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Combining ability and gene action in cucumber (*Cucumis sativus* L.)

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Abstract
The experimental material for the present study comprised of F_1 population of twenty four crosses, developed by crossing four female parents *viz.*, Sheetal, Shubhangi, Himangi, and Puna khira of cucumber with six male parents *viz*., AAUC-2, DC-2, AAUC-1, VRC-19, DARL-103 and Fansu local. The experiment was laid out with 24 F1s, 4 females 6 males and one check Konkan kakadi in Randomized Block Design (RBD) with two replications during the *kharif* 2017.Observations were recorded on thirteen different quantitative characters The perusal of estimates of gca effects revealed that two female parents *viz*., sheetal (0.572), Puna khira (0.235) and two male parents Fansu local (0.596) and VRC-19 (0.376) exhibited significant positive gca effect in *kharif* 2017. This showed that these parents were good general combiner for the marketable yield vine^{-1}. The best three hybrids with respect to marketable yield vine^{-1}based on significant positive sca were *viz.*, Sheetal x Fansu local (0.942), Shubhangi x DC-2 (0.532), Puna khira x VRC-19 (0.484). A perusal of the data indicated that the estimates of σ^2SCA were higher in magnitude as compared to σ^2 GCA (average) both in females and males for the traits under study *viz*., days to first male flower appearance, days to first female flower appearance, nodal position of first female flower, days to first picking, fruit length and diameter, average fruit weight, marketable yield vine^{-1}, harvest duration and total soluble solids. In all the traits studied, the SCA variances were higher than GCA values, indicated the role of non-additive gene action.While lower magnitude of SCA showed additive gene action. The heritability estimates from different variance components having very high heritability obtained for number of marketable fruits vine^{-1} (69.02%) and number of primary branches plant^{-1} (94.40%).

Keywords: Cucumber, F_1 hybrids, GCA, SCA and yield characters

Introduction
Cucumber (*Cucumis sativus* L.) belongs to the family cucurbitaceae and its centre of origin is India (Renner *et al*., 2007) [17]. It is an important and one of the most popular fruit vegetable in Asia. Cucumber is also an ideal vegetable for its edible tender fruits, preferred as salad ingredient, pickles, desert fruit and as a cooked vegetable. Since there exist a considerable variability of this crop, it is possible to develop high yielding varieties through breeding approaches like selection or hybridization. Combining ability is one of the important and powerful tools to identifying the best combiner that may be used in crosses to exploit heterosis. It helps to know the genetic architecture of various characters that enable the breeder to design effective breeding plan for future improvement of the existing materials. The combining ability analysis gives useful information regarding the selection of parents in terms of the performance of their hybrids. Information on the relative importance of general combining ability (GCA) and specific combining ability (SCA) is of value in breeding programs for species which are amenable to the development of F1 hybrid cultivars such basic information on combining ability in cucumber would aid the breeder in developing improved hybrid cultivars (Tasdighi and Baker, 1981) [20]. The line x tester technique was developed by Kempthorne in 1957 [4]. It is a good approach for screening the germplasm on the basis of GCA and SCA variances and effects. Line × tester analysis involving parents give the additional information about the presence or absence of epistasis, average degree of dominance, as well as distribution of dominant and recessive genes in the parents. Application of line × tester technique in a cross-pollinated crop like cucumber for this purpose may be appropriate. The estimates of gene effects and genetic variance help in understanding the

genetic potential of the breeding material. Fruit yield being a polygenic character, many genes are involved in its inheritance. Because of the small effect of individual genes, it is apparently difficult to study their individual effects. The present investigation was undertaken to generate information for identification of good general and specific combiners of cucumber genotypes for the improvement of yield and its attribute

Materials and Methods

The experimental material for the present study comprised of F_1 population of twenty four crosses, developed by crossing four females (lines) *viz.*,Sheetal, Shubhangi, Himangi, and Puna khira of cucumber with six males (testers) *viz*., AAUC-2, DC-2, AAUC-1, VRC-19, DARL-103 and Fansu local were used in this experiment. All the lines used as female parents were crossed to each of the tester by hand pollination in a line x tester model and thus line x tester full-sib crossed true to type seeds was produced at theEducational Experimental Botany Farm, at Department of Agriculture Botany, College of Agriculture, Dapoli during *kharif* 2017.The experiment was laid out with 24 F1s, 4 females 6 males and one check Konkan kakadi in Randomized Block Design (RBD) with two replications. The unit plot size was 3.0 m X 6.0 m accommodating 10 plants in each plot with spacing of 3.0 m X 0.60 m. All the recommended agronomic practices were adopted to raise a good crop. Data on 13 quantitative characters: *viz*. Days to first male flower appearance, days to first female flower appearance, nodal position of first female flower, days to first picking, fruit length (cm), fruit diameter (cm), average fruit weight (g), number of marketable fruits vine^{-1}, marketable yield vine^{-1} (kg), harvest duration, number of primary branches plant^{-1}, vine length (m), total soluble solids (^{0}Brix) were recorded. The collected data were statistically analyzed. Analysis of variance for each of the character was performed. The data for each character was analyzed by using standard statistical procedure (Panse and Sukhatme, 1985) [12].

Results and Discussion

Analysis of variance for combining ability

Various genetic variances were estimated from the analysis (Table 1) of variance for combining ability for thirteen characters in each season as suggested by Kempthorne (1957) [4]. The analysis of variances indicated that variance due to females and females × males was significant fordays to first male flower appearance. Regarding days to first female flower appearance variance due to females × males interaction was found to be highly significant. In case of days to first picking combining ability variances in females as well as in females × males were highly significant.

Table 1: Analysis of variance for combining ability for different characters in cucumber

Sr. No.	Source of variance	D.F.	Days to first male flower appearance	Days to first female flower appearance	Nodal position of first female flower	Days to first picking	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of marketable fruits vine^{-1}
1	Females	3	106.909*	25.916	1889	18.62	0.553	0.16	183.85	0.49
2	Males	5	34.83	20.033	4.133	11.97**	0.888	2.36**	379.00	66.383**
3	Females × Males	15	27.326**	14.533**	3.0889**	3.15	1.823**	0.272	971.764	13.156
4	Error	23	1.62	1.62	0.69	18.62	0.59	0.323	557.537**	6.053**

Table 1: Cont.

Sr. No.	Source of Variance	D.F.	Marketable yield vine^{-1} (kg)	Harvest duration	Number of primary branches plant^{-1}	Vine length (m)	Total soluble solids (^{0}Brix)
1	Females	3	0.082	11.13	0.04	0.29	0.009
2	Males	5	2.845*	48.055	4.487**	0.734	0.905
3	Females × Males	15	1.465	48.933	0.156*	0.196	0.288
4	Error	23	0.609**	19.855	0.054	0.334	0.483

*, ** significant at 5 and 1percent probability level respectively

For the fruit length estimates of variances due females and males for combining ability were found to be non-significant whereas estimates of gca variances due females x males were significant. For average fruit weight the mean squares due to females x males were significant. Number of marketable fruits vine^{-1} showed that general combining ability variance due to females and females × males were significant.

In case of marketable yield vine^{-1}the mean squares due to females and females × males were found to be significant to were highly significant while, variances for males were non-significant. The variance due to females × males was non significant.

The mean square for number of primary branches plant^{-1} due to females and females x males. Total soluble solid exhibits non - significant results in all interaction.

Studies on combining ability effects

The estimates of general combining ability (gca) effects (Table 2) of parents and specific combining ability (sca) effects of hybrid for thirteen characters are presented in (Table 3).

Table 2: General combining ability effects for different characters in cucumber

Sr. No.	Female parents	Days to first male flower appearance	Days to first female flower appearance	Nodal position of first female flower	Days to first picking	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of marketable fruits vine^{-1}
1	Sheetal	2.021**	0.208	0.417*	-0.979**	0.067	-0.541**	3.552	2.700**
2	Shubhangi	0.688	-0.042**	-0.250**	-0.146**	0.263*	0.003	4.444	-2.342**
3	Himangi	-4.396**	-1.875**	0.250*	-1.813**	-0.091**	-0.009**	-0.098**	-1.550**

4	Punakhira	1.688**	1.708**	-0.417**	2.938**	-0.238**	0.548**	-7.898**	1.192**
No. of female parents showed (-ve) significant gca effects		01	02	02	03	01	01	-	02
SE(gi)±		0.60	0.58	0.33	0.68	0.30	0.16	5.82	0.25
	Males parents								
5	AAUC-2	1.188*	0.292	0.292	-0.271**	0.215	-0.171**	8.610	0.692**
6	DC-2	-2.188**	-1.083**	-0.208**	-1.396**	0.056	-0.203**	10.523	-1.646**
7	AAUC-1	-2.688**	-1.708**	0.292	-1.771**	-0.237**	-0.086**	-16.865**	-1.333**
8	VRC-19	1.063	1.917**	-0.333**	2.229*	0.182	0.084*	4.123	0.817**
9	DARL-103	-0.063**	-1.208**	-1.083**	-0.021**	0.336*	0.274**	-10.290**	-0.133**
10	Fansu local	2.688**	1.792**	1.042**	1.229	-0.552**	0.102*	3.898	1.604**
No. of female parents showed (-ve) significant gca effects		03	01	03	03	01	03	-	03
SE(gj)±		0.74	0.71	0.40	0.84	0.36	0.19	7.14	0.31

Table 2: cont.

Sr. No.	Female parents	Marketable yield vine^{-1} (kg)	Harvest duration	Number of primary branches plant^{-1}	Vine length (m)	Total soluble solids (^{0}Brix)
1	Sheetal	0.572**	2.667	0.502**	-0.324**	0.263**
2	Shubhangi	-0.360**	0.250	-0.406**	-0.041**	-0.029**
3	Himangi	-0.447**	-2.000**	-0.640**	0.111	0.138**
4	Punakhira	0.235**	-0.917**	0.544**	0.254	-0.371**
No. of female parents showed (-ve) significant gca effects		02	-	02	-	02
SE(gi)±		0.13	1.25	0.08	0.52	0.07
	Males parents					
5	AAUC-2	-0.017**	2.792	0.152**	-0.131**	0.317**
6	DC-2	-0.258**	2.417	0.077**	0.187	-0.121**
7	AAUC-1	-0.583**	-2.833**	0.090**	0.114	-0.196**
8	VRC-19	0.376**	-2.708**	0.027*	0.042	-0.133**
9	DARL-103	-0.114**	-0.708**	-0.173**	-0.236**	0.079**
10	Fansu local	0.596**	1.042	-0.173**	0.024	0.054**
No. of female parents showed (-ve) significant gca effects		02	-	04	-	03
SE(gj)±		0.16	1.53	0.091	0.64	0.08

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

Table 3: Estimation of specific combining ability for different characters in cucumber

Sr. No.	Hybrids	Days to first male flower appearance	Days to first female flower appearance	Nodal position of first female flower	Days to first picking	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of marketable fruits vine^{-1}
1	Sheetal x AAUC-2	0.479	1.042	0.958	-1.396	0.730	-0.084	-1.977	-1.125*
2	Sheetal x DC-2	2.354*	0.417	0.958	1.229	0.088	0.208	0.310	-1.238**
3	Sheetal x AAUC-1	2.854*	1.042	1.958**	0.604	-0.879	0.231	-25.602*	-0.750
4	Sheetal x VRC-19	0.104	0.917	-0.417	2.104	-1.153*	0.051	10.060	1.500**
5	Sheetal x DARL-103	-1.271	0.542	-1.667**	0.854	1.618**	-0.319	15.623	0.450
6	Sheetal x Fansu local	-4.521**	-3.958**	-1.792**	-3.396**	-0.404	-0.087	1.585	1.163*
7	Shubhangi x AAUC-2	2.313*	3.792**	0.125	5.271**	-0.306	0.172	-14.519	-0.033
8	Shubhangi x DC-2	-2.813*	-2.333*	0.125	-1.104	0.402	0.435	-9.731	1.154*
9	Shubhangi x AAUC-1	-1.313	-1.708	-1.375*	-0.729	-0.535	0.027	18.306	2.092**
10	Shubhangi x VRC-19	1.438	0.667	-0.750	-2.229	1.396*	-0.302	-0.031	-1.358**
11	Shubhangi x DARL-103	2.563*	-0.208	1.000	0.021	-0.958	-0.283	-1.919	0.092
12	Shubhangi x Fansu local	-2.188*	-0.208	0.875	-1.229	0.000	-0.050	7.894	-1.946**
13	Himangi x AAUC-2	-0.104	-2.375*	-0.875	-2.563*	-1.013	-0.346	8.323	0.025
14	Himangi x DC-2	-5.229**	-1.000	0.625	-0.938	-0.414	-0.303	11.510	0.913*

15	Himangi x AAUC-1	-3.229**	-0.875	-0.375	-1.563	1.138*	-0.451	18.348	1.150*
16	Himangi x VRC-19	0.021	-2.000*	-0.250	1.438	-0.360	0.129	-5.040	-1.750**
17	Himangi x DARL-103	2.646*	3.625**	0.500	0.188	0.526	0.989**	-34.077**	1.100*
18	Himangi x Fansu local	5.896**	2.625*	0.375	3.438**	0.123	-0.018	0.935	-1.438**
19	Punakhira x AAUC-2	-2.688*	-2.458*	-0.208	-1.313	0.590	0.258	8.173	1.133*
20	Punakhira x DC-2	5.688**	2.917**	-1.708**	0.813	-0.077	-0.340	-2.090	-0.829
21	Punakhira x AAUC-1	1.688	1.542	-0.208	1.688	0.276	0.193	-11.052	-2.492**
22	Punakhira x VRC-19	-1.563	0.417	1.417*	-1.313	0.117	0.122	-4.990	1.608**
23	Punakhira x DARL-103	-3.938**	-3.958**	0.167	-1.063	-1.187*	-0.387	20.373	-1.642**
24	Punakhira x Fansu local	0.813	1.542	0.542	1.188	0.281	0.155	-10.415	2.221**
No. of crosses showed (-ve) significant sca effects			06	04	02	07	01	-	10
SE±			1.22	0.73	1.53	1.35	0.35	13.02	0.56

Table 3: cont.

Sr. No.	Hybrids	Marketable yield vine^{-1} (kg)	Harvest duration	Number of primary branches plant^{-1}	Vine length (m)	Total soluble solids (^{0}Brix)
1	Sheetal x AAUC-2	0.134	0.458	-0.027	-0.116	-0.250*
2	Sheetal x DC-2	-0.550*	-2.167	0.148	0.217	0.238
3	Sheetal x AAUC-1	-0.745**	0.083	-0.015	-0.221	0.562**
4	Sheetal x VRC-19	0.257	-2.042	-0.002	-0.308	0.350**
5	Sheetal x DARL-103	-0.038	0.958	-0.002	0.259	-0.012
6	Sheetal x Fansu local	0.942**	2.708	-0.102	0.169	-0.888**
7	Shubhangi x AAUC-2	-0.079	2.875	0.281*	0.301	0.042
8	Shubhangi x DC-2	0.532*	2.750	-0.044	-0.037	-0.521**
9	Shubhangi x AAUC-1	0.407	-2.000	-0.156	0.106	-0.546**
10	Shubhangi x VRC-19	-0.517*	-1.625	-0.094	-0.272	0.492**
11	Shubhangi x DARL-103	0.183	1.375	0.006	-0.204	0.229
12	Shubhangi x Fansu local	-0.527*	-3.375	0.006	0.106	0.304*
13	Himangi x AAUC-2	-0.257	-4.875*	-0.185	0.669	-0.225
14	Himangi x DC-2	0.385	1.500	-0.110	-0.148	0.463**
15	Himangi x AAUC-1	0.420	3.750	0.177	-0.416	0.138
16	Himangi x VRC-19	-0.224	4.625*	0.240	0.367	-0.675**
17	Himangi x DARL-103	0.341	-2.375	0.040	-0.226	0.113
18	Himangi x Fansu local	-0.664**	-2.625	-0.160	-0.246	0.187
19	Punakhira x AAUC-2	0.202	1.542	-0.069	-0.854	0.433**
20	Punakhira x DC-2	-0.367	-2.083	0.006	-0.032	-0.179
21	Punakhira x AAUC-1	-0.082	-1.833	-0.006	0.531	-0.154
22	Punakhira x VRC-19	0.484*	-0.958	-0.144	0.213	-0.167
23	Punakhira x DARL-103	-0.486*	0.042	-0.044	0.171	-0.329*
24	Punakhira x Fansu local	0.249	3.292	0.256	-0.029	0.396**
No. of crosses showed (-ve) significant sca effects		03	01	01	-	07
SE±		0.28	2.80	0.16	0.56	0.15

Days to first male flower appearance

Earliness is desirable character, the exhibited significant negative or positive GCA effects were designated as good or poor general combiners, respectively. The remaining males exhibited non-significant GCA effects were assigned as average general combiners for early male flower appearance.

For days to first male flower appearance the estimates of GCA effects revealed that the single female parent Himangi (-4.396) and three male parents *viz*, DC-2(-2.188), AAUC-1 (-2.688) and DARL-103 (-0.063) had significant negative GCA effects.

The hybrids having highest significant negative sca effects in order were Himangi × DC-2(-5.229), Sheetal x Fansu local (-4.521) and Puna khira x DARL-103 (-3.938). The cross combinations exhibited significant negative sca effects were designated as good specific combiners. Hence, they were considered as good cross combinations for exploiting earliness in male flowering.

Days to first female flower appearance

In days to first female flower appearance the estimates of gca effects revealed that the two female parent *viz*. Himangi (-1.875) and Shubhangi (-0.042) and three male parents *viz*.

AAUC-1-(1.708), DARL-103(-1.208) and DC-2(-1.083) had significant negative gca effects.),Pati *et al.* (2015) [13], Kumar and Kumar (2017) [5] and Naik *et al.* (2018) [10] had revealed significant gca effects for this trait.

The estimates of sca effects revealed that significant negative sca effects in order were Sheetal x Fansu local and Puna khira x DARL-103 exihibited (-3.958) same sca effects. The cross combinations in F_1exhibited significant negative sca effects were designated as good specific combiners. These cross combinations were exploiting earliness and used in crop improvement. Kaur and Dhall (2017) [3] and Nimitha *et al.* (2017) [11] reported highly significant sca effects for above trait.

Nodal position of first female flower

In nodal position of first female flower the estimates of gca effects revealed that the two female parent Puna khira (-0.417), Shubhangi (-0.250) and three male parents *viz*, DARL-103 (-1.083), VRC-19 (-0.333) and DC-2 (-0.208) had exhibited significant negative gca effects Thus, negative estimates of gca effects indicated the parents are good general combiners for node bearing of first female flower. Kumar and Kumar (2017) [5] recorded highly significant gca effects for nodal position of female.

The estimates of sca effects revealed that four hybrids recorded significant negative sca effects. The hybrids having highest significant negative sca effects in order were Sheetal × Fansu local (-1.792), and Puna khira x DC-2 (-1.708). The cross combinations were designated as good specific combiners which bearing first female flower earlier. Pati *et al.* (2015) [13], Tiwari and Singh (2016) [21] and Kaur and Dhall (2017) [3]. The cross combinations were designated as good specific combiners which bearing first female flower earlier.

Days to first picking

An examination of gca estimates revealed that the three female parents *viz*., Himangi (-1.813), Sheetal (-0.979), Shubhangi (-0.146) and among male parents DC-2 (-1.396), AAUC-2 (-0.271) and DARL-103 (-0.021) recorded significant negative gca effects.In overall result in the female parent Himangi is good general combiner in all season and on pooled basis in early picking. Singh and Ram (2016) [19] and Bhutia *et al.* (2017) [2] also reported similar finding in cucumber.

The estimates of sca effects revealed that two hybrids Sheetal × Fansu local (-3.396) and Himangi x AAUC-2 (-2.563) were found good specified combination designated as good specific combiners in early picking character These results are in agreement with Reddy *et al.* (2014) [15].

Fruit length (cm)

The estimates of gca effects revealed that only one female parent Shubhangi (0.263) exhibited highly significant positive gca effects while in only one male parent DARL-103 (0.336) showed significant positive gca effects. This indicated that these parents were good general combiners for this character. Naik *et al.* (2018) [10] and Pati *et al.* (2015) [13] explain the positive gca effects for this trait.

A study of estimates for the sca effect revealed that three hybrids *viz*., sheetal x DARL-103 (1.618), Shubhangi x VRC - 19 (1.396) and Himangi x AAUC-1 (1.138) highly significant positive sca effects this indicates that they are good specific combiners for this trait. Similar results were reported by earlier workers Mule *et al.* (2012), Xian and Ying (2012), Kaur and Dhall (2017) and Malav and Verma (2018) [9, 23, 3, 7].

Fruit diameter (cm)

For fruit diameterthe estimates of gca effects revealed that only one female parent Punakhira (0.548) exhibited highly significant positive gca effects. These parents were good general combiners for said trait. As regard to sca effects only one hybrid Himangi x DARL-103 exhibited highly (0.989) significant positive sca effects. Malav and Verma (2018) [7] had reported highly significant gca and sca effects for this trait.

Average fruit weight (g)

Theaverage fruit weight estimates of gca and sca effects wasnon significant indicating that they are poor specific combiners for this trait.

Number of marketable fruits per vine

An examination of gca estimates revealed that among these two female parents Sheetal (2.700) and Punakhira (1.191) as well as three male parents Fansu local (1.604), VRC-19 (0.817) and AAUC-2(0.692) exhibited highest sca effects These parents were exhibits good general combining ability. These results were in similar line with Pati *et al.* (2015) [13] and Reddy *et al.* (2014) [15].

A perusal of estimates of sca effects of hybrids revealed that ten hybrids showed significant positive sca effects, among these Puna khira x Fansu local (2.221) and Shubhnagi x AAUC-1(2.092) recorded highest significant positive sca effects.Bhutia *et al.* (2017) [2] and Naik *et al.* (2018) [10] obtained similar findings for this trait.

Marketable yield per vine (kg)

The perusal of estimates of gca effects revealed that two female parents *viz*., Sheetal (0.572), Puna khira (0.235) and two male parents Fansu local (0.596) and VRC-19(0.376) exhibited significant positive gca effect These showed that these parents were good general combiner for the said trait. Ahammed *et al.* (2018) [1] exhibits similar finding for this fruit.

With regards to sca effect three hybrids towards significant positive direction for this trait. The best three hybrids with respect to marketable yield vine^{-1}based on significant positive sca were *viz.*, Sheetal x Fansu local (0.942), Shubhangi x DC-2 (0.532), Puna khira x VRC-19 (0.484). Kumar and Kumar (2017) [5] and Moradipour *et al.* (2017) [8] found similar results for positive marketable yield in cucumber.

Harvest duration

An examination of gca estimates all male and female parents had non significant gca effects.

A perusal of estimates of sca effects of hybrids revealed that onlyone Himangi x VRC-19 (4.625), hybrid recorded significant positive sca effects registered significant highest positive effects which are good specific combiner for longest harvest duration.

Number of primary branches per plant

An examination of gca estimates revealed that female parent Sheetal (0.502) and Punakhira (0.544) recorded significant positive gca effects.

A perusal of estimates of sca effects of hybrids revealed that two hybrids Shubhnagi x AAUC-2(0.281) and Punakhira x Fansu local (0.283) recorded significant positive sca effects. Similar findings were obtained by Prasad and Singh (1992) [14].

Vine length (m)

The persual of estimates of gca and sca effects indicated that all these parents and hybrids exhibitsn on significant gca and sca effects respective.

Total soluble solids (^{0}Brix)

Based on estimates of general combining ability effects among female two parents Sheetal (0.263) and Himangi (0.138) were observed to be the good general combiners while three male parents *viz*., AAUC-2(0.317), DARL-103(0.079) and Fansu local (0.054).The parent had highest gca effects exhibits good general combining ability. Similar findings obtained by Li. *et. al*. (2005) [6] and Reena Kumari *et al.* (2017) [16].

In regards to sca effects seven hybrids showed positive significant sca effects. Among these the hybrids Sheetal x AAUC-1 (0.562) displayed highly significant positive sca effects followed by Shubhangi x VRC-19 (0.492) and Himangi x DC-2(0.463). This indicated that these were good general combiner for total soluble solids. Nimitha *et al.* (2017) [11] and Malav and Verma (2018) [7] revealed the similar results for estimation of highest sca effects for this trait.

The best performing hybrids were found to be good specific combinations as evident from its significant positive sca effects. Expliotation for these traits might also be possible in H x L and L x L cross combinations.

Gene action

A perusal of the data indicated that (Table 4) the estimates of σ^2 SCA were higher in magnitude as compared to σ^2 GCA (average) both in females and males for the traits under study *viz*., days to first male flower appearance, days to first female flower appearance, nodal position of first female flower, days to first picking, fruit length and diameter, average fruit weight, marketable yield vine^{-1}, harvest duration and total soluble solids. In all the traits studied, the SCA variances were higher than GCA values, indicated the role of non-additive gene action. While lower magnitude of SCA showed additive gene action. Components of dominance variance (σ^2D) were also higher than the additive components (σ^2A) indicating the role of non-additive gene action. For the five traits *viz*., days to first male flower appearance, days to first female flower appearance, nodal position of first female flower, fruit length, average fruit weight and total soluble solids.

Table 4: Estimation of random effect of GCA and SCA variances, additive and dominance variance components, heritability and genetic advance in cucumber

Sr. No.	Characters	σ^2GCA of Females	σ^2GCA of Males	σ^2GCA (Average)	σ^2SCA of female x male	σ^2A	σ^2D	σ^2A/ σ^2D	h ^{2} in%	Genetic Advance
1	Days to first male flower appearance	6.63	0.93	4.354	12.56	8.70	12.56	0.69	38.92	3.79
2	Days to first female flower appearance	0.94	0.68	0.844	6.36	1.68	6.36	0.26	18.85	1.16
3	Nodal position of first female flower	-0.10	0.13	-0.0078	1.22	-0.015	1.22	-0.012	-1.01	-0.02
4	Days to first picking	3.30	0.83	2.3122	4.58	4.62	4.58	1.009	43.57	2.92
5	Fruit length (cm)	-0.10	-0.11	-0.1103	0.64	-0.22	0.64	-0.34	-31.89	-0.54
6	Fruit diameter (cm)	0.17	-0.00	0.099	0.08	0.19	0.08	2.26	55.20	0.68
7	Average fruit weight (g)	-14.87	51.77	11.78	176.92	23.56	176.92	0.13	7.79	2.79
8	Number of marketable fruits vine^{-1}	5.02	0.88	3.371	2.83	6.74	2.83	2.37	69.02	4.44
9	Marketable yield vine^{-1} (kg)	0.186	0.107	0.154	0.255	0.309	0.255	1.212	50.34	0.81
10	Harvest duration	2.35	3.63	2.863	5.21	5.72	5.21	1.09	36.58	2.98
11	Number of primary branches plant^{-1}	0.369	0.0128	0.228	0.01	0.453	0.01	45.28	94.40	1.34
12	Vine length (m)	0.033	-0.017	0.0131	-0.64	0.026	-0.647	-0.0406	13.59	0.12
13	Total soluble solids (^{0}Brix).	0.035	-0.02	0.0113	0.226	0.0226	0.2276	0.0993	8.54	0.09

Heritability

The effectiveness of selection for a trait depends on relative importance of genetic and non-genetic factors in the expression of phonotypic difference among genotypes in population, a concept referred to as heritability. The heritability has major impact on the methods chosen for population improvement, in breeding and other aspect of single plant selection may be effective for the character with low (5 to10%), medium (10 to 30%), high (30 to 60%) and very high (above 60%) heritability (Robinson, 1966) [18].

The heritability estimates were made from different variance components (Table 4)obtained for *kharif* 2017 very high heritability obtained for number of primary branches plant^{-1}(94.40%), number of marketable fruits vine^{-1} (69.02%). High heritability observed for marketable yield vine^{-1} (50.34%) similar results obtained by Gu-Xing *et al.* (2004) for this character. The fruit diameter (55.20%),days to first picking (43.57%) and days to first male flower appearance (38.92%), similar findings obtained by Uddin *et al.* (2009) [22] for all these characters. The harvest duration (36.58%) recorded high heritability which had utility in prolongs the duration of harvesting in cross combination.

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