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COMBINING ABILITY ANALYSIS FOR QUANTITATIVE TRAITS IN GYNOECIOUS CUCUMBER UNDER GREENHOUSES CONDITIONS

El-Gazar, T. M.*; Y. T. E. El-Lithy; E. A. Tartoura* and M. Y. Abed***

*** Veg. and Flori. Dept., Fac. Agric., Mansoura Univ. Egypt**

**** Veg. Res. Dept., Hort. Res. Inst., Agric. Res. Center. Egypt**

ABSTRACT

A half-diallel cross was performed among five inbreds of cucumber to obtain ten gynoecious F_1 hybrids suitable for the greenhouses culture. Theses genotypes were used to study the general combining ability (GCA) and specific combining ability (SCA) and to illustrate their relation to the type of gene action for some quantitative traits. All entries were evaluated in greenhouses in two consecutive seasons of 2004/05 and 2005/06. Traits evaluated included relative increasing in plant height, length of stem internodes, number of lateral branches, number of leaves on stem, days to anthesis, early yield , total yield , average fruit weight, fruit length and fruit diameter.

The combining ability analyses showed that GCA and SCA mean squares were significant for all studied traits in both growing seasons. The magnitudes of GCA mean squares were larger than SCA mean squares and the GCA:SCA ratios had values over than unity at both seasons. It could be concluded the importance of both additive (GCA) and non-additive (SCA) genetic variances in the inheritance of studied traits. In addition, the additive effects (GCA) were relatively more important than non-addirtive effects (SCA) in the expression of such traits.

It is suggested that selection could be effective in improving new recombininat inbreds and also developing superior hybrids is possible.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a warm season crop. However, it has the ability to grow under a very wide range of climate. Hence, it is grown in open field at warm seasons or under protected cultivation at cold seasons.

Nearly all new cultivars of greenhouses cucumbers being developed by seed companies for yield production are gynoecious hybrids or predominantely female hybrids. More recently, gynoecy has been considered to be an essential character for breeding cultivars with superior performance. Development of gynoecious sex expression provided more concentrated fruit set and earlier matuarity than normal monoecious types (Denna, 1973). Moreover, the gynoecious hybrids tend to have higher quality yield and higher total yield than monoecious hybrids (Wehner and Miller, 1985)

The diallel crosses mating design is used to obtain estimates for general combining ability (GCA) and specific combining ability (SCA). These two components are utilized to obtain information on the relative importance of additive genetic variance and non-additive genetic variance (including Dominance and Epistasis). Such basic information on the nature of genetic variances would aid the breeder in developing improved hybrid varieties and to define the proper breeding plan.

The relative importance of general combining ability (GCA) and specific combining ability (SCA) in cucumber has been reported by several workers. The vegetative traits, i. e., plant height, length of stem internodes, number of lateral branches and number of leaves are expressed by both GCA and SCA, and generally GCA is the major component constitutes the total genetic variation. (Delaney and Lower, 1987; El-Shawaf and Baker, 1981a; Darwish, 1992; Balliu and Hallidri, 2000; Lobez-sese and Staub, 2002). However, others reported that SCA variance could be much greater than GCA variance in the inheritance of such traits (Gendy, 1991; Awny *et al.*, 1992; Metwally *et al.* 1992).

As for earliness traits, it was reported that GCA variance is the major portion contributing in the inheritance of days to anthesis (El-Shawaf and Baker, 1981b; Kupper and Staub, 1988; Fredrcik and Staub, 1989; Abd El-Hafez *et al.*, 1997)and early yield components(El-Gazar *et al.*, 1984; Gendy, 1991; Kamooh *et al.*, 2000; Lobez-sese and Staub, 2002).

Many investigators reported that GCA and SCA are responsible for the expresion of total yield characters in cucumber. It was also reported that GCA is much greater determining the inheitance of yield traits (Tasdighi and Baker, 1981; Prudek and Wolf, 1985; Darwish, 1992; Ljiljana *et al.*, 2000; Asem 2004).

Fruit length, diameter and average fruit weight is mainly controlled by additive gene action. However, the non-additive gene action played a role in expression of these traits. (Smith *et al.* 1978; El-Gazar *et al.*, 1984; Owens et al, 1985; Kupper and Staub 1988; El-Mighawry *et al.*, 1992; Abd El-Hafez *et al.*, 1997; Kamooh *et al.*, 2000; Asem, 2004)

The present research was undertaken to estimate the the GCA and SCA for some quantitative characters related to yield and horticultural quality traits in gynoecious cucumber. Determination of combining ability for those traits will help provide plant breesers with information that may be helpful in the exploitation of gynoecious inbreds for development of higher yielding commercial genotypes.

MATERIALS AND METHODS

Five parental inbred lines were isolated from three gynoecious cucumber hybrids by inbreeding. These hybrids were subjected to controlled self pollination to gain new recombinant inbreds from the segregating generations. Some plants were sprayed with silver nitrate solution at 300 ppm to induce staminate flowers. Individual plants with desirable characterisics were selected, whereas plants with defects were discarded due to decline or unfavourable characteristics. Five gynoecious segregating inbreds were collected from F_5 generation, hereafter will be refered to as P_1, P_2,P_3,P_4 and P_5. The parental inbred lines were crossed in all possible combinations, excluding reciprocals to produce ten single crosses. Therefore, the genetic populations used in the present work includ five inbreds and ten single crosses. All the genotypes developed in the present study are characterized by gynoecy plant habit.

All fivteen entries were evaluated under greenhouses at Badaway, Dakahlia Governorate in two consecutive seasons of 2004/05 (Y1) and 2005/06 (Y2).

The experimental design used was randomized complet blocks with three replicates. Each block contained 15 plots. Seeds were sown on 8^{th} of October in 2004 and 2005, respectively. The plants were spaced 50 cm apart in rows and 120 cm between rows. All agricultural practices were applied in accordance with the regular procedures for cucumber cultivation under greenhouses. Data were collected for the different characters as follow:

1. Vegetative traits: Relative increasing in plant height (cm.) at 50, 70, and 90 days old, length of stem internodes (cm), number of lateral branches, and number of leaves on stem.
2. Earliness traits: Number of days to the first flower anthesis and early yield which was measured as number and weight of fruits.
3. Total yield traits: It was measured as the total number and weight of all harvested fruits throughout the entire season per plot and per plant.
4. Fruit traits: Average fruit weight (gm), fruit length (cm), and fruit diameter (cm).

The statistcal analysis for half diallel crosses to estimate the GCA and SCA was done following Method II, Model II according to Griffing (1956).

RESULTS AND DISCUSSION

Vegatative traits

The analysis of variance of half diallel cross for the vegetative traits was calculated and the results are presented in Table 1 for the two evaluating seasons. The results revealed that, test of significance showed that the mean squares of general combining ability (GCA) was highly significant for all traits in both seasons, indicating the presence of significant genetic variability. The results also demonstrated that the mean sqaures for the specific combining abiltiy (SCA) were significant or highly significant for all vegetative traits in the two seasons, except for the relative increasing in plant height at 50 days old, which exhibited non-significant value in the first season only. Furthermore, the estimated ratio between mean squares of GCA and SCA show values over unity for all examined traits.

The hereinabove results indicated the importance of both additive and non-additive genetic variances in the inheritance of relative increasing in plant height, length of stem internodes, number of laterals and number of leaves on stem. Moreover, the additive variance was more contributing in the inheritance of such vegetative traits.

Table 1. The ananlysis of variance and mean sqaures of the half diallel analysis for vegetative traits in two seasons.

S.V.	d.f.	Relative increasing in plant height (cm)						Length of stem internodes		Number of laterals		Number of leaves	
		50		70		90							
		Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
Replication	2	16.04	10.57	0.59	1.35	0.83	7.16	2.41	0.46	0.11	4.03	1.70	12.02
GCA	4	25.27**	55.45**	14.99**	27.42**	25.31**	111.28**	1.52**	1.16**	3.79**	6.82**	33.01**	79.1**
SCA	10	3.02**	38.29**	4.12**	13.44**	4.30*	21.03**	0.49**	2.93**	1.22**	2.93**	5.81**	7.88**
Error	28	1.57	2.35	0.78	1.24	1.52	1.40	0.09	0.01	0.27	0.39	1.12	1.07
GCA/SCA		8.37	1.45	3.64	2.04	5.89	5.29	3.10	2.04	3.11	2.33	5.68	10.04

Y1= 1st season; Y2= 2nd season.

Many authors confirmed the importance of additive and non-additive variances for inheritance of vegetative traits in cucumber (El-Shawaf and Baker, 1981a; Gharib, 1991; Metwally *et al.*, 1992; Balliu and Hallidri, 2000; Asem 2004)

Earliness traits

Analysis of combining ability for days to anthesis and early yield components were carried out for both growing seasons, and the estimates of GCA and SCA mean squares are arranged in Table 2.

Table 2. The ananlysis of variance and mean sqaures of the half diallel analysis for earliness traits in two seasons.

S.V.	d.f.	Days to anthesis		Early yield			
				Number of fruits		Weight of fruits	
		Y1	Y2	Y1	Y2	Y1	Y2
Replication	2	0.82	1.77	197.09	462.47	0.79	1.60
GCA	4	7.77**	7.90**	6111.07**	6504.50**	40.23**	39.68**
SCA	10	3.97**	4.45*	1275.34**	1095.82**	11.03**	12.88**
Error	28	0.55	0.46	31.74	20.28	0.41	0.35
GCA/SCA		1.96	1.78	4.79	5.94	3.65	3.08

Y1= 1st season; Y2= 2nd season.

The results of the analysis of variance proved that estimates of GCA and SCA for days to anthesis, early yield components, e. g., number of fruits , weight of fruits were highly significant in both seasons, indicating that additive and non-additive gene actions were involved in the expression of these traits. The magnitudes of GCA were larger than those of SCA for all earliness traits, which mean that the additive genetic variance was predominated in the inheritance of flowering time and early yield. Nevertheless, since overall SCA were highly significant, it is likely that non-additive variance influence the expression of those traits to some degree.

These findings are in agreement with several investigations on flowering time (EL-Shawaf and Baker, 1981b; Kupper and Staub, 1988; Fredrick and Staub, 1989; Abd El-Hafez *et al.*, 1997) and on carly yield characters (El-Gazar *et al.*, 1984; Gendy, 1991; Kamooh *et al.*, 2000; Lobez-sese and Staub, 2002).

Total yield

The analysis of variance for half diallel crosses pertaining to different types of genetic effects for total yield characteristics in both evaluating seasons are presented in Table 3.

Table 3. The ananlysis of variance and mean sqaures of the half diallel analysis for total yield traits in two seasons.

S.V.	d.f.	Total yield/plot				Total yield/plant			
		No.		Wt.		No.		Wt.	
		Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
Replication	2	442.22	2086.69	8.88	19.67	1.73	14.49	0.05	0.14
GCA	4	59714.2**	62701.8**	359.06**	376.96**	428.09**	435.42**	2.49*	2.62**
SCA	10	10475.7**	9653.98**	97.11**	95.36**	70.48**	67.04**	0.67**	0.66**
Error	28	132.49	78.21	1.39	0.94	1.04	0.54	0.01	0.01
GCA/SCA		5.70	6.49	3.70	3.95	6.07	6.49	3.72	3.97

Y1= 1st season; Y2= 2nd season.

Test of significance revealed that the mean squares of GCA and SCA were highly significant for total yield per plot and total yield per plant, determined as number and weight of fruits. These findings were confirmed in both seasons of the study. The statistical significance of GCA mean squares indicates that genetic differences exist among the inbreds and suggests the importance of additive effects in determining the total number and weight of fruits in F_1 hybrids. Meanwhile, the significance of SCA mean squares indicates that dominance and epistatic effects were also involved. Furthermore, the estimation of GCA:SCA ratios had values over unity, which reflected that variation of those characters was mostly due to additive proportion. Therefore, it could be concluded the importance of selection and heterosis for breeding superior cultivars and to improve yield components in the commercial cultivars.

These findings are in agreement with those reported by El-Shawaf and Baker (1981a&b), El-Gazar *et al.* (1984), Prudek and Wolf (1986), Gendy (1991), Ljiljana *et al.* (2000), Kamooh *et al.* (2000) and Asem 2004.

Fruit traits

The estimates of GCA and SCA mean squares for fruit quality traits ,i.e., average fruit weight (gm), fruit length (cm) and fruit diameter (cm) in both seasons are presented in Table 4.

Table 4. The ananlysis of variance and mean sqaures of the half diallel analysis for fruit traits in two seasons.

S.V.	d.f	Average fruit weight		Fruit length		Fruit diameter	
		Y1	Y2	Y1	Y2	Y1	Y2
Replication	2	1.08	0.07	0.15	1.69	0.03	0.17
GCA	4	785.31**	690.52**	4.48**	4.43**	0.14**	0.12**
SCA	10	86.76**	73.61**	1.07**	1.46**	0.05**	0.04
Error	28	1.95	1.71	0.09	0.15	0.01	0.02
GCA/SCA		9.05	9.38	4.19	3.03	2.80	3.00

Y1= 1st season; Y2= 2nd season.

The results presented in Table 4 show the presence of highly significant values for GCA and SCA mean squares for all fruit traits in the two seasons of the study. Additionally, the magnitudes of the GCA mean squares were larger than those for SCA and the ratios of GCA:SCA mean squares had values over than one for all fruit traits.

The forementioned findings would indicate that the fruit traits were affected by both additive and non-additive genetic effects and the overall variation was mostly ascribed to additive gene action.

These results are in consistent with those of Owens *et al.* (1985), Kupper and Staub (1988), El-Mighawry *et al.* (1992), Kamooh *et al.* (2000) and Asem (2004).

Diallel analysis provided further information about the nature of the genetic system conditioning the economical traits in gynoecious cucumber. The formentioned findings of this study demonstrated that additive effects (GCA) were found to be relatively more important than non-additive effects (SCA) for the studied traits.

The significance of GCA (additive effects) indicates that selection could be effective in improving the genetical base of the population. However, the presence of significant estimates of SCA (non additive) genetic variances should not be ignored and could be utilized for breeding superior hybrids.

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تحليل القدرة على التآلف للصفات الكمية فى الخيار الأنثوى تحت ظروف الصوب الزراعية

طه محمد عمر الجزار* ، يوسف طلعت امام الليثى** ، السيد احمد طرطورة* و محمد يوسف عابد*
* قسم الخضر و الزينة- كلية الزراعة- جامعة المنصورة
** قسم بحوث الخضر - معهد بحوث البساتين - مركز البحوث الزراعية

استخدمت طريقة التهجين النصف دائرى (بدون استخدام التهجينات العكسية) للتهجين بين خمسة سلالات من الخيار للحصول على عشرة هجن انثوية تصلح للزراعة تحت ظروف الصوب الزراعية. استخدمت هذه التراكيب الوراثية لدراسة القدرة العامة و الخاصة على التآلف و تحديد التفاعل الجينى لبعض الصفات الكمية. و قد تم تقييم الآباء و الهجن فى موسمى ٢٠٠٤/٢٠٠٥ و ٢٠٠٥/٢٠٠٦ فى الصوب الزراعية. و قد كانت الصفات المدروسة التى شملتها الدراسة هى : الزيادة النسبية فى طول النبات, طول سلاميات الساق, عدد الافرع الجانبية , عدد الاوراق على الساق , عدد الايام حتى الازهار , المحصول المبكر , المحصول الكلى , متوسط وزن الثمرة , طول الثمرة و قطر الثمرة.

و قد اظهر تحليل التباين وجود فروقا معنوية لكل من القدرة العامة و القدرة الخاصة للتآلف للصفات محل الدراسة فى كلا الموسمين. و اظهرت القدرة العامة على التآلف قيما اعلى من القدرة الخاصة على التآلف لجميع الصفات المدروسة و كانت النسبة بين القدرة العامة و القدرة الخاصة على التآلف اكبر من الواحد فى كلا الموسمين.

مما سبق يتضح اهمية كل من التأثير المضيف وغير المضيف فى توارث جميع الصفات المدروسة وان الفعل المضيف للجينات اكثر تأثيرا من الفعل الغير مضيف فى وراثة تلك الصفات.

لذلك يمكن القول ان الانتخاب له دورا فعالا فى تحسين هذه الصفات فى السلالات المرباة داخليا كما انه يمكن الاستفادة من قوة الهجين فى انتاج الهجن.