



ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(7): 1378-3184
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www.thepharmajournal.com

Received: 19-04-2021

Accepted: 30-06-2021

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To study the combining ability of different traits in cucumber (*Cucumis sativus* L.)

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Abstract

The present study was undertaken on cucumber in a Line x tester was undertaken with the study of combining ability variances and their effect. The 36 F₁ hybrid along with their twelve line and three testers were crossed in line x tester fashion to obtained 36 F₁ and evaluated in randomized block design in three replications having each experimental unit of single row with spacing of 2.5 m x 0.5 m at Vegetable Research Farm, Kalyanpur, C. S. Azad University of Agriculture and Technology, Kanpur during zaid and summer - 2018-19. The selected parental lines are consisted 12 lines (No-100, No.-512, No.- 40, No.-1, 5- URC-11-1, Panjab Naveen, Pusa Barkha, Poinsett-76, Pahari Barsati, Poinsett, Swarn Ageti, Pusa Uday with 3 testers (PCUC-8, Swarna Pooana and Boro Patana). Observations were recorded on all the six plants maintained for 20 metric traits viz. day to first male flower initiation day to first female flower initiation, number of node for first male flower, number of node for first female flower, number of branches per plant, vine of length @ 60das, number of fruit per plant, day to first fruit set, number of fruit per vine @ 60das, length of fruit (cm.), number of node/wine, duration of crop average weight of fruit diameter of fruit, fruit yield (kg.)/plant, day to first fruit picking, T.S.S, specific gravity of fruit, dry matter (%).

Highly significant variances were observed for general as well as specific combining ability for all the 19 traits studied during both the seasons and pooled which suggested that both additive and non-additive gene action were important in the expression of all the characters. Parents, L9 and L10 in E1, E2 and pooled had showed significant positive GCA effects indicating their good general combining ability for fruit yield per plant. Parent, (L9, L11), and (T2) were also found good general combiners for days to first picking during both the seasons and pooled. The crosses with top sca as well as *per se* performance were L3xT1, L6xT3 and L12xT3.

Keywords: Combining ability, GCA, SCA

Introduction

Cucumber (*Cucumis sativus* L.) is a member of the family Cucurbitaceae, which comprises of 117 genera and 825 species in warmer parts of the world (Gopalakrishnan, 2007) [7]. It is thought to be one of the oldest vegetable crops and has been found in cultivation for over 3000 years in India (De-Candolle, 1982) [4] where (Chakravarthy, 1982) [3] estimated 36 genera and 100 species. Cucumber is a Thermophilic and frost-susceptible crop, growing best at temperature above 20 °C. The crop is grown throughout the world, is the second most widely cultivated cucurbit after watermelon and ranks fourth among the economic vegetables in Asia after tomato, onion and cabbage (Tatlioglu, 1993) [15]. Today, Cucumber is nutritionally very rich in vitamins and minerals. In India, it is cultivated in an area of 0.26 lakh hectares with an annual production of 1.65 lakh metric tonnes, whereas the world area is 2.44 million hectares with a production of 80.61 million metric tonnes cucumber is grown throughout the world in large commercial farms, glasshouses and small gardens. It is a low energy and high water content vegetable. Its fruits are eaten at immature stage as refreshing salad vegetable and are said to have cooling effect, prevent constipation and are useful to jaundice patients. The fruit is also used as an astringent and antipyretic.

Cucumber are rich in vitamin 'B' and 'C' as well as minerals such as calcium, phosphorus, iron and potassium. Besides those, it contains about 2.5% carbohydrate, 0.4% protein, 0.1% fat and 0.4% fibre. It has Antioxidants which help to discard substances from the body known as free radicals. Some free radicals come from natural bodily processes, and some come from outside pressures, such as pollution. If more accumulation in the body, they can lead to cell damage and various types of disease.

The cucumber is native to the North-West of India and has been cultivated from at least 3000 years. The calyx and corolla of staminate, pistilata and hermaphroditic flower are five lobed. The staminate flower have three stamens (two have bilocular anthers and the third has one anther, pistilata flowers are epigynous. Cucumber is open-pollinated and self-compatible. Pollination is takes placed by insects mainly bees. The study of general combining ability (GCA) of parents and specific combining ability (SCA) of crosses provides information for selecting suitable parents and cross combinations, respectively. The combining ability of parents depends upon the nature of the genetic system operating in the parent, which predicts the efficiency of selection. The "Line x Tester" mating design as proposed by Kempthorne (1957) [9] gives comparable estimate of the genetic make-up of genotypes. This mating design is useful to select suitable parents from a large number of genotypes.

Material and Methods

The experiment entitled "Line x tester analysis for yield and quality traits in cucumber (*Cucumis sativus* L.)" was undertaken with the objectives (i) To estimate genetic variability, heritability and genetic advance for different characters (ii) to find out nature and magnitude of gene action involve in the inheritance of various characters (iii) To estimate combining ability variances and their effect and (iv) To work out heterosis extent for different characters for planning of an appropriate strategy for development of high yielding cucumber hybrid as well as breeding procedure. The materials of experiment consisted 12 lines No-100, No.-512, No.- 40, No.-1, 5- URC-11-1, Panjab Naveen, Pusa Barkha, Poinsett-76, Pahari Barsati, Poinsett, Swarn Ageti, Pusa Uday with 3 testers (PCUC-8, Swarna Poona and Boro Patana) were crossed in line x tester fashion to obtained 36 F₁ and evaluated in randomized block design in three replications having each experimental unit of single row with spacing of 2.5 m x 0.5 m at Vegetable Research Farm, Kalyanpur, C. S. Azad University of Agriculture and Technology, Kanpur during zaid and summer - 2018-19. Observations were recorded on all the six plants maintained for 20 metric traits viz. day to first male flower initiation day to first female flower

initiation, number of node for first male flower, number of node for first female flower, number of branches per plant, vine of length @ 60das, number of fruit per plant, day to first fruit set, number of fruit per vine @ 60das, length of fruit (cm.), number of node/wine, duration of crop average weight of fruit diameter of fruit, fruit yield (kg.)/plant, day to first fruit picking, T.S.S, specific gravity of fruit, dry matter (%). The combining ability analysis for different characters was carried out following the method 2 model 1 of Griffing (1956b) [8], where parents and F₁'s were included but not the reciprocals. Thus the experimental material for this method comprises of n (n+1)/2 genotypes.

Result and Discussion

Combining ability studies (Griffing, 1956b) [8] are not only useful in analysing genetic architecture of the traits on the study but also help in evaluating the breeding value of parental lines on the basis of several parameters. The information thus, obtained helps in designing suitable breeding procedures for the genetic improvement of the crop and the selection of suitable parents which when crossed will give rise to more desirable F₁ or segregates. Fixed effect model is appropriate if the number of parents does not exceed ten. Genetic analysis in the present investigation was done by two methods namely, variance component analysis Hayman (1954 a) and combining ability analysis (Griffing, 1956b) [8]. This analysis can be equated as gca variance consist of additive genetic variance and additive x additive interaction. The sca variance accounts for non-additive type of gene action which is composed of dominant and epistatis (Griffing, 1956b) [8] and can be equated to dominance variance. The choice of parents especially for heterosis breeding should be based on combining ability test and their mean performance. The analysis of variance (Table 1,2) for combining ability in (E₁), (E₂) and pooled over environments revealed that. Mean squares due to general combining ability and specific combining ability were observed to be significant for all the traits in E₁, E₂ and over environments pooled when tested against mean squares due to error. In cucumber, combining ability analysis have been made for two seasons F₁ following this design Naik *et al.* (2018) [12], Malav and Verma (2018) [11].

Table 1: Analysis of variance (mean squares) for combining ability in line tester cross of cucumber during two seasons (E₁, E₂)

Source of Variation	Season	d.f.	Day to first male flower initiation	Day to first female flower initiation	Number of node for first male flower	Number of node for 1 st female flower	Number of branches per plant	Vine of length @ 60DAS	Number of fruit per plant	Day to first fruit set	Number of fruit per vine @ 60DAS
GCA	E ₁	11	9.90	24.77	2.40	16.31	4.13	0.33	27.16	21.69	2.10
	E ₂	11	22.32	36.90	3.51	15.17	3.62	0.31	2.92	19.65	1.98
SCA	E ₁	2	20.33	43.17	1.83	2.03	4.56	1.07	4.17	26.69	0.09
	E ₂	2	34.35	71.86	1.54	2.52	4.09	1.38	3.39	21.17	0.00
Error	E ₁	70	3.22	2.08	0.22	0.13	0.03	0.02	0.15	1.60	0.04
	E ₂	70	3.87	3.62	0.32	0.11	0.05	0.07	0.51	1.98	0.10

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

Source of Variation	Season	d.f.	Length of fruit (cm.)	Number of node/wine	Diameter of fruit (cm.)	Average weight of fruit (kg.)	Duration of crop (days)	Fruit yield (kg.)/plant	Day to first fruit picking	T.S.S	Specific gravity	Dry weight
GCA	E ₁	11	35.17	51.61	0.86	5808.43	106.72	0.24	26.43	0.35	0.02	0.56
	E ₂	11	35.07	50.99	0.45	5916.80	96.33	0.19	23.05	0.40	0.01	0.58
SCA	E ₁	2	2.92	26.84	1.08	15885.19	26.14	0.43	44.48	0.45	0.00	2.66
	E ₂	2	2.19	25.87	0.18	11659.37	7.58	0.42	44.77	0.44	0.00	2.46
Error	E ₁	70	0.20	0.27	0.03	33.81	7.19	0.00	2.09	0.01	0.00	0.00
	E ₂	70	0.24	0.36	0.10	116.61	5.20	0.03	3.20	0.03	0.00	0.01

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

Table 2: Analysis of variance (mean squares) for combining ability in Line × Tester cross of cucumber over seasons (pooled)

Source of variation	d.f.	Day to first male flower initiation	Day to first female flower initiation	Number of node for first male flower	Number of node for 1 st female flower	Number of branches per plant	Vine of length @ 60DAS	Number of fruit per plant	Day to first fruit set	Number of fruit per vine @ 60DAS
GCA	11	26.41	60.04	5.73	31.93	7.72	0.63	49.73	40.67	4.03
SCA	2	53.76	113.19	3.34	4.55	8.66	2.44	7.48	47.18	0.04
Environments	1	13.49**	43.56**	0.88	1.36**	0.78**	0.54**	4.38**	40.90**	1.33**
GCA×Environments	11	5.81	1.64	0.19	0.08	0.03	0.01	0.35	0.67	0.05
SCA×Environments	2	0.93	1.83	0.02	0.01	0.00	0.01	0.00	0.68	0.05
Error	200	3.54	2.85	0.27	0.12	0.04	0.05	0.33	1.79	0.07

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

Source of variation	d.f.	Length of fruit (cm.)	Number of node/wine	Diameter of fruit (cm.)	Average weight of fruit (kg.)	Duration of crop (days)	Fruit yield (kg.)/plant	Day to first fruit picking	T.S.S	Specific gravity	Dry weight
GCA	11	70.22	102.54	1.19	11633.39	202.21	0.42	48.99	0.70	0.03	1.14
SCA	2	5.08	53.70	1.07	27360.45*	30.88	0.86	89.18	0.88	0.00	5.12
Environments	1	1.86**	2.20**	0.93**	3498.90**	85.75*	1.12**	56.01**	3.79**	0.03**	0.94**
GCA×Environments	11	0.01	0.06	0.12	91.85	0.84	0.01	0.49	0.04	0.00	0.00
SCA×Environments	2	0.02	0.01	0.19	184.48	2.85	0.00	0.07	0.01	0.00	0.00
Error	200	0.20	0.30	0.06	75.21	6.21	0.02	2.67	0.02	0.00	0.02

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

Table 3: Estimates of G.C.A. effects of parents in Line x Tester cross of cucumber during two seasons (E₁, E₂) and over seasons (pooled)

Traits / Parents	Day to first male flower initiation			Day to first female flower initiation			Number of node for first male flower			Number of node for 1 st female flower			Number of branches per plant		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1	0.16	-1.33*	-0.58	-2.43**	-2.22**	-2.32**	0.52**	0.78**	0.65**	1.42**	1.22**	1.35**	-0.19**	-0.11	-0.15**
L2	-0.05	-1.44*	-0.75	-0.65	-1.44*	-1.05**	0.051	0.18	0.11	0.77**	0.53**	0.65**	-0.21**	-0.07	-0.14**
L3	-0.83	-2.55**	-1.69**	-1.88**	-2.77**	-2.3**	0.19	0.02	0.11	-0.08	-0.29*	-0.18*	-1.29**	-1.19**	-1.24**
L4	2.05**	1.55*	1.80**	0.78	1.00	0.89*	0.79**	1.17**	0.98**	2.50**	2.52**	2.51**	0.40**	-0.40**	-0.40**
L5	1.61*	1.66**	1.63**	2.34**	2.44**	2.39**	-0.51**	-0.66**	-0.59**	-0.70**	-0.73**	-0.71**	0.65**	0.58**	0.61**
L6	-0.50	-0.55	-0.52	-0.88	-0.66	-0.77	-0.41**	-0.10	-0.26*	-0.06	0.03	-0.06	0.95**	0.85**	0.90**
L7	-1.72**	-1.33*	-1.50**	-1.65**	-2.00**	-1.82**	-0.40**	-0.53**	-0.47**	1.48**	1.56**	1.52**	-0.62**	-0.70**	-0.66**
L8	0.61	2.22**	1.41**	2.12**	2.33**	2.22**	-0.21	0.345*	-0.281*	-0.16	-0.14	-0.15	0.43**	0.45**	0.44**
L9	-0.61	0.11	-0.25	0.45	0.88	0.67	0.51**	0.38*	0.45**	-1.93**	-1.84**	-1.89**	0.56**	0.45**	0.51**
L10	0.27	2.11**	1.19**	2.00**	3.33**	2.67**	-0.46**	-0.59**	-0.52**	-0.35**	-0.20	-0.27**	-0.17**	-0.12	-0.15**
L11	-0.61	-0.44	-0.52	-1.10*	-1.22	-1.16**	0.63**	0.50**	0.56**	-1.06**	-0.96**	-1.01**	-0.49**	-0.50**	-0.49**
L12	-0.38	0.00	-0.19	0.89	0.33	0.61	-0.68**	-0.81**	-0.74**	-1.81**	-1.70**	-1.76**	0.78**	0.76**	0.77**
T1	0.05	0.11	0.08	-0.18	-0.19	-0.19	0.03	0.06	0.04	0.15	0.17**	0.16**	-0.29**	-0.28**	-0.29**
T2	-0.77*	-1.02**	-0.90**	-0.99**	-1.30**	-1.14**	0.20**	0.16	0.18**	0.12	0.12*	0.12**	0.39**	0.37**	0.38**
T3	0.72*	0.91**	0.81**	1.17**	1.50**	1.38**	-0.24**	-0.23**	-0.23**	-0.27**	-0.30**	-0.28**	-0.09**	-0.09*	-0.09**

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

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Traits/ Parents	Vine of length @ 60DAS			Number of fruit per plant			Day to first fruit set			Number of fruit per vine @ 60DAS			Length of fruit (cm.)		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1	-0.01	-0.03	-0.02	-0.46**	-0.18	-0.32*	0.33	1.20*	0.76*	0.45**	0.40**	0.42**	0.41**	0.43*	0.42**
L2	0.04	0.08	0.06	-3.11*	-2.81**	-2.96**	0.33	0.4	0.4	-0.56**	-0.48**	-0.52**	0.74**	0.83**	0.78**
L3	-0.15**	-0.04	-0.09	0.82**	0.71**	0.77**	-0.55	-0.8	-0.67*	-0.17**	-0.16	-0.17**	-3.84**	-3.86**	-3.85**
L4	-0.13**	-0.23**	-0.18**	-0.13	0.11	-0.01	3.88**	3.64**	3.76**	-0.31**	-0.29**	-0.30**	-0.21	-0.15	-0.18
L5	-0.11*	-0.10	-0.10*	1.23**	1.33**	1.28**	0.33	0.3	0.3	0.13*	0.16	0.15*	-0.17	-0.2	-0.19
L6	0.24**	0.27**	0.25**	1.56**	1.27**	1.41**	0.00	0.0	0.0	0.74**	0.66**	0.70**	-2.10**	-2.12**	-2.11**
L7	-0.04	-0.08	-0.06	-2.43**	2.10**	-2.27**	-0.66	-0.6	-0.6	-0.83**	-0.74**	-0.78**	-1.72**	-1.80**	-1.76**
L8	0.16**	0.21*	0.19**	1.27**	1.28**	-1.27**	-0.44	-0.5	-0.45	0.25**	0.30**	0.27**	2.73**	2.66**	2.70**
L9	-0.16**	-0.13	-0.15**	2.22**	2.16**	-2.19**	-2.11**	-1.79**	-1.95**	0.44**	0.44**	0.44**	0.11	0.16	0.14
L10	-0.33**	0.30**	-0.31**	1.15**	0.52	-0.83**	0.77	0.0	0.4	0.27**	0.08	0.18**	0.90**	0.91**	0.90**
L11	0.26**	0.15	0.20**	2.18**	-2.25**	-2.22**	-2.22**	-2.13**	-2.17**	-0.54**	-0.70**	-0.62**	3.40**	3.34**	3.37**
L12	0.23**	0.21*	0.22**	0.07	-0.04	0.01	0.33	0.2	0.26	0.13*	0.32**	0.22**	-0.26	-0.2	-0.23*
T1	0.04*	0.04	0.04	-0.30**	-0.23	-0.27**	0.86**	0.84**	-0.85**	-0.05	-0.00	-0.02	0.21**	0.19*	0.20**
T2	0.14**	0.17**	0.15**	0.36**	0.34*	0.35**	-0.86**	-0.65*	-0.75**	0.01	0.01	0.01	-0.32**	-0.27**	-0.29**
T3	-0.19**	-0.21**	-0.20**	-0.05	-0.11	-0.08	0	-0.2	-0.1	0.04	-0.01	0.01	0.1	0.07	0.09

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

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Traits / Parents	Number of node/wine			Diameter of fruit (cm.)			Average weight of fruit (kg.)			Duration of crop (days)			Fruit yield (kg.)/plant		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1	-3.17**	-3.08**	-3.13**	0.31**	0.39**	0.35**	-41.33**	-40.20**	-40.77**	-0.9	-1.71*	-1.31*	-0.12**	-0.12	-0.12**
L2	0.22	0.17	0.19	0.38**	0.09	0.23**	-44.19**	-44.09**	-44.14**	0.31	0.33	0.32	0.05*	-0.01	0.02
L3	4.67**	4.51**	4.59**	0.00	0.02	0.01	-21.20**	-17.61**	-19.41**	6.10**	5.62**	5.86**	-0.23**	-0.14*	-0.18**

L4	1.68**	1.61**	1.65**	-0.06	-0.02	-0.04	44.00**	46.91**	45.46**	0.09	-0.06	0.01	0.02	0.05	0.04
L5	-2.43**	-2.60**	-2.51**	-0.34**	-0.33	-0.33**	5.68**	8.59*	7.13**	-3.56**	-2.93**	-3.25**	-0.12**	-0.05	-0.09**
L6	-0.2	-0.23	-0.21	-0.24**	-0.24 *	-0.24**	16.87**	24.16**	20.52**	4.43**	4.59**	4.51**	-0.29**	-0.32**	-0.30**
L7	-0.83**	-0.62**	-0.73**	0.23**	0.05	0.14*	4.87**	8.88*	6.88**	-4.23**	-3.63**	-3.93**	0.24**	0.11	0.18**
L8	-0.75**	-0.85**	-0.80**	-0.36**	-0.04	-0.20**	2.53	-0.90	0.81	4.31**	4.10**	4.21**	0.05*	0.06	0.05
L9	1.32**	1.52**	1.42**	-0.37**	-0.14	-0.26**	-3.83*	-4.19	-4.01	-3.56**	-3.67**	-3.62**	0.16**	0.17**	0.16**
L10	3.03	3.10**	3.06	0.20**	0.07	0.13*	21.45**	16.44**	18.94**	0.29	0.05	0.17	0.11**	0.09	0.10**
L11	-0.39 *	-0.40*	-0.40**	-0.21**	-0.22	-0.22**	15.10**	9.11	12.10*	-3.23**	-3.09**	-3.16**	-0.01	-0.03	-0.02
L12	-3.14**	-3.12**	-3.13**	0.45**	0.83**	0.42**	0.04	-7.10*	-3.53	-0.04	0.42	0.18	0.13**	0.18**	0.15**
T1	0.84**	0.83**	0.83**	-0.06*	-0.04	-0.05	-12.08	-11.34**	-11.71**	0.97 *	0.53	0.75*	-0.12**	-0.12**	-0.12**
T2	0.03	0.06	0.05	0.19**	0.08	0.14**	-12.17**	-9.40**	-10.78**	-0.4	-0.26	-0.33	0.07**	0.07	0.07**
T3	-0.88**	-0.89**	-0.88**	-0.13**	-0.04	-0.08**	24.25**	20.75**	22.50**	-0.57	-0.26	-0.42	0.04**	0.04	0.04**

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

Cont....

Traits / Parents	Day to first fruit picking			T.S.S			Specific gravity			Dry weight		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1	1.176 *	0.750	0.96*	0.02	-0.04	-0.01	-0.00	-0.01	-0.01	0.08*	0.04	0.06**
L2	0.731	0.417	0.57	-0.11**	-0.08	-0.10**	-0.04**	-0.04**	-0.04**	0.24**	0.23**	0.23**
L3	-1.38**	-1.47	-1.42	0.057	0.25**	0.15**	0.00	0.08	0.013	-0.29**	-0.29**	-0.29**
L4	3.95**	3.75**	3.85**	0.37**	0.23**	0.30**	0.07**	0.06**	0.06**	0.14**	0.11	0.13**
L5	-0.15	-0.361	-0.25	0.29**	0.36**	0.32**	0.02*	0.01	0.02*	-0.12**	-0.12	-0.12**
L6	-0.15	0.417	0.13	-0.09**	-0.20**	-0.15**	0.04**	0.03**	0.03**	0.03	0.09	0.06**
L7	0.28	0.528	0.40	-0.01	-0.03	-0.02	-0.10**	-0.09**	-0.10**	0.17**	0.16*	0.17**
L8	-0.49	-0.028	-0.25	-0.16**	-0.27**	-0.22**	-0.04**	-0.00	-0.02*	-0.24**	-0.26**	-0.25**
L9	-2.04**	-1.91**	-1.98**	0.01	-0.02	-0.00	0.05**	0.05**	0.05**	0.52**	0.54**	0.53**
L10	0.95	0.528	0.74	-0.29**	-0.20*	-0.25**	-0.01	-0.01	-0.01	-0.24**	-0.26**	-0.25**
L11	-2.71**	-2.58**	-2.64**	0.13**	0.19**	0.16**	-0.01	-0.01	-0.01	-0.27**	-0.26**	-0.26**
L12	-0.15	-0.028	-0.09	-0.19**	-0.16*	-0.18**	0.02	0.00	0.01	-0.03	0.01	-0.01
T1	1.09**	1.05**	1.07**	0.12**	0.12**	0.124 **	-0.00	0.00	-0.00	0.30**	0.29**	0.30**
T2	-1.13**	-1.16**	-1.14**	-0.04**	-0.02	-0.034	-0.00	-0.01	-0.00	-0.20**	-0.18**	-0.19**
T3	0.03	0.111	0.07	0.08**	-0.10*	-0.09**	0.01*	0.00	0.01 *	-0.09**	-0.11**	-0.10**

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

General combining ability effects

Perusal of Table-2 revealed that gca effects of all the characters differed over seasons. Line L7 had good gca effects for Day to first male flower initiation, L1 for Day to first female flower initiation, Diameter of fruit, L12 for Number of node for first male flower, T3 for Number of node for 1st female flower, Duration of crop, Number of node/wine, Day to first fruit picking, L4 for Average weight of fruit, T.S.S, Specific gravity, L9 for Fruit yield (kg./)plant, Dry weight, L6 for Number of branches per plant, Number of fruit per vine @ 60DAS, L11 for Vine of length @ 60DAS, Day to first fruit set, Length of fruit and L10 for Number of fruit per plant such variation may be due to differences in genotypic constitution of the parents for different characters. Similar results had also been reported by Singh *et al.* (2005) and Yadav and Kumar (2012).

Specific combining ability effects

The SCA effects represent non-additive gene action which is non-fixable. Specific combining ability effects helps in the identification of superior cross combinations for development

of promising varieties/hybrids. The crosses showing high SCA effects involving parents with high GCA effects may give rise desirable segregants in future generation. The specific combining ability effects of the forty five crosses for 19 traits in both the seasons and over environments have been presented in Table-2 Perusal of Table-4.7 revealed that significant positive and negative sca effects were observed for all the traits. However, none of the crosses had significant sca effect for all the traits. Further, sca effects were found to vary in nature and magnitude for all the characters with the change of seasons. This varying magnitude of sca effects over seasons may be due to environmental effects and genotypes. The specific combining ability effects of the crosses showing significant sca effects for fruit yield and their relationship with other yield components. The sca effects of the cross is an estimate value while *per se* performance is the realized value, the later should also be given due to consideration, while making selection of best cross combinations. The best five crosses on the basis of desirable and significant SCA effects and *per se* performance with combining ability effects and best common crosses over season for all the traits studied.

Table 4: Estimates of SCA effects of F₁ hybrids in line x tester cross of cucumber over two seasons (E₁, E₂) and pooled

Traits / Parents	Day to first male flower initiation			Day to first female flower initiation			Number of node for first male flower			Number of node for 1 st female flower			Number of branches per plant		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1xT1	0.28	0.22	0.25	0.4	0.97	0.69	0.34	0.49	0.42	-1.11**	-1.09**	-1.10**	-0.02	-0.07	-0.05
L1xT2	-1.55	-0.63	-1.09	-0.12	-0.25	-0.18	0.06	-0.02	0.01	1.55**	1.66**	1.61**	1.26**	1.14**	1.20**
L1xT3	1.27	0.41	0.84	-0.28	-0.72	-0.5	-0.4	-0.46	-0.43*	-0.43	-0.57**	-0.50**	-1.23**	-1.07**	-1.15**
L2xT1	-2.16*	-1.33	-1.75*	-0.03	-0.80	-0.42	-0.01	-0.03	-0.02	1.13**	1.28**	1.20**	-1.00**	-0.97**	-0.99**
L2xT2	-0.66	-0.52	-0.59	0.43	-0.02	0.2	-0.45	-0.48	-0.47*	-0.89**	-0.87**	-0.88**	-0.70**	-0.80**	-0.75**
L2xT3	2.83*	1.86	2.34**	-0.39	-0.83	0.21	0.46	0.52	0.49*	-0.23	-0.40*	-0.32*	1.70**	1.77**	1.74**
L3xT1	-0.05	-0.22	-0.13	0.18	0.19	0.19	0.33	0.23	0.28	0.99**	0.72**	0.85**	-0.25**	-0.23	-0.24**
L3xT2	-2.22*	-1.75	-1.98*	-1.34	-1.02	-1.18	-0.44	-0.98**	-0.71**	-0.51*	-0.47*	-0.49**	0.04	0.16	0.1
L3xT3	2.27*	1.97	2.12**	1.15	0.83	0.99	0.1	0.75*	0.42*	-0.47*	-0.25	-0.36*	0.20*	0.06	0.13
L4xT1	-0.94	-1	-0.97	-2.1**	-2.91**	-3.03**	-0.75**	-0.85**	-0.80**	-1.79**	-1.85**	-1.82**	0.18	0.21	0.19*
L4xT2	1.88	2.13	2.01**	2.65*	3.19**	2.92**	1.07**	1.60**	1.33**	0.96**	1.06**	1.01**	-0.50**	-0.49**	-0.50**
L4xT3	-0.94	-1.13	-1.04	0.49	-0.27	0.10	-0.32	-0.74*	-0.53*	0.83**	0.78**	0.80**	0.32**	0.28*	0.30**
L5xT1	0.83	0.22	0.52	-0.03	-0.02	-0.03	-0.56*	-0.71*	-0.64**	1.32**	-1.39**	-1.36**	1.39**	1.32**	1.35**
L5xT2	-0.33	-0.97	-0.65	0.1	0.08	0.09	-0.58*	-0.62*	-0.60**	-1.13**	-1.09**	-1.11**	-2.53**	-2.41**	-2.47**
L5xT3	-0.5	0.75	0.12	-0.06	-0.05	-0.06	1.15**	1.34**	1.24**	2.46**	2.48**	2.47**	1.14**	1.08**	1.11**
L6xT1	0.61	2.11	1.36	1.85*	2.41*	2.13**	1.47**	1.90**	1.69**	2.35**	2.35**	2.35**	1.15**	1.11**	1.13**
L6xT2	1.11	2.25*	1.68*	1.65	2.19*	1.92**	-0.38	-0.45	-0.42	-0.57*	-0.61**	-0.59*	0.57**	0.57**	0.57**
L6xT3	-1.72*	-4.36**	-3.04**	-3.50**	-4.61**	-4.06**	-1.09**	-1.44**	-1.27**	-1.77**	-1.73**	-1.75**	-1.72**	-1.68**	-1.70**
L7xT1	0.16	-0.44	-0.13	-0.37	0.08	-0.14	0.85*	0.81**	0.83**	0.89**	0.85**	0.87**	-0.44**	-0.36**	-0.40**
L7xT2	0.66	-0.97	-0.15	-1.23	-2.13	-1.68*	-0.65*	-0.61*	-0.63**	0.04	0.07	0.06	-0.04	-0.07	-0.05
L7xT3	-0.83	1.41	0.29	1.6	2.05	1.82**	-0.19	-0.2	-0.19	-0.94**	-0.92**	-0.93**	0.48**	0.43**	0.45**
L8xT1	1.16	1.33	1.25	1.18	0.75	0.96	-0.72**	-0.76*	-0.74**	0.22	0.10	0.16	1.06**	0.93**	1.00**

Traits / Parents	Day to first male flower initiation			Day to first female flower initiation			Number of node for first male flower			Number of node for 1 st female flower			Number of branches per plant		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L8xT2	-0.33	0.13	-0.09	0.32	1.19	0.75	0.81**	0.85**	0.83**	0.27	0.25	0.26	1.22**	-1.04**	-1.13**
L8xT3	-0.83	-1.47	-1.15	-1.5	-1.94	-1.72*	-0.08	-0.09	-0.08	-0.49*	-0.36	-0.42**	0.15	0.1	0.13
L9xT1	0.05	0.77	0.41	0.18	0.19	0.19	-1.67**	-1.70**	-1.68**	-0.01	-0.1	-0.05	-0.29**	-0.37**	-0.33**
L9xT2	-0.11	-1.08	-0.59	-1	-1.02	-1.01	0.94**	0.99**	0.97**	0.28	0.35	0.32*	0.89**	1.07**	0.98**
L9xT3	0.05	0.30	0.18	0.82	0.83	0.82	0.72**	0.71*	0.71**	-0.26	-0.25	-0.26	-0.59**	-0.70*	-0.64**
L10xT1	-0.5	-0.88	-0.69	-1.03	-1.25	-1.14	1.36**	1.32**	1.34**	-1.31**	-1.29**	-1.30**	-0.68**	-0.63**	-0.66**
L10xT2	2.33*	2.25*	2.29**	1.1	1.19	1.14	-0.89**	-0.85**	-0.87**	0.08	0.01	0.05	1.57**	1.56**	1.57**
L10xT3	-1.83	-1.36	-1.59*	-0.06	0.05	0	-0.46	-0.47	-0.47*	1.23**	1.28**	1.25**	-0.89**	-0.92**	-0.90**
L11xT1	-0.61	-3.33**	-1.97*	-1.59	-2.69*	-2.14**	-0.3	-0.33	-0.32	1.11**	1.25**	1.18**	0.43**	0.45**	0.44**
L11xT2	1.22	2.80*	2.01**	0.21	0.75	0.48	0.16	0.21	0.19	-1.63**	-1.65**	-1.64**	-0.06	-0.23	-0.14
L11xT3	-0.61	0.52	-0.04	1.38	1.94	1.66*	0.13	0.12	0.13	0.52*	0.40*	0.46**	-0.37**	-0.22	-0.29**
L12xT1	1.16	2.55*	1.86*	2.40**	3.08**	2.74**	-0.33	-0.37	-0.35	-1.14**	-0.82**	-0.98**	-1.50**	-1.38**	-1.44**
L12xT2	-2**	-3.63**	-2.81**	-2.78**	-4.13**	-3.46**	0.35	0.39	0.37	1.54**	1.27**	1.41**	0.71**	0.53**	0.62**
L12xT3	0.83	1.08	0.95	0.38	1.05	0.71	-0.01	-0.02	-0.01	-0.4	-0.44*	-0.42**	0.79**	0.85**	0.82**

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

Traits / Parents	Vine of length @ 60DAS			Number of fruit per plant			Day to first fruit set			Number of fruit per vine @ 60DAS			Length of fruit (cm.)		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1xT1	-0.54**	-0.61**	-0.57**	1.76**	2.01**	1.89**	0.69	1.38	1.03	0.36**	0.36*	0.36**	-3.92**	-3.76**	-3.84**
L1xT2	0.25**	0.21	0.23*	-1.87**	-2.01**	-1.94**	6.08**	4.88**	5.48**	-0.11	-0.24	-0.17	2.12**	2.09**	2.10**
L1xT3	0.28**	0.40*	0.34**	0.11	-0.00	0.05	-6.77**	-6.25**	-6.51**	-0.24*	-0.12	-0.18	1.79**	1.67**	1.73**
L2xT1	0.44**	0.36*	0.40**	0.51*	0.32	0.42	-0.63	0.15	-0.24	0.32**	0.46*	0.39**	-3.21**	-3.23**	-3.22**
L2xT2	0.04	0.16	0.1	-0.62**	-0.55	-0.59*	-0.91	-1.34	-1.13*	-0.08	-0.23	-0.16	2.22**	2.28**	2.25
L2xT3	-0.48**	-0.52**	-0.50**	0.1	0.23	0.17	1.55*	1.18	1.37*	-0.23*	-0.22	-0.23*	0.99**	0.95**	0.97**
L3xT1	0.22**	-0.39*	-0.31**	-3.16**	-3.41**	-3.28**	2.58**	2.04*	2.31**	-0.04	-0.05	-0.04	-1.56**	-1.57**	-1.56**
L3xT2	0.06	0.36*	0.21*	2.61**	2.74**	2.67**	-3.69**	-3.12**	-3.40**	0.19	0.22	0.2	-0.92**	-0.95**	-0.93**
L3xT3	0.15*	0.03	0.09	0.55*	0.66	0.60*	1.11	1.07	1.09*	-0.15	-0.17	-0.16	2.48**	2.52**	2.50**
L4xT1	0.1	-0.1	0	1.32**	1.29**	1.31**	-2.19**	-2.73**	-2.46**	0.06	-0.05	0	-0.16	-0.23	-0.2
L4xT2	-0.65**	-0.50**	-0.57**	-2.70**	-2.71**	-2.70**	3.52**	3.10**	3.31**	-0.63**	-0.46*	-0.55**	1.44**	1.38**	1.41**
L4xT3	0.55**	0.60**	0.57**	1.37**	1.42**	1.39**	-1.33	-0.37	-0.85	0.57**	0.51**	0.54*	-1.28**	-1.14**	-1.21**
L5xT1	0.36**	0.39*	0.38**	-1.88**	-1.79**	-1.84**	6.69**	5.60**	6.14**	-0.22*	-0.16	-0.19	1.58**	1.38**	1.48**
L5xT2	-0.04	-0.26	-0.15	2.23**	2.07**	2.15**	-0.25	0.10	-0.07	0.23*	0.23	0.23*	0.17	0.26	0.21
L5xT3	-0.32**	-0.13	-0.23*	-0.34	-0.27	-0.31	-6.44**	-5.70**	-6.07**	0	-0.06	-0.03	-1.76**	-1.64**	-1.70**
L6xT1	0.04	0.09	0.06	1.35**	0.84	1.09**	-4.97**	-5.06**	-5.01**	0.30**	0.29	0.30*	4.65**	4.63**	4.64**
L6xT2	0	-0.06	-0.02	1.48**	1.56**	1.52**	3.75**	3.43**	3.59**	0.1	0.03	0.07	-1.21**	-1.29**	-1.25**
L6xT3	-0.05	-0.02	-0.04	-2.84**	-2.41**	-2.62**	1.22	1.63	1.42*	-0.41**	-0.33	-0.37**	-3.44**	-3.34**	-3.39**
L7xT1	-0.05	-0.29	-0.17	0.19	0.39	0.29	1.69*	2.49**	2.09**	-0.12	-0.32	-0.22*	0.14	0.14	0.14
L7xT2	0.56**	0.53**	0.54**	0.3	-0.00	0.14	-4.91**	-5.00**	-4.96**	-0.46**	-0.35	-0.40**	-1.26**	-1.11**	-1.18**
L7xT3	-0.50**	-0.23	-0.37**	-0.49*	-0.39	-0.44	3.22**	2.51**	2.87**	0.59**	0.67**	0.63**	1.11**	0.96**	1.04**
L8xT1	-0.04	0.26	0.11	-1.32**	-1.39**	-1.32**	-0.52	-0.62	-0.57	-0.28**	-0.27	-0.27*	-0.74**	-0.65**	-0.70**

L3×T3	0.51	0.55	0.537	0.50**	0.39**	0.450 **	-0.01	-0.02	-0.016	0.1	0.08	0.096 *
L4×T1	-3.20**	-3.27**	-3.241**	-0.48**	-0.75**	-0.617**	0.03	0.02	0.031	-0.80**	-0.79**	-0.802 **
L4×T2	3.68**	3.61**	3.648**	0.48**	0.58**	0.532 **	-0.06**	-0.07**	-0.069**	0.18**	0.17	0.183 **
L4×T3	-0.48	-0.33	-0.407	0	0.17	0.085	0.02	0.04*	0.038 *	0.61**	0.62**	0.620 **
L5×T1	6.90**	6.16**	6.537**	-0.09	0.25*	0.079	0.31	-0.05*	-0.045 *	0.13*	0.18	0.162 **
L5×T2	-0.53	0.05	-0.241	-0.42**	-0.69**	-0.562**	-0.01	0.01	-0.002	-0.20**	-0.23	-0.219 **
L5×T3	-6.37**	-6.22**	-6.296**	0.52**	0.44**	0.483 **	0.05*	0.04	0.047**	0.06	0.04	0.056
L6×T1	-3.75**	-3.27**	-3.51**	-0.12*	-0.12	-0.125	-0.14**	-0.12**	-0.136**	0.61**	0.58**	0.598 **
L6×T2	3.46**	2.61*	3.03**	-0.13 *	-0.02	-0.084	0.08**	0.08**	0.085 **	-0.66**	-0.62**	-0.645 **
L6×T3	0.29	0.66	0.481	0.26**	0.15	0.209 **	0.05**	0.04*	0.052 **	0.05	0.04	0.046
L7×T1	-0.2	0.61	0.204	0.57**	0.62**	0.599**	0.08**	0.06*	0.071 *	0.1	0.05	0.081 *
L7×T2	-6.31**	-5.83**	-6.074**	-0.27**	-0.39**	-0.335**	-0.04*	-0.02	-0.035 *	-0.51**	-0.48**	-0.496 **
L7×T3	6.51**	5.22**	5.870**	-0.29**	-0.23	-0.264**	-0.03	-0.03	-0.036 *	0.40**	0.42**	0.416 **
L8×T1	-1.42	-2.50*	-1.96**	0.17**	0.14	0.162 *	0.03	0.04	0.036 *	-0.19**	-0.19	-0.198 **

Traits / Parents	Day to first fruit picking			T.S.S			Specific gravity			Dry weight		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L8×T2	3.79**	2.38*	3.093**	-0.54**	-0.52**	-0.537**	0	-0.02	-0.011	0.26**	0.26*	0.266**
L8×T3	-2.37**	0.11	-1.130	0.37*	0.37**	0.375**	-0.03	-0.01	-0.025	-0.07	-0.06	-0.068
L9×T1	-0.2	0.72	0.259	0.11	0	0.057	0.01	0.01	0.017	-0.1	-0.08	-0.092 *
L9×T2	-3.64**	-3.38**	-3.51**	0.51**	0.41**	0.467 **	-0.06**	-0.04	-0.052**	0.63**	0.53**	0.582**
L9×T3	3.85**	2.66*	3.259 **	-0.63*	-0.41**	-0.524 **	0.04*	0.02	0.034*	-0.52**	-0.45**	-0.490 **
L10×T1	-2.53**	-2.38*	-2.463 **	-0.14*	-0.18	-0.167**	-0.09**	-0.05*	-0.074**	-0.60**	-0.52**	-0.568**
L10×T2	0.35	0.16	0.259	-0.25**	0	-0.127*	0.09**	0.04*	0.07 **	0.23**	0.17	0.205**
L10×T3	2.18*	2.22*	2.204 **	0.40**	0.18	0.294**	0	0	0.001	0.36**	0.35**	0.363**
L11×T1	-0.87	-0.94	-0.907	0.05	-0.06	-0.004	-0.12**	-0.10**	-0.113**	0.12*	0.11	0.118 **
L11×T2	-2.31*	-2.38*	-2.352**	0.31**	0.32**	0.324 **	0.08**	0.08**	0.081 **	-0.12*	-0.08	-0.102 *
L11×T3	3.18**	3.33**	3.259**	-0.37**	-0.26*	-0.319 **	0.03	0.02	0.031	-0.00	-0.03	-0.016
L12×T1	-0.09	-0.5	-0.296	0.77**	0.73**	0.754 **	-0.04*	-0.02	-0.034 *	0.36**	0.34**	0.357 **
L12×T2	-0.53	0.38	-0.074	-0.50**	-0.48**	-0.494 **	0.06**	0.04	0.056 **	-0.36**	-0.29*	-0.329**
L12×T3	0.63	0.11	0.370	-0.26**	-0.25*	-0.260 **	-0.02	-0.01	-0.021	-0.05	-0.05	-0.028

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

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