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Studies on heterosis and combining ability for earliness and yield in sponge gourd

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ABSTRACT

Combining ability studies of seven parental lines of sponge gourd in 2 × 5 Line × Tester design for earliness and yield revealed the predominant role of non-additive gene effect in controlling earliness and increasing yield. Among parents, Pusa Sneha was found the best general combiner for imparting earliness; PSG-9 for ratio of male and female flowers and NSG-1-11 for total yield per plant. Significant sca effect for earliness was lacking, but five hybrids exhibited desirable sca effects for earliness. DSG-6 × Pusa Sneha was found superior for days to first fruit picking and DSG-7 × NSG-1-11 for number of male and female flowers and total yield per plant. The parent NSG-1-11 and Pusa Sneha were most promising for yield improvement and imparting earliness, therefore, they may be recommended as useful parent in breeding superior varieties. DSG-6 × Pusa Sneha exhibited maximum standard heterosis (%) for earliness and DSG-7 × NSG-1-11 for ratio of male and female flowers and total yield per plant. Therefore, they may be recommended for commercial cultivation in North Indian plains.

Key words: Combining ability, heterosis, earliness, yield, sponge gourd.

INTRODUCTION

Sponge gourd (*Luffa cylindrica* Roem.), is a very popular vegetable in the tropical and sub-tropical regions. It is an important component of crop rotation during pre-*kharif* and *kharif* seasons under North Indian conditions and is cultivated both on commercial scale and in kitchen gardens (Choudhury, 2). Attention to the improvement on yielding ability and other characters has been very limited which is prominent from the presence of very few varieties for commercial cultivation. Earliness is a major criterion for any crop improvement programme as it benefits the grower to reap good profit by catching the high early market price. Being monoecious and essentially cross-pollinated, it provides ample scope for successful exploitation of hybrid vigour. The studies of combining ability is useful in connection with testing procedures in which it is desired to study and compare the performance of a genotype in hybrid combinations. The selection of best parent for hybridization has to be based on genetic information and knowledge of their combining ability along with the extent of heterosis they reflect. The present study was undertaken to study the combining ability of parents and extent of heterosis in F_1 hybrids over their respective better parent and standard cultivar Pusa Sneha.

MATERIALS AND METHODS

Seven promising lines/varieties of diverse origin of sponge gourd were crossed in 2 × 5 Line × Tester fashion (Kempthorne, 4) to obtain ten F_1 hybrids. The F_1 hybrids along with their parents were evaluated at the experimental farm of Division of Vegetable Science, IARI, during August-November in randomized block design with three replications. Distance between rows was kept 120 cm and plants were spaced at 60 cm apart within row. Observations were recorded on ten randomly selected plants in each replication on days to first female flower opening, days to first fruit setting, days to first fruit picking, ratio of male and female flowers and total yield per plant. Data thus recorded were analyzed as per the method of Kempthorne (4) to work out the general combining ability effect of the parents and specific combining ability effects of the crosses. Heterosis was calculated as percentage increase in F_1 over better parent and standard variety Pusa Sneha.

RESULTS AND DISCUSSION

The analysis of variance for combining ability is presented in Table 1. Treatment differences were found significant for all the characters studied. Parents differed significantly for ratio of male and female flowers and total yield per plant. Crosses exhibited significant differences for all the characters except for the ratio of male and female flowers. The estimate of gca effects of the parents and sca effects of the crosses have been presented in Tables 2 & 3, respectively. Parents with early flowering were considered better than those flowering late. Therefore, parents with significant negative gca effects were considered more desirable. The estimate

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Table 1. ANOVA for line × tester analysis including parents in sponge gourd.

Source of variation	df	MSS				
		Days to first female flowering	Days to first fruit setting	Days to first fruit picking	Ratio of male and female flowers	Total yield (kg/plant)
Replication	2	22.76	26.25	34.25	0.08	0.08
Treatment	16	69.09**	66.82*	77.25*	1.92**	5.93**
Parent	6	12.08	12.11	15.60	1.84**	3.05**
P vs. C	1	308.24**	300.64**	353.89**	17.58**	38.92**
Cross	9	80.52**	77.32**	87.61*	0.24	4.19*
Tester	4	124.88**	118.05	139.88	0.23	3.10
Line	1	149.63**	112.13	136.53	0.04	13.76**
Line × tester	4	18.88	27.88	23.12	0.29	2.88*
Error	32	7.70	13.03	11.05	0.07	0.08

*,** Significant at 5 and 1% levels

Table 2. Estimates of general combining ability (GCA) effects in sponge gourd.

Genotype	Days to first female flowering	Days to first fruit setting	Days to first fruit picking	Ratio of male and female flowers	Total yield (kg/plant)
Pusa Sneha	-5.93**	-5.57**	-6.10**	-0.004	0.23*
PSG-9	3.57**	3.60*	4.40**	-0.20	0.20
NSG-1-11	3.23**	3.10*	3.57*	-0.19	0.97**
CHSG-1	3.07*	2.93	2.40	0.24	-0.86**
CHSG-2	-3.93**	-4.07**	-4.27**	0.14	-0.55**
SE (gi)	1.13	1.47	1.36	0.11	0.11
SE (gi-gj)	1.60	2.08	1.92	0.15	0.16
Lines					
DSG-6	2.23**	1.93*	2.13*	-0.04	0.68**
DSG-7	-2.23**	-1.93*	-2.13*	0.04	-0.68**
SE (gj)	0.72	0.93	0.86	0.07	0.07
SE (gi-gj)	1.01	1.32	1.21	0.09	0.23

*,** Significant at 5 and 1% levels

Table 3. Estimates of specific combining ability (SCA) effects in sponge gourd.

Cross	Days to first female flowering	Days to first fruit setting	Days to first fruit picking	Ratio of male and female flowers	Total yield (kg/plant)
DSG-6 × Pusa Sneha	-2.40	-2.43	-2.97	-0.03	-0.42*
DSG-6 × PSG-9	0.10	-0.27	-0.13	-0.24*	0.23
DSG-6 × NSG-1-11	2.43	3.23	1.70	0.36	-0.97**
DSG-6 × CHSG-1	0.60	0.73	1.87	-0.01	0.39*
DSG-6 × CHSG-2	-0.73	-1.27	-0.47	-0.09	0.77**
DSG-7 × Pusa Sneha	2.40	2.43	2.97	0.03	0.42*
DSG-7 × PSG-9	-0.10	0.27	0.13	0.24	-0.23
DSG-7 × NSG-1-11	-2.43	-3.23	-1.70	-0.36	0.97**
DSG-7 × CHSG-1	-0.60	-0.73	-1.87	0.01	-0.39*
DSG-7 × CHSG-2	0.73	1.27	0.47	0.09	-0.77**
SE (sca effects)	1.60	2.08	1.92	0.15	0.16

*,** Significant at 5 and 1% levels

of gca effect revealed that Pusa Sneha was the best general combiner for days to first female flower opening (-5.93), days to first fruit setting (-5.57) and days to first fruit picking (-6.10) followed by CHSG-2 and DSG-7. Four parents, namely PSG-9, NSG-1-11, CHSG-1 and DSG-6 were found poor general combiner as they exhibited significant positive gca effect. The performance of genotype on yield aspect is the foremost breeding objective for any crop improvement programme. Therefore, with an eye on earliness combining ability effects of parents regarding yield parameters were also taken into consideration. Sponge gourd, being monoecious crop ratio of male and female flowers is an important yield attributing traits as lower ratio have been reported to be associated with higher fruit set and subsequently higher yield (Seshadri and Parthasarathy, 8). Like earliness, here also negative gca effect of the genotypes were considered superior. In the present study PSG-9 was found the best general combiner for ratio of male and female flowers followed by NSG-1-11 and DSG-6 (-0.20, -0.19 and -0.04, respectively). Total yield per plant is a complex trait and is influenced by various yield attributing traits and environment effects. High and positive gca effect is the desired criterion to attribute superiority to a genotype over others. In the present study, NSG-1-11 emerged as the best general combiner for total yield per plant followed by DSG-6 and Pusa Sneha (0.97, 0.68 and 0.23, respectively). Regarding specific combining ability effects the criteria for sorting out the desirable specific combinations remained same as described for gca effects. Out of 10 crosses, 5 crosses showed desirable negative sca effect for days to first female flower opening, days to first fruit setting and days to first fruit picking. The best specific combinations for days to first female flowering and days to first fruit setting were DSG-7 × NSG-1-11, DSG-6 × Pusa Sneha and DSG-7 × CHSG-2. DSG-6 × Pusa Sneha was found best specific combination for days to first fruit picking followed by DSG-7 × CHSG-1 and DSG-7 × NSG-1-11 (-2.97, -1.87 and -1.70, respectively). In order of merit, DSG-7 × NSG-1-11 was found superior to other crosses for the ratio of male and female flowers and total yield per plant (-0.36 and 0.97, respectively) followed by DSG-6 × PSG-9 and DSG-6 × CHSG-2 for the ratio of male and female flowers and DSG-6 × CHSG-2 and DSG-7 × Pusa Sneha for total yield per plant.

It is apparent from the result that in majority of the hybrids showing the best sca effects, the parental lines involved were either one or both good general combiners having high and desirable gca effects. The general combining ability in turn is influenced by *per se* performance of the genotypes. The result suggests that from economic point of view, it is necessary to utilize the early flowering genotypes with higher yield in order to achieve early flowering F_1 hybrids for

Table 4. Mean performance of parents and hybrids for earliness and yield.

Parent/F_1	Days to first female flowering	Days to first fruit setting	Days to first fruit picking	Ratio of male and female flowers	Total yield (kg/plant)
Pusa Sneha	51.00	56.33	60.67	16.96	1.78
PSG-9	53.00	56.67	62.00	17.57	0.50
NSG-1-11	53.67	57.67	62.67	17.01	0.63
CHSG-1	55.00	59.67	65.00	17.27	0.81
CHSG-2	55.00	59.00	65.33	17.57	0.89
DSG-6	49.67	53.67	59.00	15.71	2.84
DSG-7	52.00	56.00	61.33	15.78	2.57
DSG-6 × Pusa Sneha	41.67	46.00	50.00	15.57	3.86
DSG-6 × PSG-9	53.67	57.33	63.33	15.57	3.24
DSG-6 × NSG-1-11	55.67	60.33	64.33	15.78	4.56
DSG-6 × CHSG-1	53.67	57.67	63.33	15.84	2.64
DSG-6 × CHSG-2	45.33	48.67	54.33	15.66	3.94
DSG-7 × Pusa Sneha	42.00	47.00	51.67	15.70	4.83
DSG-7 × PSG-9	49.00	54.00	59.33	15.71	3.56
DSG-7 × NSG-1-11	46.33	50.00	56.67	15.13	1.34
DSG-7 × CHSG-1	48.00	52.33	55.33	15.93	4.43
DSG-7 × CHSG-2	42.33	47.33	51.00	15.91	1.28

exploitation of heterosis. While selecting the parental lines for obtaining early flowering F_1 hybrids, it would be more useful to select those parents which have high negative sca effect in respect of earliness and ratio of male and female flowers and high positive sca effect for total yield per plant. Therefore, the parents DSG-6, DSG-7 and Pusa Sneha were found promising for selection and recombination breeding. Report on combining ability of parents and crosses pertaining to earliness in sponge gourd is lacking. However, similar reports of combining ability effects of parents and crosses for earliness in ridge gourd have been presented by Shaha *et al*. (9), Rao *et al*. (6), Shaha and Kale (10), and Tyagi *et al*. (12).

A perusal of the mean performance of parents (Table 4) revealed that among the parents, the genotype DSG-6 was the earliest (53.67 days) and produced the highest total yield per plant (2.85 kg). It also exhibited lowest ratio of male and female flowers (15.71). Among the hybrids, DSG-6 × Pusa Sneha was the earliest to produce marketable fruits (41.67 days) followed closely by DSG-7 × Pusa Sneha (42.00 days). The cross combination DSG-7 × NSG-1-11 had the lowest ratio of male and female flowers. The best hybrid for total yield per plant was DSG-7 × NSG-1-11 (4.53 kg) followed by DSG-6 × PSG-9 (4.38 kg). Therefore, it is inferred that lower ratio of male and female flowers have positive correlation with total yield per plant. The result of the characters studied for the estimates of heterosis over better and standard parent have been presented in Table 5. The expression of heterosis for various traits ranged from large positive effects to significant negative effects. In the present study none of the F_1 hybrid was found consistently superior to others for all the characters. Out of 10 hybrids, three hybrid combinations exhibited highly significant heterosis over better parent and standard parent (Pusa Sneha) for days to first female flowering and days to first fruit picking, while two cross combinations expressed highly significant heterobeltiosis for days to first fruit setting and three hybrids documented highly significant heterosis

Table 5. Estimates of heterosis (%) over better parent and standard parent.

Cross	Days to first female flowering		Days to first fruit setting		Days to first fruit picking		Ratio of male and female flowers		Total yield (kg/plant)	
	BP	SP	BP	SP	BP	SP	BP	SP	BP	SP
DSG-6 × Pusa Sneha	-16.11**	-18.29**	-14.29*	-18.34**	-15.25**	-17.59**	-0.89**	-8.20**	31.93**	71.69**
DSG-6 × PSG-9	8.05	5.24	6.82	1.78	7.34	4.38	-3.44**	-10.55**	53.68**	100**
DSG-6 × NSG-1-11	12.08*	9.16*	12.41*	7.10	9.03	6.03	0.45	-6.96**	38.25**	79.91**
DSG-6 × CHSG-1	8.05	5.24	7.45	2.38	7.34	4.38	0.83*	-6.60**	22.11**	58.90**
DSG-6 × CHSG-2	-8.74	-11.12*	-9.32	-13.60*	-7.92	-10.45*	-0.32	-7.67**	46.32**	90.41**
DSG-7 × Pusa Sneha	-17.65**	-17.65**	-16.07**	-16.56**	-14.83**	-14.83**	-0.51	-7.43**	25.1**	47.95**
DSG-7 × PSG-9	-5.77	-3.92	-3.57	-4.14	-3.26	-2.21	-0.44	-7.37**	-1.16	16.89
DSG-7 × NSG-1-11	-10.90*	-9.16*	-10.71	-11.24*	-7.60	-6.59	-4.12**	-10.79**	74.90**	106.85**
DSG-7 × CHSG-1	-7.69	-5.88	-6.55	-7.10	-9.78*	-8.80	0.95**	-6.07**	-48.26**	-38.81**
DSG-7 × CHSG-2	-18.6**	-17**	-15.48**	-15.98**	-16.84**	-15.98**	0.82*	-6.19**	-50.58**	-41.55**
General mean										
Range	-18.6-12.08	-18.29-9.16	-16.07-12.41	-18.34-7.10	-16.84-9.03	-17.59-6.03	-4.12-0.95	-10.79--6.07	-50.58-74.90	-41.55-106.85
CD at 5%	4.63	4.63	6.02	6.02	5.54	5.54	0.64	0.64	0.46	0.46

*,** Significant at 5 and 1% levels

over standard parent (Pusa Sneha), seven crosses revealed highly significant heterosis over respective better parent and standard cultivar (Pusa Sneha) for total yield per plant. The F_1 hybrids which showed significant heterosis over standard parent (Pusa Sneha) for various characters were DSG-6 × Pusa Sneha for days to first female flowering (-18.29%), days to first fruit setting (-18.34%), days to first fruit picking (-17.59%); DSG-7 × NSG-1-11 for ratio of male and female flowers (-10.79%) and total yield per plant (106.85%). Heterosis for earliness and increased yield in sponge gourd has been very few. Jiang *et al*. (3) reported sponge gourd hybrid 'Zhusigua 1' was early maturing as well as high yielder. However, work on ridge gourd on these aspects was earlier reported by Rao *et al*. (7), Mole *et al*. (5), and Shaha and Kale (11).

The results discussed above are quite indicative of the fact that hybrids in sponge gourd have greater potential for maximizing yield besides adapting them to produce early yield. Based on combining ability analysis and heterosis study, the F_1 hybrids DSG-7 × NSG-1-11 and DSG-6 × Pusa Sneha were found best performer keeping in view the earliness as well as increased yield over standard check (Pusa Sneha) and their respective better parent and may be entered in multi-locational trials for identification through AICRP(VC).

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