effect was varied from -

3.06 to 8.51 in Phule Prajaktha × Pusa Supriya and Pusa Supriya × Pusa Sneha, while eight crosses showed significantly positive *sca* effects. This finding is in confirmation with the findings of Malaviya *et al.* (2017); Patel and Mehta (2021) in bottle gourd.

For sex ratio, the estimate of *gca* effect among six parents ranged from -5.08 Pusa Sneha (P_2) to 6.62 Pusa Supriya (P_6). The highly significant and negative effect (-0.66, -5.08, -0.92, -1.48) was observed in Phule Prajaktha (P_1), Pusa Sneha (P_2), Kashi Shreya (P_4), Kashi Rakshita (P_5). The estimate of *sca* effect among 30 crosses ranged from -2.12 (Pusa Chikni× Kashi Rakshita) to 6.87 (Pusa Supriya × Kashi Shreya). The *sca* effect was significantly negative (-0.76, -0.84, -1.40, -2.12, -1.97) in the hybrids *viz.*, Phule Prajaktha × Pusa Chikni, Pusa Sneha × Pusa Chikni, Pusa Sneha × Pusa Supriya, Pusa Chikni × Kashi Rakshita, Kashi Shreya × Pusa Supriya. This finding is in confirmation with the findings of Muthaiah *et al.* (2017) in ridge gourd. For days to first fruit harvest, the *gca* effect among six parents varied from -4.44 to 4.15 in Kashi Shreya (P_4) and Pusa Supriya (P_6). Negative and significant (-2.57, -4.44, -1.00) *gca* effect was observed in three parents *viz.*, Pusa Sneha (P_2), Kashi Shreya (P_4), Kashi Rakshita (P_5). The *sca* effect of 30 crosses were ranged from -3.45 to 3.45 in Kashi Rakshita × Pusa Sneha and Pusa Supriya × Pusa Sneha. Negative and significant *sca* effect was observed in the 14 crosses. Sarkar *et al.* (2015) in ridge gourd narrated similar significant negative SCA effects.

For fruit length, the highest *gca* effect (1.16) was recorded by the parent Kashi Shreya (P_4) while, Phule Prajaktha (P_1) recorded the lowest effect (-1.35). The *gca* effect was significantly positive (0.67, 1.16) in two parents *viz.*, Pusa Sneha (P_2) Kashi Shreya (P_4). The *sca* effect of 30 crosses were ranged from -1.38 to 1.47 in Pusa Supriya × Pusa Sneha and Pusa Sneha × Phule Prajaktha. For the length of fruit, 12 crosses recorded significantly positive SCA effects. Significant positive combining ability effect was also found by Quamruzzaman *et al*. (2020); Mishra *et al.* (2019); Wani *et al*. (2009) in bottle gourd. For fruit girth, the *gca* effect among six parents was ranged from -0.85 to 1.20 in the parents Kashi Shreya (P_4) and Phule Prajaktha (P_1). The *gca* effect was significantly positive (1.20) in the parent Phule Prajaktha (P_1). The *sca* effect was ranged from -2.06 to 1.38 in Kashi Shreya × Phule Prajaktha and Kashi Shreya × Pusa Supriya. Seven crosses *viz.*, Phule Prajaktha × Pusa Chikni, Phule Prajaktha × Kashi Rakshita, Pusa Sneha × Kashi Shreya, Kashi Shreya × Pusa Sneha ($P_4 \times P_2$), Pusa Sneha × Pusa Supriya, Pusa Chikni × Kashi Rakshita and Kashi Shreya × Pusa Supriya was found to be significantly positive (0.98, 0.58, 1.26, 1.80, 0.66, 0.90, 1.38). Significant GCA effect for this character was reported by Quamruzzaman *et al*. (2020); Wani *et al.* (2009) in bottle gourd.

For fruit weight, the highest positive and negative *gca* effects for fruit weight (78.00 and -71.23) was recorded in Kashi Shreya (P_4) and Pusa Chikni (P_3) respectively. The *sca* effects among 30 crosses ranged from -37.11 in Kashi Shreya × Phule Prajaktha to 75.70 in Kashi Rakshita × Pusa Sneha and the *sca* effects were positive and significant for fifteen crosses. Quamruzzaman *et al.* (2020); Shinde *et al*. (2016) in bottle gourd; Thangamani and Pugalendhi (2013) in bitter gourd also found significant result in desirable direction.

For number of fruits per vine, the *gca* effects of parents ranged from -2.81Pusa Chikni (P_3) to 3.50 Pusa Sneha (P_2). Among six parents, two parents Pusa Sneha (P_2) and Kashi Shreya (P_4) recorded significantly positive *gca*values of 3.50and 2.74. The *sca* effects for 30 crosses ranged from -3.32 in Pusa Chikni × Pusa Supriya to 3.63 in Kashi Shreya × Pusa Supriya. The *sca* effects were positive and significant for 11 crosses. Similar result was also noticed by Quamruzzaman *et al.* (2020) in bottle gourd; Chauhan *et al.* (2019); Kumar *et al.* (2018) in sponge gourd.

For fruit yield per vine, among six parents, the *gca* effects was varied from -1.87 in Kashi Rakshita (P_5) to 2.78in Kashi Shreya (P_4). The parents Pusa Sneha (P_2) and Kashi Shreya (P_4) were significantly positive with the *gca* values of 2.47 and 2.78. The specific combining ability effects of the hybrids varied from -1.62 in Phule Prajaktha × Pusa Supriya to 2.71 in Pusa Sneha × Pusa Supriya. The *sca* effects were positive and significant for 13 crosses. Similar result was also noticed by Chauhan *et al.* (2019); Kumar *et al.* (2018) in sponge gourd; Rajaguru *et al.* (2020) in cucumber.

For TSS, among six parents, Kashi Shreya (P_4) and Kashi Rakshita (P_5) showed significant positive *gca*effects of 0.15 and 0.33. The *sca* effects among 30 crosses ranged from -0.29 in Pusa Sneha × Kashi Rakshita and Pusa Supriya × Kashi Rakshita to 0.79 in Kashi Rakshita × Kashi Shreya. The *sca* effects were positive and significant for eight crosses. Similar result was also noticed by Reddy *et al.* (2018) in sponge gourd and Rajaguru *et al.* (2020) in cucumber. For crude fibre, the *gca* effects varied from -0.03 in Pusa Chikni (P_3) and Pusa Supriya (P_6) to 0.06 in Kashi Rakshita (P_5). Among six parents, two showed significant and positive *gca* effects *viz.*, Kashi Shreya (P_4) and Kashi Rakshita (P_5) with values of 0.02 and 0.06 respectively. The *sca* effects were positive and significant for 13 crosses. Similar result was also noticed by Chandan *et al.* (2018) in ridge gourd.

In the present study, the parent Kashi Shreya (P_4) was adjudged as a best general combiner, since it expressed significant *gca* effects for nine characters out of twelve characters studied (Table 5). The parent Kashi Shreya (P_4) was the best combiner for 9 traits out of 12 traits studied *viz.*, number of primary branches per vine, sex ratio, days to first fruit harvest, fruit length, fruit weight, number of fruits per vine, TSS, crude fibre and fruit yield per vine. A good combiner in fruit yield has also found to be a good combiner in number of primary branches per vine, sex ratio, days to first fruit harvest, fruit weight, number of fruits per vine, TSS. A good combiner in fruit yield has also found to be a good combiner in fruit weight and number of fruits per vine. This was in conformity with the findings of Sivasubramanian (2016) in snake gourd; Saravanan (2013); Muthaiah *et al.* (2022) in ridge gourd; Rajaguru *et al.* (2020) in cucumber.

The parent Pusa Sneha (P_2) was also a best combiner for

the 8 traits. The next good general combiner was Kashi Rakshita (P_5) with highly significant *gca* for 6 characters *viz.*, vine length, number of primary branches per vine, sex ratio, days to first fruit harvest, TSS and crude fibre. From the above points, it could be inferred that Kashi Shreya (P_4), Pusa Sneha (P_2) and Kashi Rakshita (P_5) were the best general combiners, since they expressed good *gca* effects for majority of the traits. In general, parents with high *per se* performance had high *gca* indicating the presence of additive gene action. This was in conformity with the results of Sivasubramanian (2016) in snake gourd; Saravanan (2013) in ridge gourd; Manikandan (2012) in ash gourd. It may be inferred that the yield contributing genotypes can maintain their superiority in combining ability effects. This was also reported by Singh *et al.* (2013) in bitter gourd; Narasannavar (2014) in ridge gourd; Bairwa *et al.* (2015) in ridge gourd; Adarsh *et al.* (2015) in bottle gourd; Muthaiah *et al.* (2017) in ridge gourd.

Table 1: Analysis of variance for 6 × 6 diallel of sponge gourd.

Sr. No.	Traits	Mean squares		
		Replication	Treatment	Error
1.	Vine length (cm)	85.47	4972.86**	19.42
2.	Number of primary branches vine^{-1}	0.34	1.77**	0.03
3.	Number of nodes vine $^{-1}$	0.59	46.74**	1.08
4.	Sex ratio	4.36	65.68**	0.64
5.	Days to first fruit harvest	0.31	46.65**	0.25
6.	Fruit length (cm)	0.002	6.61**	0.33
7.	Fruit girth (cm)	0.31	6.61**	0.33
8.	Fruit weight (g)	1.60	13926.47**	0.30
9.	Number of fruits vine $^{-1}$	0.03	35.31**	0.61
10.	Fruit yield vine^{-1} (kg)	1.83	22.59**	0.27
11.	Total Soluble Solids (°brix)	0.03	0.32**	0.01
12.	Crude fibre (g)	0.01	0.007**	0.0004

*, ** Significant at 5% and 1% level, respectively

Table 2: *Per se* performance of parents and hybrids for various characters in sponge gourd.

Sr. No.	Parents and Crosses	Vine length	Number of primary branches vine^{-1}	Number of nodes vine $^{-1}$	Sex ratio	Days to first fruit harvest	Fruit length
1.	Phule Prajaktha	424.81	3.73	45.74	20.15	53.00	26.13
2.	Pusa Sneha	386.3	4.52*	52.23**	12.90**	42.90**	33.27**
3.	Pusa Chikni	457.42	2.94	45.26	22.26	52.90	31.74
4.	Kashi Shreya	391.47	6.01**	44.86	19.59	41.30**	32.81**
5.	Kashi Rakshita	538.91**	4.90**	44.37	17.24**	43.00**	30.48
6.	Pusa Supriya	555.36**	2.51	58.97**	30.54	54.90	29.01
7.	Phule Prajaktha × Pusa Sneha	383.85	4.3025	48.21	14.85**	43.40**	33.49
8.	Phule Prajaktha × Pusa Chikni	450.15	3.57	43.59	20.19	51.70	32.15
9.	Phule Prajaktha × Kashi Shreya	443.64	4.75*	43.71	18.18**	41.40**	33.21
10.	Phule Prajaktha × Kashi Rakshita	446.37	3.84	44.83	17.42**	52.25	32.14
11.	Phule Prajaktha × Pusa Supriya	497.32	3.06	53.01**	25.51	55.25	30.91
12.	Pusa Sneha × Phule Prajakta	418.17	4.71	45.24	14.10**	44.45**	28.95
13.	Pusa Sneha × Pusa Chikni	439.10	4.36	43.82	15.12**	45.40**	34.22**
14.	Pusa Sneha × Kashi shreya	395.64	4.92**	49.98**	15.26**	40.50**	35.17**
15.	Pusa Sneha × Kashi Rakshita	449.81*	4.65	46.58	14.54**	41.70**	32.31*
16.	Pusa Sneha × Pusa Supriya	570.08**	3.90	63.44**	23.47	51.20	31.44
17.	Pusa Chikni × Phule Prajakta	441.68	3.58	45.90	20.42	50.40	30.33
18.	Pusa Chikni ×Pusa Sneha	396.19	4.84*	46.30	16.49**	48.40	32.60
19.	Pusa Chikni × Kashi Shreya	425.83	4.7	41.74	22.53	41.25**	31.59
20.	Pusa Chikni × Kashi Rakshita	398.91	4.02	42.33	18.78	44.50**	33.22**
21.	Pusa Chikni × Pusa Supriya	447.5	2.58	50.28**	35.53	53.30	31.22
22.	Kashi Shreya × Phule Prajakta	399.62	4.64	43.38	19.25	45.15**	33.96*
23.	Kashi Shreya × Pusa Sneha	441.13*	5.23	43.14	13.04**	40.60**	34.73**
24.	Kashi Shreya × Pusa Chikni	510.33**	4.53	42.72	20.23	46.70	33.47
25.	Kashi Shreya × Kashi Rakshita	444.47	5.03**	40.30	18.55	39.15**	33.61
26.	Kashi Shreya × Pusa Supriya	445.78	4.73*	48.06	30.80	49.00	34.16*
27.	Kashi Rakshita × Phule Prajaktha	458.75*	4.73*	43.95	18.54*	47.70	32.49
28.	Kashi Rakshita × Pusa Sneha	349.25	4.92**	48.28	11.52**	48.60	32.10
29.	Kashi Rakshita × Pusa Chikni	499.61**	4.36	43.80	17.49**	48.75	32.16
24.	Kashi Rakshita × Kashi shreya	467.84**	6.72**	42.61	17.20**	40.35**	31.41
25.	Kashi Rakshita × Pusa Supriya	433.66	3.51	53.57**	27.66	53.10	32.61
26.	Pusa Supriya × Phule Prajaktha	448.57	3.29	40.72	25.65	52.55	31.49
27.	Pusa Supriya × Pusa Sneha	506.81**	3.90	46.41	17.20**	44.30**	34.21**
28.	Pusa Supriya ×Pusa Chikni	507.21**	2.87	47.26	29.53	50.55	31.97
29.	Pusa Supriya ×Kashi Shreya	474.25**	5.97**	47.65	17.05**	45.20**	34.65**
30.	Pusa Supriya × Kashi Rakshita	450.76*	4.695	46.21	28.46	51.10	33.45**

*, ** Significant at 5% and 1% level, respectively

Table 3: *Per se* performance of parents and hybrids for various characters in sponge gourd.

Sr. No.	Parents and Crosses	Fruit girth	Fruit weight	Number of fruits vine $^{-1}$	Fruit yield vine^{-1}	TSS	Crude fibre
1.	Phule Prajaktha	17.16**	139.23	17.52	2.54	2.41	0.30
2.	Pusa Sneha	15.09	351.71**	21.32**	6.61**	2.31	0.36
3.	Pusa Chikni	15.87	127.84	14.38	1.65	2.14	0.28
4.	Kashi Shreya	13.16	381.42**	20.38**	7.20**	2.78	0.38*
5.	Kashi Rakshita	15.97	178.87	15.26	2.88	3.59**	0.44**
6.	Pusa Supriya	14.39	268.51**	12.14	3.77	2.56	0.27
7.	Phule Prajaktha × Pusa Sneha	13.62	171.85	23.91**	8.49*	2.15	0.36
8.	Phule Prajaktha × Pusa Chikni	16.56	125.24	19.11	4.21	2.35	0.25
9.	Phule Prajaktha × Kashi Shreya	12.89	224.39	23.39**	9.09**	2.53	0.32
10.	Phule Prajaktha × Kashi Rakshita	17.22**	159.78	19.04	4.16	3.14**	0.41**
11.	Phule Prajaktha × Pusa Supriya	16.76*	183.73	18.34	4.29	2.52	0.34
12.	Pusa Sneha × Phule Prajakta	17.18**	234.43	24.06**	8.39	2.28	0.30
13.	Pusa Sneha × Pusa Chikni	12.94	215.77	21.23	7.96	2.05	0.29
14.	Pusa Sneha × Kashi shreya	17.16**	383.94**	29.39**	13.25**	2.80**	0.42**
15.	Pusa Sneha × Kashi Rakshita	14.65	334.90**	24.52**	8.60*	2.52	0.42**
16.	Pusa Sneha × Pusa Supriya	13.68	324.29**	24.42**	10.85**	2.24	0.30
17.	Pusa Chikni × Phule Prajakta	17.89**	127.45	18.08	6.43	2.35	0.27
18.	Pusa Chikni ×Pusa Sneha	13.92	178.34	23.35**	8.29	2.08	0.28
19.	Pusa Chikni × Kashi Shreya	14.12	183.67	21.29	8.46*	2.56	0.30
20.	Pusa Chikni × Kashi Rakshita	16.18	140.81	17.45	3.19	3.07**	0.43**
21.	Pusa Chikni × Pusa Supriya	12.84	131.56	11.85	4.90	2.46	0.24
22.	Kashi Shreya × Phule Prajakta	17.02**	298.62**	21.80	7.35	2.47	0.33
23.	Kashi Shreya × Pusa Sneha	13.55	381.78**	25.72**	12.26**	2.12	0.36
24.	Kashi Shreya × Pusa Chikni	13.70	244.02**	20.65	8.45*	3.12**	0.31
25.	Kashi Shreya × Kashi Rakshita	12.90	371.24**	23.34**	8.86**	3.84**	0.49**
26.	Kashi Shreya × Pusa Supriya	14.48	349.27**	24.94**	10.44**	2.66	0.32
27.	Kashi Rakshita × Phule Prajaktha	17.29**	152.26	20.05	2.68	2.59	0.32
28.	Kashi Rakshita × Pusa Sneha	14.94	183.49	25.16**	6.55	2.12	0.38**
29.	Kashi Rakshita × Pusa Chikni	16.11	171.25	18.24	1.78	2.63	0.35
24.	Kashi Rakshita × Kashi shreya	13.74	235.07	23.55**	8.54*	2.26	0.40**
25.	Kashi Rakshita × Pusa Supriya	15.14	224.84	16.08	5.21	2.32	0.33
26.	Pusa Supriya × Phule Prajaktha	16.88*	227.95	21.57	2.43	2.53	0.25
27.	Pusa Supriya × Pusa Sneha	17.53**	351.48**	23.87**	12.50**	2.32	0.25
28.	Pusa Supriya ×Pusa Chikni	14.49	196.55	12.19	3.90	2.33	0.30
29.	Pusa Supriya ×Kashi Shreya	17.11**	326.40**	24.16**	12.92**	2.44	0.27
30.	Pusa Supriya × Kashi Rakshita	15.51	193.65	16.45	2.84	2.91**	0.41**

*, ** Significant at 5% and 1% level, respectively

Table 4: Analysis of variance for combining ability in 6 × 6 diallel of sponge gourd.

Sr. No.	Traits	Mean squares			
		gca	*sca*	Reciprocal	Error
1.	Vine length (cm)	6529.04**	2003.49**	1621.86**	9.71
2.	Number of primary branches vine^{-1}	4.75**	0.23**	0.24**	0.01
3.	Number of nodes vine $^{-1}$	90.89**	4.75**	19.47**	0.54
4.	Sex ratio	181.46**	6.39**	9.75**	0.32
5.	Days to first fruit harvest	125.38**	5.16**	7.47**	0.12
6.	Fruit length (cm)	9.00**	3.16**	1.54**	0.16
7.	Fruit girth (cm)	5.67**	1.86	2.37**	0.21
8.	Fruit weight (g)	27362.69**	4488.18**	2638.46**	0.15
9.	Number of fruits vine $^{-1}$	82.10**	12.65**	1.18**	0.30
10.	Fruit yield vine^{-1} (kg)	53.77**	7.21**	1.21**	0.13
11.	Total Soluble Solids (°brix)	0.55**	0.05**	0.14**	0.005
12.	Crude fibre (g)	0.01**	0.0008	0.001**	0.0002

*, ** Significant at 5% and 1% level, respectively

The estimates of SCA effects are given in Table 6 and 7. The above results revealed that the high *sca* effects of hybrids may not have superior *per se* performance, indicating that *per se* performance of crosses need not truly reflect *sca* effects. Such findings are in agreement with the reports of Rajaguru *et al.* (2020) in cucumber; Haripriya (1992) in bitter gourd.

In the present study, desirable significant *sca* effects for all the characters were observed in many hybrids. The hybrid Pusa Sneha × Pusa Supriya excelled with superior *sca* effects for eight traits followed by the hybrids Pusa Sneha × Kashi Shreya, Pusa Chikni × Kashi Rakshita, Kashi Shreya × Kashi Rakshita and Kashi Shreya× Pusa Supriya with superior *sca* effects for seven traits and Kashi Rakshita × Pusa Sneha with superior *sca* effects for six traits. All these superior hybrids based on *sca* effects performed well for fruit weight. It also indicated that all of these crosses that showed significant *sca* effects involved both or at least one good general combiner. Similar observations were made by Bhatt *et al.* (2017) in bitter gourd; Devi *et al.* (2017) in snake gourd; Narasannavar *et al.* (2014) in ridge gourd; Bairwa *et al.* (2015) in ridge gourd.

Table 5: Gene action for different characters in sponge gourd.

Sr. No.	Traits	Variance due to GCA	Variance due to SCA	GCA/SCA
1.	Vine length (cm)	543.27	1993.78	0.27
2.	Number of primary branches vine^{-1}	0.39	0.21	1.84
3.	Number of nodes vine $^{-1}$	7.52	4.21	1.43
4.	Sex ratio	15.09	6.07	2.48
5.	Days to first fruit harvest	10.43	5.03	2.07
6.	Fruit length (cm)	0.73	3.00	0.24
7.	Fruit girth (cm)	0.45	1.64	0.27
8.	Fruit weight (g)	2280.21	4488.03	0.50
9.	Number of fruits vine $^{-1}$	6.81	12.34	0.55
10.	Fruit yield vine^{-1} (kg)	4.46	7.07	0.63
11.	Total Soluble Solids (°brix)	0.045	0.048	0.93
12.	Crude fibre (g)	0.001	0.0006	2.71

Table 6: Estimates of general combining ability effects for different characters in sponge gourd.

Parents	Vine length	Number of primary branches vine^{-1}	Number of nodes vine $^{-1}$	Sex ratio	Days to first fruit harvest	Fruit length
Phule Prajaktha (P_1)	-14.13**	-0.32**	-1.28 **	-0.66**	2.08**	-1.35**
Pusa Sneha (P_2)	-23.72**	0.24**	2.19**	-5.08**	-2.57**	0.67**
Pusa Chikni (P_3)	2.74	-0.54**	-1.76**	1.53**	1.79**	-0.10
Kashi Shreya (P_4)	-13.27**	0.94**	-2.20**	-0.92**	-4.44**	1.16**
Kashi Rakshita (P_5)	6.83**	0.36**	-1.52**	-1.48**	-1.00**	-0.09
Pusa Supriya (P_6)	41.55**	-0.69**	4.59**	6.62**	4.15**	-0.28**
Parents	**Fruit girth**	**Fruit weight**	**Number of fruits vine $^{-1}$**	**Fruit yield vine^{-1}**	**TSS**	**Crude fibre**
Phule Prajaktha (P_1)	1.20**	-53.42**	-0.13	-1.50**	-0.06**	-0.02**
Pusa Sneha (P_2)	-0.32*	53.20**	3.50**	2.47**	-0.26**	0.006
Pusa Chikni (P_3)	-0.22	-71.23**	-2.81**	-1.64**	-0.10**	-0.03**
Kashi Shreya (P_4)	-0.85**	78.00**	2.74**	2.78**	0.15**	0.02**
Kashi Rakshita (P_5)	0.20	-25.01**	-0.96**	-1.87**	0.33**	0.06**
Pusa Supriya (P_6)	0.00	18.46**	-2.33**	-0.23*	-0.05**	-0.03**

*, ** Significant at 5% and 1% level, respectively

Table 7: Estimates of specific combining ability effects for different characters in sponge gourd.

Sr. No.	Crosses	Vine length	Number of primary branches vine^{-1}	Number of nodes vine $^{-1}$	Sex ratio	Days to first fruit harvest	Fruit length
1.	Phule Prajaktha × Pusa Sneha	-11.74**	0.26**	-0.80	0.02	-2.68**	-0.40
2.	Phule Prajaktha × Pusa Chikni	6.68**	0.12	1.17*	-0.76*	0.07	0.39
3.	Phule Prajaktha × Kashi Shreya	-1.57	-0.24**	0.41	0.1	-1.46**	1.47**
4.	Phule Prajaktha × Kashi Rakshita	9.24**	-0.08	0.57	-0.07	1.79**	1.46**
5.	Phule Prajaktha × Pusa Supriya	-5.08**	-0.12	-3.06**	-0.58	0.55*	0.54*
6.	Pusa Sneha × Phule Prajakta	-17.16**	-0.20*	1.48**	0.37	-0.52*	2.27**
7.	Pusa Sneha × Pusa Chikni	-11.98**	0.57**	-1.99**	-0.84*	0.58**	0.52*
8.	Pusa Sneha × Kashi shreya	4.77*	-0.43**	-0.05	-0.03	0.46*	0.80**
9.	Pusa Sneha × Kashi Rakshita	-34.19**	-0.14	0.13	-0.6	1.62**	-0.68**
10.	Pusa Sneha × Pusa Supriya	70.00**	0.03	1.51**	-1.40**	-0.93**	0.13
11.	Pusa Chikni × Phule Prajakta	4.23	-0.007	-1.15*	-0.11	0.65*	0.90**
12.	Pusa Chikni × Pusa Sneha	21.45**	-0.24*	-1.23*	-0.68	-1.5**	0.81**
13.	Pusa Chikni × Kashi Shreya	27.99**	-0.11	-0.41	0.57	-0.47*	-0.83**
14.	Pusa Chikni × Kashi Rakshita	-9.07**	0.04	-0.26	-2.12**	-1.26**	0.58*
15.	Pusa Chikni × Pusa Supriya	-14.92**	-0.35**	-0.67	4.16**	-1.12**	-0.31
16.	Kashi Shreya × Phule Prajakta	22.01**	0.05	0.16	-0.53	-1.87**	-0.37
17.	Kashi Shreya × Pusa Sneha	-22.74**	-0.15	3.42**	1.11**	-0.05	0.21
18.	Kashi Shreya × Pusa Chikni	-42.25**	0.08	-0.49	1.15**	-2.72**	-0.94**
19.	Kashi Shreya × Kashi Rakshita	16.20**	0.23**	-1.43**	0.08	-1.90**	-0.85**
20.	Kashi Shreya × Pusa Supriya	-14.82**	0.77**	-1.15*	-1.97**	0.28	1.23**
21.	Kashi Rakshita × Phule Prajaktha	-6.19**	-0.44**	0.44	-0.56	2.27**	-0.17
22.	Kashi Rakshita × Pusa Sneha	50.28**	-0.13	-0.85	1.51**	-3.45**	0.1
23.	Kashi Rakshita × Pusa Chikni	-52.21**	-0.17	-0.73	0.64	-2.12**	0.53
24.	Kashi Rakshita × Kashi shreya	-15.91**	-0.84**	-1.15*	0.67	-0.60*	1.10**
25.	Kashi Rakshita × Pusa Supriya	-56.79**	0.10	0.20	2.71**	1.84**	1.11**
26.	Pusa Supriya × Phule Prajaktha	24.37**	-0.11	6.14**	-0.07	1.35**	-0.28
27.	Pusa Supriya × Pusa Sneha	31.63**	0.00	8.51**	3.13**	3.45**	-1.38**
28.	Pusa Supriya × Pusa Chikni	-32.49**	-0.14	1.51**	3.00**	1.37**	-0.37
29.	Pusa Supriya × Kashi Shreya	-18.28**	-0.62**	0.20	6.87**	1.90**	-0.24
30.	Pusa Supriya × Kashi Rakshita	-8.54**	-0.59**	3.68**	-0.4	1.00**	-0.41

*, ** Significant at 5% and 1% level, respectively

Table 8: Estimates of specific combining ability effects for different characters in sponge gourd.

Sr. No.	Crosses	Fruit girth	Fruit weight	Number of fruits vine $^{-1}$	Fruit yield vine^{-1}	TSS	Crude fibre
1.	Phule Prajaktha × Pusa Sneha	-0.74*	-32.08**	0.11	0.74	0.006	0.01
2.	Phule Prajaktha × Pusa Chikni	0.98**	15.56**	1.04**	1.75**	-0.02	-0.01
3.	Phule Prajaktha × Kashi Shreya	-0.66*	1.48**	-0.52	0.22	-0.13**	-0.01
4.	Phule Prajaktha × Kashi Rakshita	0.58*	-0.97**	0.14	0.07	0.05	-0.01*
5.	Phule Prajaktha × Pusa Supriya	0.35	5.36**	1.92**	-1.62**	0.10*	0.01*
6.	Pusa Sneha × Phule Prajakta	-1.77**	-31.28**	-0.07	0.05	-0.06	0.03*
7.	Pusa Sneha × Pusa Chikni	-1.28**	-20.34**	1.10**	0.57*	-0.11*	-0.02*
8.	Pusa Sneha × Kashi shreya	1.26**	16.21**	0.79*	0.77**	0.03	0.02**
9.	Pusa Sneha × Kashi Rakshita	-0.35	-4.43**	1.79**	0.25	-0.29**	-0.006
10.	Pusa Sneha × Pusa Supriya	0.66*	30.78**	2.38**	2.71**	0.05	-0.02**
11.	Pusa Chikni × Phule Prajakta	-0.66*	-1.10**	0.51	-1.11**	0	-0.01
12.	Pusa Chikni × Pusa Sneha	-0.49	18.71**	-1.06*	-0.16	0	0.007
13.	Pusa Chikni × Kashi Shreya	-0.27	-28.35**	0.53	0.60**	0.24**	-0.01*
14.	Pusa Chikni × Kashi Rakshita	0.90**	16.84**	1.13**	-0.71**	0.06	0.02**
15.	Pusa Chikni × Pusa Supriya	-1.37**	-18.60**	-3.32**	-0.43	0.008	0.01
16.	Kashi Shreya × Phule Prajakta	-2.06**	-37.11**	0.79*	0.86**	0.03	-0.005
17.	Kashi Shreya × Pusa Sneha	1.80**	1.08**	1.83**	0.49	0.34**	0.03**
18.	Kashi Shreya × Pusa Chikni	0.21	-30.17**	0.32	0.007	-0.28**	-0.007
19.	Kashi Shreya × Kashi Rakshita	-1.29**	14.73**	1.16**	1.07**	0.01	0.02*
20.	Kashi Shreya × Pusa Supriya	1.38**	5.93**	3.63**	2.41**	-0.08*	-0.02**
21.	Kashi Rakshita × Phule Prajaktha	-0.03	3.76**	-0.5	0.74**	0.27**	0.04**
22.	Kashi Rakshita × Pusa Sneha	-0.14	75.70**	-0.31	1.02**	0.20**	0.02*
23.	Kashi Rakshita × Pusa Chikni	0.03	-15.22**	-0.39	0.70**	0.22**	0.04**
24.	Kashi Rakshita × Kashi shreya	-0.41	68.08**	-0.1	0.15	0.79**	0.04**
25.	Kashi Rakshita × Pusa Supriya	-0.14	-19.63**	-0.93**	-0.58*	-0.21**	0.005
26.	Pusa Supriya × Phule Prajaktha	-0.06	-22.11**	-1.61**	0.93**	-0.007	0.04**
27.	Pusa Supriya × Pusa Sneha	-1.93**	-13.59**	0.17	-0.82**	-0.04	0.02*
28.	Pusa Supriya × Pusa Chikni	-0.82*	-32.49**	-0.17	0.49	0.06	-0.03**
29.	Pusa Supriya × Kashi Shreya	-1.31**	11.43**	0.39	-1.24**	0.11*	0.02*
30.	Pusa Supriya × Kashi Rakshita	-0.18	15.59**	-0.18	1.18**	-0.29**	-0.03**

*, ** Significant at 5% and 1% level, respectively

CONCLUSIONS

Based on mean performance, the best hybrid combinations were Pusa Sneha × Kashi Shreya (P_2 × P_4) followed by Pusa Supriya × Kashi Shreya (P_6 × P_4) and Pusa Supriya × Pusa Sneha (P_6 × P_2) in terms of yield and yield component traits in the order of merit. An overview of *per se* performance and *gca* effects of parents for yield per vine and other yield components revealed that the parents Kashi Shreya (P_4) and Pusa Sneha (P_2) can be selected as desirable parents for the breeding programme. The selection of hybrids based on *sca* effects resulted in the identification of the hybrids Pusa Sneha × Pusa Supriya (P2 × P6), Pusa Chikni × Kashi Rakshita (P3 × P5), Kashi Shreya × Pusa Supriya (P4 × P6), Kashi Shreya × Kashi Rakshita (P4 × P5), Pusa Sneha × Kashi Shreya (P_2 × P_4) and Kashi Rakshita × Pusa Sneha (P_5 × P_2) which had superior *sca* effects for majority of growth and yield attributing characters.

Though, these cross combinations may be utilized for commercial cultivation as hybrids after critical evaluation in varied environments or over locations. These could be used in future crossing Programme. The preponderance of non-additive gene action for most of the traits suggested that heterosis breeding approach might be more rewarding than selection.

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