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Combining ability and gene action studies for different yield contributing traits in cucumber

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ABSTRACT

Combining ability and gene action were studied in diallel design (without reciprocal) using six genotypes namely Khira-75, UHF-CUC-1, UHF-CUC-2, UHF-CUC-3, Poinsette and PI-618860. Its information is important for making breeding plans, general combining ability (GCA) studies revealed that P1-618860, UHF-CUC-1, UHF-CUC-2 and Khira-75 were observed to be good combiners for a number of traits, including yield per plot and per hectare. However, the estimates of specific combining ability (SCA) showed the highest desirable SCA effects in crosses Khira-75 × PI-618860, UHF-CUC-1 × PI-618860 and UHF-CUC-3 × PI-618860 for earliness and other desirable traits including yield per plot and per hectare. Predictability ratio and average degree of dominance was observed to be less than 1 for most of the horticultural and yield contributing traits indicating the importance of non-additive components of variance for improvements of these traits. The results indicated the importance of heterosis breeding for effective utilization of non-additive genetic variance in cucumber.

Key words: *Cucumis sativus*, GCA, SCA, predictability ratio.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an economically and horticulturally important crop grown all over the world as a multipurpose vegetable and a better choice to the breeders for using it as a model plant for study and significant biological processes. It belongs to the family *Cucurbitaceae* which comprises of 117 genera and 960 species. India being native place of cucumber possesses high genetic variability for vegetative and fruit characters but very little work has been done for its improvement by using genetically superior parents. Low fruiting ability and yield suppression due to its inherent fruiting habits are the two main reasons limiting fruit yield in cucumber. Development of high yielding varieties mainly depends upon genetically superior parents, coupled with suitable breeding methodology (Valcarcel, 10). Combining ability analysis is one of powerful tools available which give the estimates of combining ability effects and aids in selecting desirable parents for breeding programme. General combining ability (GCA) enables the breeders to exploit the existing variability in the breeding materials, to identify individual genotypes having desirable attributes and to distinguish relatedness among genotypes, while, specific combining ability (SCA) is helpful to determine heterotic patterns among populations or inbred lines, to identify promising single crosses and to assign inbred lines into heterotic groups. The combining ability of parents depends upon the nature of the genetic system operating in the parent, which predicts the efficiency of selection. Moreover, combining ability also indicates the nature and magnitude of gene action involved in the expression of quantitative traits. In order to exploit different types of gene actions present in the population, information regarding relative magnitude of genetic variances and combining ability of the parents is essential. Therefore, the present investigation was undertaken to identify the best combiners among the existing germplasm as well as to study the gene action of different quantitative characters in 6×6 half-diallel (excluding reciprocal) set for formulation of a sound breeding programme in cucumber.

MATERIALS AND METHODS

Experiment was carried out at the Experimental Research Farm of the Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during 2015 and 2016. Six genetically diverse genotypes of cucumber *viz*, Khira 75, UHF CUC 1, UHF CUC-2, UHF CUC 3, Poinsette and PI 618860 were crossed in 6 × 6 half-diallel (excluding reciprocal) mating scheme (Hayman, 7). The resulting 15 F_1 hybrids along with 6 parental lines were evaluated in a randomized complete block design with three replications. The seeds were sown in rows of 100 cm with 75 cm spacing between the plants. The recommended package of practices was followed to

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grow a successful crop (Anonymous, 1). Out of 16 plants, 10 were marked for taking observations on individual plant basis for quantitative characters, *viz.*, days taken to first female flower appearance, node number bearing first female flower, days to marketable maturity, fruit length (cm), fruit breadth (cm), average fruit weight (g), number of marketable fruits per plant, harvest duration (days) and marketable yield per plot (kg) and per hectare (q). The combining ability estimates were calculated according to Method-2, Model 1 (Griffing, 6). For the gene action, relative importance of general combining ability (GCA) and specific combining ability (SCA) was estimated by predictability ratio 2 σ^2g/2 σ^2g + σ^2s (Baker, 3) model, where σ^2g is the additive component of variance and σ^2s is the non-additive component of variance. Average degree of dominance was estimated by using the formula σ^2s/2σ^2g.

RESULTS AND DISCUSSION

General combining ability (GCA) has immense value in the breeding programmes for the species which are amenable to the development of F_1 hybrids. Analysis of variance for GCA and SCA presented in Table 1 revealed that mean square due to GCA and SCA were highly significant for all the characters indicating the importance of both additive and non-additive genetic components for the characters under study. SCA components of variance was higher than GCA components of variance for all the traits under study, *viz*., days taken to first female flower appearance, node number bearing first female flower, days to marketable maturity, fruit length (cm), fruit breadth (cm), average fruit weight (g), number of marketable fruits per plant, fruit length (cm), harvest duration (days) and marketable yield per plot (kg) and per hectare (q), which indicated the predominance of non-additive gene action for the characters studied.

GCA studies revealed that among the six parents, the parent PI-618860 showed significant negative GCA for days taken to first female flower appearance (-5.43), node number bearing first female flower (-1.01) and days taken to marketable maturity (-5.88); UHF CUC 1 and UHF CUC 2 for fruit length (cm), fruit breadth (cm), average fruit weight (g), number of marketable fruits per plant, harvest duration and marketable yield per plot and per hectare exhibited significant positive GCA effects (Table 2). In most of the cases it was observed that *per se* performance of parents bear direct reflection of their respective GCA effects, *i.e.* parents showing highest GCA effects for a character, were also observed to be good performer with respect to that particular character. General combining ability (GCA) effects for earliness (days to first female flower appearance, node number bearing first female flower and days to marketable maturity) revealed that PI 618860 found best combiners due to its significant negative GCA effects. For marketable yield per plot and per hectare, UHF CUC 1, UHF CUC 2 and PI 618860 exhibited the highest positive general combining ability (GCA) effects. All of these parents were also found good combiners for average fruit weight and number of marketable fruits per plant. Beside this, the parent Khira 75 also exhibited significant positive general combining ability (GCA) effects for fruit length, fruit breadth and harvest duration thereby suggesting close association between general combining ability (GCA) of the parents for fruit length, fruit breadth, average fruit weight, number of marketable fruits per plant and harvest duration. The present findings are in line with those of Bairagi *et al.* (2), Golabadi

Table 1. Analysis of variance for combining ability for earliness and yield components in cucumber.

Source	gca	sca	Error	σ^2g	σ^2s	PR	Add
df	5	15	40				
Days to first female flower appearance	91.681	24.998	0.983	11.34	24.01	0.47	1.05
Node number bearing first female flower	5.810	2.006	0.314	0.69	1.69	0.41	1.22
Days taken to marketable maturity	99.875	28.402	1.185	12.34	27.22	0.45	1.10
Fruit length (cm)	46.231	9.399	0.589	5.71	8.81	0.65	0.77
Fruit breadth (cm)	0.752	0.507	0.136	0.08	0.37	0.21	2.3
Average fruit weight (g)	1823.738	828.437	130.297	211.68	698.14	0.30	1.65
Number of marketable fruits per plant	6.515	2.234	0.954	0.70	1.28	0.54	0.91
Harvest Duration (days)	32.238	8.844	2.073	3.77	6.77	0.56	0.89
Marketable yield per plot (kg)	247.309	87.835	20.302	28.38	67.53	0.42	1.18
Marketable yield per hectare (kg)	10992.19	3903.78	902.29	1261.2	3001.4	0.42	1.18

Predictability ratio (PR) = 2 σ^2g/2 σ^2g + σ^2s; Average degree of dominance (Add) = σ^2s /2σ^2g; *,**Significant at 5 and 1% levels

Table 2. Estimates of general combining ability effects of parents for different horticultural traits in cucumber.

Parents \ Character	Days to first female flower appearance	Node number bearing first female flower	Days taken to marketable maturity	Fruit length (cm)	Fruit breadth (cm)	Average fruit weight (g)	Number of marketable fruits per plant	Harvest duration (days)	Marketable yield per plot (kg)	Marketable yield per hectare (q)
Khira-75	-0.03	-0.23*	-0.14	-0.85*	0.22*	2.02	0.37	1.50*	1.39	9.28
UHF-CUC-1	-0.83*	-0.46*	-0.38	0.82*	0.29*	9.13*	0.78*	1.96*	4.83*	32.22*
UHF-CUC-2	-0.25	-0.39*	-0.26	0.68*	0.27*	19.79*	0.62*	1.10*	4.93*	32.87*
UHF-CUC-3	1.59*	0.91*	1.69*	-1.79*	-0.06	-18.83*	-0.62*	-1.93*	-4.92*	-32.77*
Poinsette	4.95*	1.17*	4.97*	-2.83*	-0.43*	-16.85*	-1.55*	-3.00*	-8.66*	-57.73*
PI-618860	-5.43*	-1.01*	-5.88*	3.98*	-0.28*	4.75*	0.40*	0.37	2.42*	16.13*
SE(gi)	0.185	0.104	0.203	0.143	0.069	2.127	0.182	0.268	0.84	5.597
SE (gi-gj)	0.286	0.162	0.314	0.222	0.107	3.295	0.282	0.416	1.301	8.671
CD (gi)	0.38	0.22	0.42	0.30	0.14	4.42	0.38	0.56	1.75	11.64
CD (gi-gj)	0.59	0.34	0.65	0.46	0.22	6.85	0.59	0.87	2.71	18.04

*Significant at 5% level of significance

et al. (5) and Kumar *et al.* (8), who had also reported significant general combining ability (GCA) effects of different parental material for earliness, yield and yield contributing traits in cucumber.

Specific combining ability effect helps in identifying the best cross combinations for various traits. These effects arise due to non-additive gene interactions. The number of crosses having significant SCA effects were recorded 7 for days taken to first female flower appearance, 5 for node number bearing first female flower, 7 for days to marketable maturity, 7 for fruit length, 3 for fruit breadth, 6 for average fruit weight, 5 for number of marketable fruits per plant, 5 for harvest duration and 6 for marketable yield per plot and per hectare. The crosses showing highest significant negative SCA effects for earliness character were *viz.,* Khira 75 × PI 618860 (-3.05), UHF CUC 1 × UHF CUC 2 (-2.56), UHF CUC 1 × PI 618860 (-5.03), UHF CUC 3 × PI 618860 (-5.82) and UHF CUC 3 × Poinsette (-7.37) found as best specific combiners for earliness. Specific combining ability effect for marketable yield per plot and per hectare was found significantly high for Khira 75 × PI 618860 (6.21 & 41.43), UHF CUC 1 × PI 618860 (9.88 & 65.90), UHF CUC 3 × Poinsette (12.18 & 81.21) and UHF CUC 3 × PI 618860 (15.50 & 103.32). Beside this, above cross combinations also revealed significant SCA effects of yield contributing traits *viz.,* fruit length, fruit breadth, average fruit weight, number of marketable fruits per plant and harvest duration. These results indicated that out of these 15 crosses two involved the parents with good × average, one with poor × poor and one with poor × average GCA effect, hence indicated the importance of additive × dominance, additive × additive and additive × dominance type of gene action, respectively controlling these traits as reported by Dogra and Kanwar (4). The crosses which involved average × poor combiners may be used for exploitation of heterosis in F_1 generations. Different crosses expressing high desirable specific combining ability (SCA) in respect to yield and its contributing traits had also been reported by different workers *viz.,* Bairagi *et al.* (2), Reddy *et al.* (9) and Kumar *et al.* (8). In most of the cases, these 5 hybrids which showed best *per se* performance also possessed desirable significant SCA effects (Table 3). This indicated the *per se* performance of hybrids had a direct relation with respective SCA effects. A comparison of the SCA effects of the crosses and GCA effects of the parents involved indicated that in most of the cases GCA effects were reflected in the SCA effects of the cross combination. It is apparent that in almost all the hybrids which showed the best SCA effects, the parental lines involved were at least one of the four outstanding parental lines, *viz.*, P1 618860, UHF CUC 1, UHF CUC 2 and Khira 75 also had high GCA effects for one or more characters contributing towards yield. This indicated that there was strong tendency of transmission of higher gain from the parents to the offspring. The results indicated the importance of heterosis breeding for effective utilization of non-additive genetic variance which had a predominant role for the improvement of yield attributing traits under study.

After identification of appropriate parents and potential crosses through combining ability analysis,

Table 3. Estimates of specific combining ability effects of parents for different horticultural traits in cucumber.

Hybrids \ Characters	Days taken to first female flower	Node number bearing first female flower	Days taken to marketable maturity	Fruit length (cm)	Fruit breadth (cm)	Average fruit weight (g)	Number of marketable fruits per plant	Harvest duration (days)	Marketable yield per plot (kg)	Marketable yield per hectare (q)
Khira-75 × UHF-CUC-1	-0.99	-0.64*	0.52	0.95*	-0.04	16.87*	-1.25*	-1.74*	-3.93*	-26.19
Khira-75 × UHF-CUC-2	-1.58*	-0.74*	-1.87*	-1.27*	0.01	-3.73	-0.84	0.25	-3.94*	-26.28
Khira-75 × UHF-CUC-3	2.14*	0.66*	4.33*	-0.66	-0.41*	-8.46	-0.07	0.53	-1.49*	-9.92
Khira-75 × Poinsette	-0.27*	0.44	-0.98	-0.41	-0.13	-30.37*	-0.10	0.84	-3.55*	-23.65
Khira-75 × PI-618860	-3.05*	-0.98*	-3.39*	3.39*	0.26	16.52*	0.94	0.11	6.21*	41.43*
UHF-CUC-1 × UHF-CUC-2	-2.56*	-0.72*	-1.85*	0.38	0.17	6.43	1.09*	1.90*	5.69*	37.96*
UHF-CUC-1 × UHF-CUC-3	7.69*	1.72*	6.41*	-3.32*	-0.73*	-37.44*	-1.47*	-2.03*	-11.00*	-73.33*
UHF-CUC-1 × Poinsette	4.10*	1.48*	3.37*	-3.10*	-0.62*	-47.58*	-1.63*	-2.20*	-11.86*	-79.09*
UHF-CUC-1 × PI-618860	-5.03*	-0.83*	-5.88*	4.20*	0.78*	28.91*	1.42*	1.72*	9.88*	65.90*
UHF-CUC-2 × UHF-CUC-3	5.51*	1.65*	5.11*	-2.16*	-1.01*	-14.50*	-1.29*	-3.68*	-7.61*	-50.73*
UHF-CUC-2 × Poinsette	4.47*	1.47*	4.90*	-0.29	0.13	12.93*	-0.32	-3.68*	-0.60	-3.98
UHF-CUC-2 × PI-618860	-4.38*	-0.26	-5.14*	2.21*	-0.72*	6.57	1.11*	1.71*	5.70*	38.01*
UHF-CUC-3 × Poinsette	-7.37*	-3.15*	-7.17*	2.19*	1.43*	41.72*	1.84*	5.77*	12.18*	81.21*
UHF-CUC-3 × PI-618860	-5.82*	-1.38*	-7.37*	4.81*	0.91*	39.33*	2.52*	4.75*	15.50*	103.32*
Poinsette × PI-618860	-0.07	-0.14	0.29	-1.07*	0.20	-0.66	-1.19*	-0.41	-5.60*	-37.30*
SE(sij)	0.507	0.287	0.557	0.393	0.189	5.842	0.5	0.737	2.306	15.373
SE(sij-sik)	0.10	0.10	0.1	0.10	0.10	0.10	0.10	0.10	0.10	0.10
SE(sij-skl)	0.701	0.396	0.77	0.543	0.261	8.071	0.691	1.018	3.186	21.24
CD(sij)	1.05	0.60	1.16	0.82	0.39	12.15	1.04	1.53	4.80	31.98
CD(sij-sik)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
CD(sij-skl)	1.46	0.82	1.60	1.13	0.54	16.79	1.44	2.12	6.63	44.18

*Significant at 5% level of significance

the next important step is to adopt suitable breeding methodology to achieve the desired result which depends upon the type of gene action governing the traits. Mean sum of squares due to GCA and SCA were used to estimate the variances for general combining ability (GCA) and specific combining ability (SCA), respectively, based on which nature of gene action has been worked out. The relevant results regarding relative importance of GCA and SCA (predictability ratio) observed to be <0.5 for days to first female flower appearance (0.48), node number bearing first female flower (0.44), days taken to marketable maturity (0.47), fruit breadth (0.30), average fruit weight (0.37), marketable yield per plot (0.45) and per hectare (0.45), thus suggesting the predominant role of non-additive components of variance for improvement of these characters. Average degree of dominance which was found to be >1 for these characters further confirmed the results. Predictability ratio and average degree of dominance was observed to be >0.5 and <1 for fruit length, number of marketable fruits per plant (0.52) and harvest duration (0.52), indicating the predominance of additive gene action for improvement of these characters. Again it confirmed the role of non-additive gene action governing different traits in cucumber. The results of present investigation are in line with the findings of earlier workers *viz.,* Dogra & Kanwar (4) and Kumar *et al.* (8) for the traits related to earliness, fruit length, fruit breadth and average fruit weight; number of fruits per plant and marketable yield by Kumar *et al.* (8) in cucumber. Here, gene action studies revealed the importance of non-additive gene action in the expression of different traits under study; hence hybrid breeding could be exploited for the improvement in yield and its contributing traits in cucumber.

For yield and component traits UHF CUC 1, UHF CUC 2 and PI 618860 were considered good general combiners and expressed significant positive GCA effects for all these traits and parent Khira 75 also exhibited significant positive GCA effects for fruit length, fruit breadth and harvest duration. Among crosses Khira 75 × PI 618860 which exhibited significant negative SCA effect for earliness and highest SCA effect for yield and yield related components may be exploited for commercial cultivation. The estimates of predictability ratio were found < 1 for almost all the traits under study indicated predominance of non-additive gene action *i.e.* dominance and epistasis and heterosis breeding will be an effective tool for genetic improvement of these traits in cucumber.

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