Minufiya J. Agric. Res. Vol. 34 No.3:1235-1244 (2009) "http://www.mujar.net"

GENETIC ANALYSIS, COMBINING ABILITY AND HETEROSIS OF SOME TRAITS IN WATERMELON (CITRULLUS LANATUS,THUNB)

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(Received: Apr. 16 , 2009)

ABSTRACT: ***Half diallel cross for five inbred lines of watermelon was conducted to obtain informations on genetic variance, combining ability and heterosis performance for number of fruits/ plant, fruit weight, total yield/ plant, rind thickness, flesh fruit thickness and total soluble solids. The results revealed that, importance of dominance gene action was predominant for all traits expect fruit weight and flesh fruit thickness.***

Heritability in broad sense ranged from 17% to 97% for number of fruits/ plant and total yield/ plant, respectively. Heritability in narrow sense ranged from 5% to 49% for number of fruits/ plant and flesh fruit thickness, respectively. The ratio of GCA/ SCA mean squares for number of fruits/ plant, fruit weight and flesh fruit thickness indicated the predominant role of additive gene action in the expression of these traits. On the other hand, this ratio for the rest traits revealed that non-additive gene effects was predominant. Estimates of GCA effects revealed that the inbred line VIP_3 had the highest positive value for total yield/ plant;inbred line VIP_4 had significant positive values for total yield/ plant and rind thickness. Inbred line VIPI had highest significant value for TSS. The crosses VIP_1x VIP_2 and VIP_3 x VIP_4 had the highest SCA values for total yield/ plant, and rind thickness, respectively. Accordingly,prospective watermelon improvement could be achieved through breeding programs.

Key words: ***Combining ability, heterosis, inbred line, water melon, traits***

INTRODUCTION

Although, Egypt is one of the first countries in the world planted watermelon, however, we find a severe shortage in the local cultivars or hybrids, versus imported. A research is an attempt to provide appropriate local hybrids, through gathering information on genetic components and combining ability in a set of diallel crosses (excluding reciprocals) involving five inbred lines with diverse traits. The analysis of combining ability,therefore, helps the breeder in selecting suitable genotypes as parents for hybridization and for characterizing the nature and magnitude of gene action in the expression of a particular trait (Gopal *et. al.* 1996). The results

obtained from many investigation improvement and development of watermelon as, Hassan *et al.* (2002), Rajan *et al.* (2002). Abdelsalam and El-Ghareeb (2007), El-Mighawry *et al.* (2002) and Khereba *et al.* (2007). Ferreira *et. al.* (2002) reported that GCA and SCA were significant for mean weight of fruits per plant and the additive gene effects were the most important in the inheritance of this trait. They also reported that partial and complete dominance for the high yield were observed. Therfore, the objectives of this study were to measure and evaluate GCA, SCA and heterosis among 10 hybrids resulting from the crossing of five parental line concerning some traits in watermelon.

MATERIALS AND METHODS

This investigation was conducted at the Experimental Farm of El-Kasaseen Research Station, during the summer seasons of the years 2007 and 2008, five inbred lines of watermelon viz. VIP1, VIP_2, VIP_3, VIP_4 and VIP_5.Five parental inbred lines viz Sun- gold,Korgan,Sharmen,Krimson sweet (CS) and Giza1(G1) the inbred lines were derived through development of the Improvement vegetable crops and hyprid production Project (Ministry Of Agriculture); over eight successive selfing generations. The crosses were made in half diallel design at summer season of 2007 to produce F_1's seed generation. At final evaluation in March 2008, pure seed of the parents and F_1's were planted in randomized complete block design with three replications. Observations were recorded on 10 individual plants on the basis of number of fruits/plant, fruit weight, total yield/plant, rind fruit thickness, flesh fruit thickness and total soluble soilds, the obtained data were subjected to Hayman approach of diallel analysis (1954a) as described by Mather and Jinks (1971) to calculate and test the genetic components of variation and their ratios. General and specific combining ability were estimated according to method 2 as described by Griffing (1956).

The average degree of heterosis (ADH%) was calculated as percent increase or decrease of the F_1 hybrids over their mid and better parents according to Bhatt (1971), as follows:

a) **ADH % (in relation to MP)=** $\frac{\overline{F_1} - \overline{M.P.}}{M.P.} \times 100$

b) **ADH %(in relation to BP)=** $\frac{\overline{F_1} - \overline{B.P.}}{\overline{B.P.}} \times 100$

The significant of heterosis over mid and better parents was determined using t. test as follow:

t= $F_1 - M.P./\sqrt{3/8\,MSE}$

t= $F_1 - M.P./\sqrt{2/bc\,MSE}$

According to Wynne et al. (1970).

RESULTS AND DISCUSSION

Genetic analysis

The analysis of variance showed significant differences for F_1 crosses and their parental lines for all traits (Table 1). From partition of genetic components of variation in Table (2) it was clear that the dominance (H_1 and H_2) components of genetic variation exceeded the additive component (D) for all traits except fruit weight and flesh fruit thickness, indicating over-dominance, this consistence with the values of $(H_1/D)^{0.5}$ which exceeded 1.0 for these traits, the ratio $(H_1/D)^{.5}$ was lower than 1.0 for fruit weight and flesh fruit thickness, indicating partial dominance. Similar results were obtained by AbdEl-Salam and El-Ghareeb (2007), El-Mighawry et. al. (2007) and Hatem(2009). The F values were positive for all traits under study indicating that there were more dominant than recessive alleles in the parent inbred.

Table (1):- Mean squares for the studied traits of watermelon genotypes

Source of variation	d. f	Number of fruits/ plant	Fruit Weight kg	Total yield/ plant kg	Rind thickness cm	Flesh fruit thickness cm	total soluble solids %
Replication	2	1.405	0.528	1.415	0.0029	2.576	0.182
Genotypes	14	0.423**	2.012**	12.411**	0.143**	3.993*	0.929**
Error	28	0.121	0.497	0.568	0.020	1.491	0.218

* Significant at 5% level, ** significant 1% level.

H_1 and H_2 were similar in total soluble solids, indicating that positive (increasing T.S.S) and negative allele frequencies were about equal.

Concerning the estimated values of heritability showed that heritability in broad sense were larger in magnitude than the value of heritability in narrow sense for all traits. The large differences between the narrow and broad heritability indicated that much of the genetic variation was non-fixable.

Table (2):-The Components of variance and heritability in broad (H2b) and narrow (H2n) sense for some traits in watermelon

Components and ratio	Number of fruits/ plant	Fruit weight kg	Total yield/ plant kg	Rind fruit thickness cm	Flesh fruit thickness cm	total soluble solids %
D±S-E. (D)	0.052±0.15	1.60±0.58	7.41±1.03**	0.057±0.022	2.50±1.29	0.48±0.18
F±S.E. (F)	0.13±0.23	1.56±0.71	10.11±1.49**	0.097±0.032*	1.68±1.51	0.10±0.19
H1±S.E. (H)	0.18±0.28	1.18±0.64	17.37±1.77**	0.23±0.043*	1.39±1.43	0.56±0.22
H2±(S.E) (H)	0.12±0.19	0.72±0.41	12.70±1.24**	0.17±0.032*	0.87±0.96	0.54±0.19
H2±SE (H2)	-0.04±0.11	0.45±0.51	0.30±0.39	-0.003±0.007	0.21±0.99	-0.02±0.09
E±S.E (E)	0.11±0.02*	0.17±0.04*	0.14±0.03*	0.007±0.001**	0.49±0.18	0.07±0.01**
(H1/D)0-5	1.88	0.860	1.53	1.983	0.746	1.188
H2b%	17	71	97	88	65	82
H2n%	5	41	23	9	49	44

* Significant at 5% level, ** Significant at1% level

Heritability in broad sense the estimated BSH values were high (97,88,82,71 and 65)for total yield/ plant, rind fruit thickness, total soluble solids and fruit thickness respectively. This high BSH values means that improvement of these traits could be achieved by breeding and selection. Similar results were obtained for these traits by Afaf *et. al.* (2008).

On the other hand, heritability in narrow sense value ranged from 5% to 49% for number of fruits/plant and flesh fruit thickness, respectively. The broad and narrow heritability for number of fruits/plant were very low indicating that response in fruits number due to selection would be slow. Similar result was obtained by Abd El-Salam and El-Ghareeb (2007) and Hatem(2009) for same trait. The low narrow sense heritability for all studed traits indicating that there was a greater environmental influence.

General and specific combing ability effects.

The analysis of variance for general and specific combining ability as well as the ratio of G.C.A./S.C.A are shown in Table (3). The data showed that mean square due to general and specific combining ability was significant for total yield/plant suggesting the presence of both additive and non-additive gene effects in the expression of this trait, the significant variance of specific combining ability showed the importance of non-additive gene effects in the expression of rind thickness and total soluble solids. The magnitude of general combining ability variance was higher than of the specific combining ability variance for all studied traits, indicating that

additive gene effects play an important role in the expression of these traits. High values of G.C.A/S.C.A ratio for these traits further substantiated this finding. Similar results of additive gene effects were reported by Abd El-Salam and El-Ghareeb (2007), El-Mighawry *et. al.* (2007) and Hatem(2009).

Table (3): Analysis of variance for general and specific combining ability for some traits in watermelon.

		M.S.S					
Source of variation	d.f	Number of fruits/plant	Fruit weight kg	Total yield/plant kg	Rind fruit thickness cm	Flesh fruit thickness cm	Total soluble solids %
G.C.A	4	0.26	0.98	8.22**	0.093	3.54	0.76
S.C.A	10	0.094	0.079	4.87**	0.09**	0.39	0.44**
Error	28	0.23	0.39	0.16	0.0007	0.96	0.11
G.C.A/S.C.A		2.76	12.4	1.68	1.03	9.07	1.72

*** Significant at 5% level, ** Significant at1% level**

VIP_1 gaves the higher general combining ability for the traits of number of fruits/plant, flesh fruit thickness and T.S.S, whereas VIP_3 was the best general combiner for fruit weight and total yield/plant. VIP_5 showed the highest value for rind thickness (Table 4).

The crosses combination VIP_1× VIP_2 and VIP_3× VIP_4 recorded best specific combining ability for total yield/plant. VIP_1× VIP_5 and VIP_3× VIP_4 were the best specific crosses combination for rind thickness. For number of fruits/plant and T.S.S the cross VIP_1× VIP_2 had highest values of specific combining ability effect. The highest crosses in this study involved at least one good general combiner parent denoting the role of both additive and non-additive gene effects in the inheritance. The cross VIP_3× VIP_4 in total yield resulted from good×good general combining parents which suggested the involvement of additive gene effects in the inheritance of this trait. In other cases, the crosses showing high specific combining ability effects were not always involving the two parents with good general combining ability effects. Some of the crosses including parents with high general combining ability did not exhibit high specific good combination in some traits, it may be due to the lack of genetic diversity of the parental lines of the crosses (Chadha and Nodpuri 1980).

HEROSIS

The estimates of heterotic values relative to the better parent indicating that over dominant gene effect was present in controlling these hybrids, Data in such (Table 5) showed negative values without significant effect for the better parent, indicating the presence of additive gene action and partial dominance in controlling these traits, crosses $VIP_1 \times VIP_2$ for number of fruits/plant and total yield/plant, and $VIP_2 \times VIP_3$ for fruit weight and total yield/plant exhibited significant effect heterosis over mid and better parent. Cross $VIP_3 \times VIP_4$ exhibited significant desirable heterosis for total yield/plant, rind thickness and T.S.S over-mid parent. Crosses combination $VIP_2 \times VIP_5$ and $VIP_3 \times VIP_5$ recorded significant heterosis for rind thickness over-mid and better parents. The heterosis for all studied traits have also been for other parental reported by Rajan *et al.* (2002) , Khereba *et al.* (2007) and Hatem (2009) in watermelon.

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التحليل الوراثى والقدرة على التآلف وقوة الهجين لبعض الصفات فى البطيخ

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الملخص العربى

تم هذا البحث باستخدام نظام التزاوج النصف الدائرى لعدد خمسة سلالات من البطيخ وذلك بغرض الحصول على معلومات عن التباين الوراثى والقدرة على التآلف وقوة الهجين لصفات متوسط عدد الثمار على النبات وزن الثمرة والمحصول الكلى للنبات وسمك القشرة وسمك اللحم ونسبه المواد الصلبة الذائبة الكلية . وأظهرت النتائج ان الفعل السيادى للجين كان واضح وذو تأثير على كل الصفات المدروسة ماعدا صفات وزن الثمرة وسمك اللحم . معامل التوريث بمعناه الواسع تراوحت قيمته بين ١٧ % إلى ٩٧ % لصفات عدد الثمار لكل نبات والمحصول الكلى للنبات على الترتيب أيضاً تراوحت قيمة معامل التوريث بمعناه الضيق بين ٥% إلى ٤٩% لصفات عدد الثمار لكل نبات ووزن الثمرة وسمك لحم الثمرة. هذا أثبت أهمية دور الفعل المضيف للجين فى التعبير عن تلك الصفات فى حين باقى الصفات أثر فى تعبيرها الفعل السيادى غير المضيف، أوضح تأثير القدره العامة على التآلف أن السلاله VIP_3 كانت أعلى قيمة موجبة لصفة المحصول الكلى للنبات فى حين السلالة VIP_4 كانت قيمه معنوية موجبة لصفات المحصول الكلى للنبات وسمك القشرة. السلالة VIP_1 كانت أعلى قيمه معنوية موجبة لصفة TSS الهجن VIP_1xVIP_2، VIP_3xVIP_4 كانت أعلى قيمه معنوية موجبة للقدرة الخاصة على التآلف لصفات المحصول الكلى للنبات وسمك القشرة على الترتيب وبذلك يمكن توقع التحسن في البطيخ من خلال برامج التربية .

Table (4): General and specific combining ability effects for some traits in watermelon.

Parents G.C.A	Number of fruits/plant		Fruit weight kg		Total yield/plant kg		Rind fruit thickness cm		Flesh fruit thickness cm		Total soluble solids %	
	M	Effects	M	Effects	M	Effects	M	Effects	M	Effects	M	Effects
V.I.P1	1.4	0.19	5.1	0.22	7.2	-0.40**	1.4	-0.11**	17.3	0.62	10.5	0.38**
V.I.P2	2.2	0.17	2.5	-0.21	5.5	0.03	1.1	0.00	15.3	0.07	9.1	-0.33**
V.I.P3	1.8	-0.17	2.3	0.32	4	1.30**	0.9	-0.08**	15	0.28	8.9	0.07
V.I.P4	2.4	-0.14	4.8	0.14	11.4	0.37**	1.3	0.04**	18.6	0.08	9.8	0.13
V.I.P5	2.3	-0.04	3	-0.47*	6.8	-1.29**	0.8	0.14**	14.5	-1.05**	9	-0.24**
S.E.(gi)		0.16		0.21		0.14		0.009		0.33		0.11
Crosses S.C.A												
1x2	2.8	0.38	3.2	0.12	9	2.76**	1.1	0.09**	16.2	-0.18	10	0.57
1×3	1.9	-0.19	3.5	-0.08	6.4	-1.08**	0.7	-0.23**	16.3	-0.33	9.3	-0.56
1×4	1.7	-0.08	3.3	-0.17	5.4	-1.16**	1	-0.02	16.2	-0.23	9.6	-0.33
1×5	1.5	-0.11	3	0.14	4.4	-0.52	1.3	0.15**	16	0.74	9.8	0.32
2×3	1.5	-0.17	3.4	0.18	7	-0.94**	0.9	-0.14**	16.4	0.35	9.3	0.22
2×4	1.7	-0.09	2.8	-0.17	5.8	-1.16**	1.1	-0.03	15.8	-0.05	8.9	-0.32
2×5	2.1	-0.12	2.3	-0.13	4.7	-0.66	1.3	0.07**	14.6	-0.12	8.3	-0.47
3×4	1.9	0.14	3.7	0.13	9.8	1.58**	1.4	0.32**	16.5	0.44	10	0.4
3×5	2.1	0.21	2.7	-0.23	7	0.44	1.2	0.05*	14.5	-0.46	9.1	-0.07
4×5	1.9	0.02	3	0.22	6.4	0.73*	1	-0.27**	14.6	-0.16	9.5	0.23
S.E(g_{ij})		±0.42		0.55		0.35		0.02		0.86		0.29

*Significant at 5 % Level, ** Significant at 1 % Level

1=V.I.P1, 2=V.I.P2, 3=V.I.P3, 4=V.I.P4 and 5=V.I.P5

Table (5):- Percentages of heterosis over mid-parent M.P. and better parent B.P. for all studied traits.

Crosses	Number of fruits/plant		Fruit weight kg		Total yield/plant kg		Rind fruit thickness cm		Flesh fruit thickness cm		Total soluble solids %	
	M.P.	B.P	M.P.	B.P	M.P.	B.P	M.P.	B.P	M.P.	B.P	M.P.	B.P
1×2	55.6**	27.3**	-15.8	-37.3	41.7**	25**	-12	-21.4**	-0.61	-6.4*	2	-4.8**
1×3	18.8	5.6	-5.4	-31.4	14.3	-11.1**	-39.1**	-50**	0.93	-5.8*	-4.1	-11.4**
1×4	10.5	-12.5*	-33.3**	-35.3	-41.9**	-25**	-25.9**	-28.6**	-9.7**	-12.9**	-5.4	-8.6**
1×5	13.5	-8.7	-25.9*	-41.2	-37.1**	-38.9**	18.2**	-7.1	0.63	-7.5*	0.51	-6.7**
2×3	-5	-13.6*	41.7*	36**	47.4**	27.3**	-10	-18.2**	8.3	7.2*	3.3	2.2
2×4	-13.0	-16.7**	-23.3	-41.7**	-31.4**	-49.1**	-8.3	15.4	-6.8	-15.1**	-5.8	-9.2**
2×5	-6.7	-8.7	-16.4	-23.3*	-23.6**	-30.9**	36.8**	18.2**	-2	-4.6	-8.3**	-8.8**
3×4	-9.5	-20.8**	4.2	-22.9**	27.3**	-14.0**	27.3**	7.7	-1.8	-11.3**	7*	2
3×5	2.4	-8.7	1.9	-10	29.6**	2.9	41.2**	33.3**	-1.7	-3.3	1.7	1.1
4×5	-19.1	-20.8**	-23.1	-37.5	-29.7**	-43.9**	-4.8	-23.1**	-11.8**	-21.5**	1.1	-3.1

*Significant at 5 % Level, ** Significant at 1 % Level

1=V.I.P1, 2=V.I.P2, 3=V.I.P3, 4=V.I.P4 and 5=V.I.P5