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Heterosis and combining ability in cucumber (C*ucumis sativus.* L.)

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Abstract
The present study on heterosis and combining ability for fruit yield and its components was carried out in a set of 42 F_1 hybrids of cucumber obtained from a full diallel involving three gynoecious and four monoecious parents at College of Horticulture and Forestry, Jhalawar during *summer* 2014. The results revealed that there was significant differences among the parents and hybrids for most of the characters except for days to fruit maturity from anthesis, fruit length, fruit diameter, fruit weight, days to fruit harvesting and total soluble solids indicating the importance of both additive and non-additive gene action. Among the parents, Poinsette was found to be the good general combiner for fruit length, fruit diameter, fruit weight, number of branches per plant and vine length at final stage. Hilton and Isatis was also found good general combiner for yield per plant. The cross combination Poinsette x JWRC-1, Hilton x Swarna Sheetal and Isatis x Swarna Agetiwere found to be good specific combiner for fruit yield and its related contributing characters. Hilton x Swarna Sheetal was found heterosis yield per plant ranged from -36.10 percent to 25.78 percent over mid parent -41.26 percent to 17.87 percent over better parent and -39.74 percent to 15.99 percent over standard parent.

Keywords: Heterosis, cucumber, Horticulture and Forestry

1. Introduction

Cucumber (*Cucumis sativus* L.) is one of the most important and popular cucurbitaceous vegetables grown extensively throughout the tropical and subtropical region of the World. According to De Candle (1967) [1] India is considered as a centre of origin of cucumber. The immature fruits are used as salad. Fruit is demulcent while seeds are cooling, tonic, diuretic and anthelintic when leaves along with cumin seeds administered. High degree of cross-pollination, wide range of genetic variability in vegetative and fruit characters exist in this crop. The success of any breeding procedure is determined by useful gene combination organized in the form of high combining inbreds and heterosis in their crosses. The genetic improvement of yield and its contributing characters require the selection of appropriate breeding procedures which is largely dependent upon the study of general combining ability (gca) of parents and specific combining ability (sca) of hybrids. The general combining ability in respect of characters is the manifestation of additive gene action for the selection of parents, while, the specific combining ability in respect of a particular character in the hybrid is the capitalization of non-additive gene action. The diallel analysis was adopted in the present study in cucumber to gather information on the magnitude of heterosis, general and specific combining abilities and various types of gene effects involved for different quantitative characters.

Materials and Methods

The present material comprised of fifty genotypes involving seven parents (Three gynoecious and four monoecious). They all possible 52 F_1s combinations and one check variety were evaluated in RBD design with three replications during *summer,* 2014 under naturally ventilated polyhouse condition at College of Horticulture and Forestry, Jhalawar. Each genotype was grown in two rows of three meter length on raised bed accomdating 10 plant. The bed to bed distance were 1.5 meter and plant to plant distance on the bed was kept at 30cm distance. Observations were recorded on fifteen important characters, *viz*., days to germination, days to fruit maturity from antheis, days to anthesis of first male flower, days to anthesis of first female flower, node number at which first male flower appeared, node number at which first female flower appeared, fruit length (cm), fruit diameter (cm), fruit weight (g), days to fruit harvesting, number of branches per plant, yield per plant (kg), vine length at 30DAS and final stage of harvesting and total soluble solids. Combining ability analysis was done by using Model 1 and Method l of Griffing (1956) [4]. Heterosis was calculated as the percentage of F_1 performance in the favorable direction of its better parent as suggested by Hayes *et al.* (1955) [5].

Results and Discussion

The mean sum of square due to gca and sca were highly significant for all fifteen characters, except days to fruit maturity from anthesis, fruit weight, days to anthesis of first female flower and node at which first female flower appeared for gca variance (Table 1). It indicated that both additive and non-additive gene action were involved in the expression of these traits. Similar results have been reported by Prajapati (2008) and Prasad and Singh, (1992) in cucumber. The estimates of sca variance (σ2 sca) was higher than gca variance (σ2 gca) for days to fruit maturity from anthesis and fruit weight. This indicated the preponderances of non-additive genes in the control of these characters. The present study was in accordance with reports of Imam *et al.* (1977) [6], Ghaderi and Lower (1979) Nienhuis and Lower (1988) [13], Owens *et al.* (1983) [14] and Sarkar and Sirohi (2005) [10].

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

Characters	GCA	SCA	GCA/SCA Ratio
Days to germination	10.28**	7.35**	1.39
Days to fruit maturity from anthesis	0.27	0.70**	0.38
Days to anthesis of first male flower	1250.76**	160.93**	7.77
Days to anthesis of first female flower	264.41**	26.26	10.06
Node at which first male flower appeared	2.55**	0.30**	8.5
Node at which first female flower appeared	1.73**	0.06	28.83
Fruit length (cm)	2.30**	0.85**	2.70
Fruit diameter (cm)	0.42**	0.08*	5.25
Fruit weight (g)	97.63	162.81**	0.59
Days to fruit harvesting	173.88**	24.18**	7.19
Yield per plant (kg)	0.79**	0.17**	4.64
Number of branches per plant	4.78**	2.22**	2.15
Vine length that 30 DAS (cm)	122.36**	92.25**	1.32
Vine length at final harvest (cm)	3344.01**	1035.08**	3.23
Total soluble solids (%)	0.44**	0.17**	2.58

The estimates of gca effects (Table 2) revealed that the none of the parents exhibited good gca for all the characters so it was difficult to pick good combiners for all the characters together because the combining ability effects were not consistent for all the yield components, possibly because of negative association among of the characters (Solanki and Shah, 1990) [19]. This shows that genes for different desirable characters would have to be combined from different sources (Nehe *et al.* 2007) [12]. Among the seven parents, parent Swarna Sheetal and Swarna Ageti for days to anthesis of first male flower; Swarna Sheetal and Poinsette for node at which first male flower appeared; Poinsette, JWRC – 1 and Swarna Sheetal for fruit length; Poinsette for fruit diameter and fruit weight; Isatis, Hilton, Kian for yield per plant; Poinsette and Swarna Ageti for number of branches per plant and total soluble solids; Isatis for vine length at 30 DAS and Poinsette, Isatis and Hilton for vine length at final stage of harvesting were most desirable parents in desirable direction. The high general combining ability effects observed were primarily due to additive and additive x additive gene effects (Griffing, 1956) [4]. Similar results were reported by Musmade and Kale (1986) in cucumber; Maurya (1991 and 1994) [9] in bottle gourd; Matoria
Khandewal (1999) [9] in bitter gourd; Shaha*et al.* (1999) [17] in ridge gourd and Gill and Kumar (1988) [3] in watermelon

Table 2: Estimates of general combining ability (gca) effects of parents for different characters in Cucumber

Parents	Days to germination	Days to fruit maturity from anthesis	Days to anthesis of first male flower	Days to anthesis of first female flower	Node at which first male flower appeared	Node at which first female flower appeared	Fruit length	Fruit diameter
Kian	-0.88**	0.08	0.00	-4.33**	0.00	-0.31**	-0.30*	-0.16**
Isatis	-0.19	0.23*	0.00	-3.65**	0.00	-0.36**	0.01	-0.06
Hilton	0.71**	0.01	0.00	-4.16**	0.00	-0.37**	-0.41*	-0.11*
Poinsette	-0.29	-0.17	4.44**	-1.25*	0.23**	0.001	0.74*	0.36**
SwarnaSheetal	-1.01**	-0.15	6.54**	3.12**	0.46**	0.35**	0.21	0.05
SwarnaAgeti	0.28	0.07	7.85**	5.17**	0.38**	0.36**	-0.35*	0.00
JWRC-1	1.38**	-0.07	10.85**	5.10*	0.27**	0.34**	0.08	-0.08

* Significance at 5% ** Significance at 1%

Parents	Fruit weight (g)	Days to fruit harvesting	Yield per plant (kg)	Number of branches per plant	Vine length (cm)		Total soluble solids
					30 DAS	Final stage	
Kian	-1.76	-4.41**	0.11	-0.60**	0.47	-8.02**	-0.18**
Isatis	0.34	-3.26**	0.18**	-0.36**	3.06	2.99	-0.10
Hilton	1.03	-3.25**	0.37**	-0.53**	1.53	0.65	-0.20**
Poinsette	4.82*	4.38**	-0.03	1.10**	-1.55	30.86**	0.24**
SwarnaSheetal	0.81	2.55**	-0.08	0.02	2.17	-19.55**	-0.06
SwarnaAgeti	-2.63	2.33**	-0.25**	0.16	-5.78**	-2.79	0.08
JWRC-1	-2.60	1.66**	-0.30**	0.21	0.11	-4.14	0.20**

* Significance at 5% ** Significance at 1%

The estimates of specific combining ability effects were found negatively significant in cross combinations Poinsette x JWRC-1 (-3.65),Isatis x Swarna Ageti (-3.00) and Kian x Swarna Ageti(-2.69) for days to germination; Isatis x JWRC-1 (-0.97), Hilton x JWRC-1 (-0.85) and Kian x Swarna Ageti (-0.65) for days to fruit maturity from anthesis; Kian x Swarna Ageti (-8.12), Hilton x Swarna Sheetal (-5.24) and Kian x JWRC-1 (-3.21) for days to anthesis of first female flower; Poinsette x JWRC-1 (-0.31) for node at which first male flower appeared; Hilton x Poinsette (-0.30) for node at which first female flower appeared, Swarna Ageti x JWRC-1 (-6.81), Hilton x Swarna Sheetal (-5.15) and Swarna Sheetal x JWRC-1 (-4.71) for days to fruit harvesting. The highest significantly positive specific combining ability effect in Kian x Poinsette (0.57) for fruit length; Hilton x Swarna Sheetal (0.40) for fruit diameter; Hilton x Swarna Sheetal (15.80) and Kian x Swarna Sheetal (15.59) for fruit weight; Poinsette x JWRC-1 (1.55), Hilton x Swarna Sheetal (1.52) and Isatis x Swarna Ageti (1.42) for yield per plant, Kian x Poinsette (0.40) for number of branches per plant; Hilton x Poinsette (13.70) and Hilton x Swarna Sheetal (11.05) for vine length at 30 DAS; Kian x Swarna Sheetal (48.17) and Poinsette x JWRC-1 (41.74) for vine length at final stage of harvesting; Kian x JWRC-1 (0.73) and Poinsette x JWRC-1 (0.36) for total soluble solids (Table 3).

This superiority of sca effects may be due to complementary type of gene action or involvement of non allelic interaction of fixable and non-fixable genetic variance (Patel and Desai, 2008, [15] and Purohit, 2007) [16].

Table 3: Estimates of specific combining ability (sca) effects of hybrids for various characters in cucumber

Cross combinations	Days to germination	Days to fruit maturity from anthesis	Days to anthesis of first male flower	Days to anthesis of first female flower	Node at which first male Flower appeared	Node at which first female flower appeared
Kian*Isatis	0.60	0.80**	-10.04**	3.66*	-0.36**	0.03
Kian*Hilton	1.09*	0.12	-10.20**	1.28	-0.51**	0.08
Kian*Poinsette	0.87	0.01	9.90**	-0.67	0.55**	-0.19
Kian*SwarnaSheetal	0.72	0.13	11.89**	3.98**	0.36**	0.07
Kian*SwarnaAgeti	-2.69**	-0.65*	0.97	-8.12**	0.14	-0.11
Kian*JWRC-1	0.37	-0.61*	6.71**	-3.21*	0.29*	0.10
Isatis*Hilton	-0.03	0.09	-11.01**	-0.80	-0.41**	-0.01
Isatis*Poinsette	0.84	-0.12	7.05**	-2.55	0.15	-0.07
Isatis*SwarnaSheetal	0.30	-0.16	4.55**	-5.58**	0.38**	0.15
Isatis*SwarnaAgeti	-3.00**	-0.09	8.67**	2.50	0.06	-0.11
Isatis*JWRC-1	-0.23	-0.97**	11.62**	0.73	0.45**	-0.12
Hilton*Poinsette	1.10**	0.40	6.94**	-3.07*	0.30*	-0.30*
Hilton*SwarnaSheetal	-0.10	0.02	2.90*	-5.24**	0.40**	-0.02
Hilton*SwarnaAgeti	-0.55	-0.47	14.17**	4.37**	0.28*	0.07
Hilton*JWRC-1	-0.04	-0.85**	8.39**	1.99	0.50**	-0.03
Poinsette*SwarnaSheetal	-2.60**	-0.31	-7.62**	-2.04	-0.68**	0.18
Poinsette*SwarnaAgeti	2.01**	0.09	-5.59**	0.77	-0.03	0.27*
Poinsette*JWRC-1	-3.65**	-0.19	-7.66**	2.70*	-0.31*	-0.08
SwarnaSheetal*SwarnaAgeti	0.34	-0.08	-3.16*	1.74	-0.19	-0.12
SwarnaSheetal*JWRC-1	2.23**	0.63*	-3.46*	3.22*	-0.16	-0.22
SwarnaAgeti*JWRC-1	-1.63*	1.65**	-8.23**	-2.11	-0.24*	-0.21

* Significance at 5% ** Significance at 1%

Cross combinations	Fruit length	Fruit diameter	Fruit weight	Days to fruit harvesting	Yield per plant	Number of branches per plant	Vine length		Total soluble solids
							30 DAS	Final stage	
Kian*Isatis	-0.04	-0.02	-1.08	-0.92	-0.62	0.04	2.35	-8.51	-0.16
Kian*Hilton	0.07	0.06	-5.09	-0.52	0.34	0.06	-5.41	-6.98	-0.18
Kian*Poinsette	0.57	-0.24	9.26	1.15	-0.65	0.40*	-1.41	-32.41**	-0.34*
Kian*SwarnaSheetal	0.32	-0.04	15.59**	-0.15	-0.08	-0.03	-3.39	48.17**	0.19
Kian*SwarnaAgeti	0.56	0.17	5.93	-1.38	0.97**	-0.35*	9.33*	29.13**	0.02
Kian*JWRC-1	-0.77*	0.02	-5.06	-1.12	0.72*	-0.21	3.82	0.06	0.73**
Isatis*Hilton	-0.10	-0.15	-8.23	-2.33	-0.89*	0.00	-0.91	-6.28	-0.01
Isatis*Poinsette	-0.08	-0.06	-6.07	-3.71*	-0.05	0.23	6.03	-12.03	0.31*
Isatis*SwarnaSheetal	-0.04	0.23	8.47	-0.04	1.01**	-0.10	2.92	-4.34	0.13
Isatis*SwarnaAgeti	0.46	0.17	9.22	1.62	1.42**	-0.13	-0.70	33.41**	-0.06
Isatis*JWRC-1	-0.03	-0.04	1.26	5.01**	0.72*	-0.40*	-3.16	-14.16*	-0.37**
Hilton*Poinsette	0.57	-0.30*	3.51	-0.72	-0.52	0.19	13.70**	-1.43	-0.31*
Hilton*SwarnaSheetal	0.52	0.40**	15.80**	-5.15**	1.52**	0.06	11.05**	-1.63	0.31*
Hilton*SwarnaAgeti	-0.41	0.03	1.80	3.72*	0.32	0.05	-7.28	0.39	0.17
Hilton*JWRC-1	-1.09**	-0.09	-2.00	5.44**	0.94**	-0.19	-1.81	25.52**	0.07
Poinsette*SwarnaSheetal	-0.43	0.20	-11.71*	3.32*	0.52	-0.51**	0.52	11.54	-0.38**
Poinsette*SwarnaAgeti	-0.18	0.11	-2.59	0.57	0.29	-0.39*	-5.74	4.11	0.05
Poinsette*JWRC-1	0.44	0.27*	7.99	2.58	1.55**	-0.20	0.35	41.74**	0.36*
SwarnaSheetal*SwarnaAgeti	-0.40	-0.04	-8.57	-0.88	-1.41**	0.35*	3.27	-22.87**	-0.20
SwarnaSheetal*JWRC-1	-0.57	-0.27*	-5.00	-4.71**	-0.97**	-0.03	3.72	-23.04**	-0.03
SwarnaAgeti*JWRC-1	-0.50	-0.12	-8.33	-6.81	-1.66**	0.32*	-1.05	-21.74**	-0.15

* Significance at 5% ** Significance at 1%

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