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EVLAUATION OF COMBINING ABILITY, HERITABILITY AND CORRELATION FOR SOME GROWTH, YIELD AND QUALITY COEFFICIENT IN WATERMELON

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ABSTRACT

Six watermelon crosses and five parental genotypes were evaluated, in the Experimental Farm of El-Kassasien Horticulture Research Station during the seasons of 2001-2003, to study the genetic behavior for morphological, yield and its quality and to study the nature of general and specific combining ability for parental genotypes and their hybrids, as well as, determine the correlation coefficient among the above mentioned coefficient.

The results revealed that highly significant difference was found among the genotypes for all studied morphological, yield and fruit coefficient. Variances due to parents vs. hybrids were significant for all studied coefficient, indicating the expression of substantial amount of heterotic effects. The estimates of variances due to specific combining ability were positive and considerably higher in magnitude than the variance of general combining ablity for all coefficient except days to flowering, number of fruits/plant and fruit length. The parents that proved to be good general combiners on the basis of their desirable (gca) affects for total yield/plant and fruit characteristics were the introduced lines and Peacock Improved for yield and Charleston Gray and Jubblee for fruit coefficient. The best specific cross combinations, which exhibited significant desirable (sca) effects for total yield/plant, were Giza 1×Peacock Improved and Giza 21× Charleston Gray. Heritability estimates in broad sense were found to be considerable high values for fruit yield/plant as well as number of fruits/plant and fruit weight. The association analysis revealed that fruit yield/plant was positively correlated with plant height, fruit number/plant, fruit weight and total soluble solids. Negative correlation coefficients were observed between days to flowering and number of fruits and fruits yield/plant.

INTRODUCTION

In recent years, genetics of economic attributes in watermelon has received a lot of attention by both geneticists and breeders. Combining ability as a landmark in the development of breeding procedures is one of great use in crop improvement. It helps the breeder to identify the best combiners which may be crossed either to exploit heterosis or to combine the favorable fixable genes.

Many investigators; Dyutin and Prosvimin (1979); Li and Shu (1985); Gill and Kumar (1989 a and b); Mondal *et al.,* (1993); Krishna Parsad *et al.,* (2002 and 2004a and b); Rao *et al.,* (2004); Choudhary *et al.,* (2004) and Bairagi *et al.* (2005), studied the nature of combining ability and heterosis among accession lines of watermelon and their F_1 hybrids, and reported that general and specific combining ability were significant for most of studied coefficient.

Also, Parsad *et al.,* (1988) reported that, phenotypic and genotypic coefficients of variation were high for average fruit weight and fruit yield/plant in nine germplasm lines of watermelon, and they added that, fruit yield/plant was positively correlated with fruit weight and that this character showed high heretability and genetic advance.

So, this work was conducted to evaluate both general and specific combining ability and the correlation coefficients for ten quantative coefficient of five inbred lines of watermelon through "line × tester" analysis to assess the genetic potentialities of these genotypes.

MATERIALS AND METHODS

A) Materials

Five *Citrullus lanatus* thumb. Mans F. (2n = 22) genotypes were used in this study. It comprised two local commercial varieties; Giza 1 as P_1 and Giza 21 as P_2 and three American commercial varieties; Peacock Improved as P_3, Charleston Gray as P_4 and Jubblee as P_5. These plant materials were obtained from the Cucurbits Research Dept. Horticultural Crops Research Institute.

B)Methods

In the winter season of 2001, seeds of all plant materials were sown under the green house conditions for selfing, to obtain homozygosity for one season (El- Adl 1996). In January of 2002, seeds of parental genotypes were sown under the greenhouse condition to raise F_1 seeds. In the winter season of 2003, all the seed population of parental genotypes and their F_1 hybrids were sown in a randomized-block design with three replicates. Each replicate (plot) represented by an area of 14 m^2 (7.0m length × 2.0m width). Seeds were directly sown in hills 50 cm apart on drip irrigation at the Experimental Farm of El-Kassasien Horticulture Research Station, Ismailia Governorate.

The morphological, yield and quality characters measured were stem length (cm), days to flowering of 50% plants, fruit length and diameter (cm), fruit shape index, cortex thickness (cm), total soluble solids, number of fruit/plant, fruit weight (kg) and total yield/plant (kg).

c) Stistical procedure :

Analysis of variance (ANOVA) was performed for all studied coefficient, on plot mean basis. Data of top crosses were subjected to further male×female analysis for partitioning the genetic variation due to male, female and male×female interaction and both the combining ability and gene effects were estimated as described by Kempthorne (1957) and adapted by singh and Chaudhary (1977). The correlation coefficients were calculated according to Kearsy and Pooni (1996).

RESULTS AND DISCUSSION

The mean performance of parents and their F_1 hybrids of the morphological, yield and quality characters is presented in Table (1).

The mean performance revealed, in general, a wide range of variation among parents and their progenies for all studied coefficient. Maximum range was observed for fruit yield/plant (9.19 kg – 15.8 kg). Large variability for yield/plant and its components in different watermelon genotypes was also reported by Parsad *et al.,* (1988), Dahiya *et al.,* (1989), Mondal *et al.,* (1989), Krishna Parsad *et al.,* (2002). The performance of F_1 hybrids for these coefficient varied according to the parental combination. The results revealed that parents P_1 and P_3 might possess some sort of interacting positive genes for fruit yield, as F_1 hybrids involving these parents expressed higher heterotic response.

The analysis of variance for mean performance of the studied characters

Table (1): Mean perormance for ten morphological, yield and quality characters in watermelon.

Genotypes	Stem ength	Days to flowering	Fruit Length (L)	Fruit diameter (D)	Fruit shape index (L/D)	Cortex thickness	T.S.S	No. of fruits/ Plant	Fruit weight (kg)	Total yield/plant(kg)
					Parents					
P_1	182.52	33.63	20.40	19.69	1.04	0.76	12.43	3.22	4.06	11.64
P_2	191.27	29.77	22.64	20.30	1.12	1.08	12.74	3.00	5.64	12.50
P_3	188.79	31.67	27.55	22.58	1.22	0.83	12.85	2.22	5.58	9.91
P_4	169.00	33.77	36.31	19.02	1.91	0.64	11.57	2.11	6.11	11.31
P_5	166.15	33.77	37.42	19.16	1.95	0.64	12.16	3.55	5.41	13.03
Means	179.55	32.52	28.86	20.15	1.43	0.79	12.55	2.82	5.36	11.68
LSD 0.05	0.11	2.72	0.34	0.09	0.06	0.04	0.45	0.34	0.40	0.22
					F_1 hybrids					
$P_1 \times P_3$	203.35	33.53	25.32	20.86	1.21	1.44	13.16	2.77	5.53	15.86
$P_1 \times P_4$	202.49	30.63	30.63	22.19	1.38	1.34	13.26	2.44	8.28	13.61
$P_1 \times P_5$	201.07	31.10	30.54	18.23	1.68	1.11	12.32	2.22	6.39	13.39
$P_2 \times P_3$	206.78	33.20	26.30	19.62	1.34	1.26	13.16	3.22	5.33	15.39
$P_2 \times P_4$	199.09	31.20	30.28	19.36	1.56	1.70	13.16	2.44	6.75	14.53
$P_2 \times P_5$	204.20	31.63	31.56	21.38	1.48	1.24	13.06	2.44	6.47	13.52
Means	202.83	31.72	29.11	20.89	1.39	1.35	13.02	2.59	6.46	14.38
LSD 0.05	0.13	1.13	0.33	0.04	0.04	0.06	0.38	0.29	0.23	0.30

Table (2): Analysis of variance (mean squares) for means of the studied morphological, yield and quality characters in watermelon.

Soure of variation	d.f	Stem length	Days to flowering	Fruit Length (L)	Fruit diameter (D)	Fruit shape index (L/D)	Coretex thickness	T.S.S	No. of fruits/ Plant	Fruit weight	Total yield/ plant
Replication	2	0.0089	1.2036	0.1769	0.2104	0.0017	0.0007	0.0036	0.00693	0.0366	0.1995
Genotypes	10	0.8207**	5.9336**	82.4749**	5.7221**	1.6132**	0.3566**	0.8168**	0.7104**	3.3621**	9.3801**
Parents (P)	4	0.5484**	9.4927**	180.5820**	6.2743 **	3.4382 **	0.0976 **	1.11226 **	1.1912 **	1.7928 **	4.3071 **
Hybrids (H)	5	0.0253**	3.2170**	20.3894**	6.4004 **	0.4739 **	0.1254 **	0.3675 **	0.3809 **	3.3179 **	3.3304 **
P vs. H	1	5.8867**	5.2801**	0.4726	0.1220 **	0.0094 **	2.5485 **	1.8400 **	0.4345 **	9.8600 **	59.9207 **
Error	20	0.0089	1.6443	0.046	0.0099	0.0017	0.0011	0.0011	0.0408	0.0401	0.0333

***,** Significant at the 0.05 and 0.01 probability levels, respectively.**

Revealed that differences among the genotypes were highly significant for all studied morphological, yield and quality coefficient. Variances due to parents vs. hybrids were also significant for all studied morphological, yield and quality coefficient, indicating the expression of a substantial amount of heterotic effects for these coefficient. These results were found in agreement with those obtained by Gill and Kumar (1988 and 1989a and b), Mondal *et al.*, 1989 and Krishna Parsad *et al.* (2002).

Further, the partitioning of hybrid sum of squares (Table 3) :

Table (3): Analysis of variance (mean squares) for combining ability for the studied morphological, yield and quality characters in watermelon.

Soure of variation	d.f	Stem length	Days to flowering	Fruit Length (L)	Fruit diameter (D)	Fruit shape index (L/D)	Coretex thickness	T.S.S	No. of fruits/ Plant	Fruit weight	Total yield/ plant
Replication	2	0.001	0.003	1.395	0.082	0.219	0.003	0.021	0.024	0.014	0.213
Hybrids	5	0.125 **	0.025 **	3.217 **	20.389 **	6.400 **	0.474 **	0.367 **	0.381 **	3.318 **	3.330 **
Male (M)	1	0.046 **	0.006	0.0270	1.339 **	0.426 **	0.046 **	0.205	0.222 **	1.345 **	0.172 **
Female (F)	2	0.179 **	0.033 **	6.225 **	49.388 **	1.407 **	0.802 **	0.500 **	0.766 **	6.514 **	7.511 **
MXF	2	0.112 **	0.027 *	1.774	0.916 **	14.381 **	0.359 **	0.316 **	0.075	1.108 **	0.728 **
Error	20	0.002	0.007	0.587	0.050	0.001	0.001	0.066	0.039	0.024	0.040
σ^2 gca		0.001	-0.0001	0.115	1.545	-0.633	0.009	0.004	0.024	0.175	0.207
σ^2 gca		0.037	0.006	0.043	0.290	4.790	0.119	0.080	0.011	0.356	0.232
σ^2A/ σ^2 D		0.058	-0.041	5.303	10.657	-0.264	0.153	0.103	4.287	0.985	1.782

*,** Significant at the 0.05 and 0.01 probability levels, respectively.

Revealed that, variances due to males were highly significant for all studied coefficient except for mean stem length, days to flowering of 50% plants and total soluble solids. Meanwhile, variance due to females were highly significant for all studied coefficient. Also, variances due to male × female interactions were significant for all studied coefficient except days of flowering of 50% plants and number of fruits/plant. These results were found in harmony with those obtained by Abd El-Hafez *et al.,* (1982); Li and Shu, (1985); Mondal *et al.,* (1989); and Krishna Parsad *et al.,* (2004b).

Data in Table (3) showed that the estimates of variances due to general combining ability (σ^2 gca) were positive and considerably higher in magnitude than the variances of specific combining ability (σ^2 sca) only for days to flowering of 50% plants, fruit length and number of fruits/plant, indicating that the additive component of genetic variance was more important in controlling the inheritance of days to flowering of 50% plants and fruit length. These results were found to be in concordance those obtained by Brar *et al.,* (1974a and b); Dyutin and Prosvimin (1979); Sharma and Choudhury (1989) and Krishna Parsad *et al.,* (2004a). The results indicate that although most of the differences noted among crosses for the majority of studied coefficient were due to genes with primarily non-additive effects, the relatively negligible contributions of the additive effects cannot be overlooked. This may be due to the fact that the parental materials included in this investigation were highly selected for yield. The preponderance of non-additive gene action observed for morphological, yield and quality attributes and the realization of high degree of heterosis suggested that biparental mating followed by recurrent selection would be the best method for utilization of such gene action for the genetic improvement of these coefficient in watermelon. These results are in harmony with those obtained by Mondal *et al.,* (1989); Guirgis *et al.,* (1999) and Bairagi *et al.,* (2005).

The (gca) effects of the parents are presented in (Table. 4):

Table (4): Estimates of general combining ability effects of parents for the studied morphological, yield and quality characters in watermelon.

Genotypes	Stem length	Days to flowering	Fruit Length (L)	Fruit diameter (D)	Fruit shape index (L/D)	Coretex thickness	T.S.S	No. of fruits/ Plant	Fruit weight	Total yield /plant
Males P1	-0.019	0.039	-0.273 **	0.154 **	-0.051 **	-0.051	-0.107	-0.111	0.273 **	-0.098
P2	0.019	-0.039	0.273 **	0.051 **	0.05 **	0.051 **	0.107	0.111	-0.273 **	0.098
Females P3	0.078 *	1.150 *	-3.295 **	-0.398 **	-0.398 **	0.001	0.141	0.408 **	-1.028 **	1.243 **
P4	-0.071	-0.800	1.350 **	0.079 **	0.079 **	0.172 **	0.191	-0.149 **	1.056 **	-0.316 **
P5	0.007	-0.35	1.945 **	0.319 **	0.319 **	-0.173 **	-0.332 **	0.259 **	-0.028	-0.927
SE Males	0.031	0.427	0.072	0.014	0.014	0.011	0.092	0.067	0.067	0.061
SE Females	0.038	0.523	0.088	0.017	0.017	0.013	0.112	0.082	0.082	0.075

***,** Significant at the 0.05 and 0.01 probability levels, respectively.**

It is evident that the parents possess significant (gca) effects of the different morphological, yield and quality characters. This findings were found to be in harmony with Li and Shu (1985) and Krishna Parsad *et al.,* (2004a). However, the estimates of (gca) effects had no definite pattern and none of the parents was superior for all studied coefficient. The parents that proved to be good general combiners on the basis of their desirable (gca) effects for total yield/plant and fruit characteristics were the introduced lines and Peacock Improved (P_3) for yield and Charleston Gray (P_4) and Jubblee (P_5) for fruit characteristics. These findings were found to be in agreement with those reported by Mondal *et al.,* (1993), which reported that, Charleston Gray was the best combiner for fruit weight. These parents were the most outstanding genotypes and may be used for hybridization to obtain desirable segregates.

The (sca) effects of hybrids are presented in Table (5).

Table (5): Estimates of specific combining ability effects of F_1 hybrids for the studied morphological, yield and quality characters in watermelon.

Genotypes	Stem length	Days to flowering	Fruit Length (L)	Fruit diameter (D)	Fruit shape index (L/D)	Coretex thickness	T.S.S	No. of fruits/ Plant	Fruit weight	Total yield/plant
P1 X P3	-0.041	0.628	-0.217	0.464 **	-0.111 **	0.144 **	0.107	-0.112	-0.177	0.333 **
P1 X P4	0.077	-0.322	0.451 **	1.263 **	-0.169 **	-0.128 **	0.157	0.111	0.490 **	-0.362 **
P1 X P5	-0.036	-0.306	-0.234	-1.727 **	0.280 **	-0.016	-0.263	0.001	-0.313 **	0.029
P2 X P3	0.041	-0.628	-0.217	-0.464 **	0.111 **	-0.144 **	-0.107	0.112	0.177	-0.333 **
P2 X P4	-0.077	0.322	-0.451 **	-1.263 ** -	0.169 **	0.128 **	-0.157	-0.111	-0.490 **	0.362 **
P2 X P5	0.036	0.306	0.234	1.727	-0.280 **	0.016	0.263	-0.001	0.313 **	-0.029
SE	0.054	0.740	0.124	0.057	0.024	0.019	0.159	0.177	0.116	0.105

***,** Significant at the 0.05 and 0.01 probability levels, respectively.**

The good specific cross combinations, which exhibited significant desirable (sca) effects for total yield/plant were $P_1\times P_3$ and $P_2\times P_4$. At least one of the parents in each of these crosses was good general combiner.

The (sca) effects of different crosses indicated that high (gca) effects of parents was no guarantee of high (sca) effects in different crosses. Some crosses, e.g., $P_2\times P_5$ for fruit weight and $P_2\times P_4$ for fruit yield/plant were found to be outstanding, showing high (sca) effects where non of the parents showed high (gca) effects. These results were found to be in agreement with those obtained by Dhaliwal *et al.,* (1983) and Krishna Parsad *et al.,* (2004a). This suggested that the crosses showing high (sca) effects involving one poor and one good or both poor general combiners could have been due to complementation of genes. The (sca) analysis of the crosses revealed that none of the crosses combined high (sca) effects for all studied coefficient. These finding were contradicted with those obtained by Gill and Kumar (1989a).

The components of phenotypic variance and hertability estimates in broad and narrow senses are presented in Table (6).

Table (6): Components of variance and heritability estimates for the studied morphological, yield and quality characters in watermelon.

Parameters	Stem length	Days to flowering	Fruit Length (L)	Fruit diameter (D)	Fruit shape index (L/D)	Coretex thickness	T.S.S	No. of fruits/ Plant	Fruit weight	Total yield/ plant
$\sigma^2 A$	0.002	0.229	3.091	1.266	0.018	0.002	0.008	0.048	0.350	0.413
$\sigma^2 D$	0.006	0.043	0.290	4.790	0.009	0.036	0.080	0.011	0.356	0.231
$\sigma^2 G$	0.005	0.272	3.381	3.523	0.137	0.039	0.088	0.059	0.706	0.644
$\sigma^2 E$	0.003	0.548	0.015	0.003	0.006	0.004	0.025	0.13	0.013	0.011
$\sigma^2 p$	0.009	0.820	3.369	3.526	0.138	0.039	0.113	0.073	0.702	0.655
$h^2 b$	65.91	33.19	99.5	99.91	99.57	98.98	77.71	81.50	98.14	98.31
$h^2 n$	22.22	27.93	91.01	35.90	13.19	5.33	7.22	66.12	48.69	62.99

Heritability estimates in broad sense were found to be of higher values for fruit yield/plant as well as the important yield components, number of fruits/plant and fruit weight. Parsad *et al.,* (1988); Rajendran and Thamburaj (1994) and Krishna Parsad *et al.,* (2004b) reported that, estimates of heritability for average fruit weight and fruit/plant were high. The heritability estimates were also of higher values for fruit length, while they were moderate values for days to flowering. Abd El-Hafez *et al.* (1982) and Vashistha *et al.* (1983) also, reported high heritability estimate for days to flowering.

The correlation coefficients obtained from the analysis of covariance between each of the studied coefficient are given in Table (7).

The association analysis revealed that fruit yield/plant was positively correlated with main stem length, fruit number/plant, fruit weight and total soluble solids. These findings were found held true with those obtained by Singh and Singh (1988); Parsad *et al.,* (1988) and Choudhary *et al.,* (2004).

Table (7): Associations among morphological, quality and yield characters in watermelon genotypes.

Traits	Days to flowering	Fruit Length (L)	Fruit diameter (D)	Fruit shape index)	Coretex thickness	T.S.S	No. of fruits/ Plant	Fruit weight	Total yield/plant
Stem length	-0.431 **	-0.411 **	0.315	-0.444 **	0.826 **	0.475 **	-0.200	0.360 **	0.601 **
Days to flowering		0.181	-0.219	0.217	-0.370 **	-0.168	0.241	-0.389 **	-0.016
Fruit length			-0.214	0.951 **	-0.213	-0.122	-0.239	0.453	-0.055
Fruit diameter				-0.499**	0.170	0.415 **	-0.195	0.284	-0.186
Fruit shape index					-0.225	-0.243	-0.184	0.326	0.013
Coretex thickness						0.537 **	-0.183	0.491 **	0.743 **
T. S. S							0.318 **	0.207	0.0513 **
No. of fruit/plant								-0.522 **	0.232
Fruit weight									0.209

***,** Significant at the 0.05 and 0.01 probability levels, respectively.**

These results suggest that selection for elevated levels of these attributes is likely to increase the fruit yield/plant, and genetic improvement in these coefficient could be carried out simultaneously with an improvement in yield. Fruit weight was negatively correlated with days to flowering, indicating that genotypes taking more days to flowering had lighter fruits. Fruit weight was also negatively correlated with fruit number/plant. This negative correlation was also detected by Vashistha *et al.,* (1984).

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تقييم القدرة على الائتلاف ، كفاءة التوريث ومعامل الارتباط لبعض صفات النمو وكمية المحصول والجودة فى البطيخ.

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تم تقييم ست هجن من البطيخ وكذلك خمس تراكيب وراثية أبوية فى المزرعة البحثية بمحطة بحوث البساتين بالقصاصين أثناء موسم٢٠٠١– ٢٠٠٣ وذلك لدراسة السلوك الوراثى للصفات المورفولوجية وصفات المحصول وجودته وكذلك طبيعة القدرة علىالائتلاف العامة والخاصة للآباء والهجن وأيضاً تعيين العلاقة الارتباطية بين الصفات السابق ذكرها.

وقد أوضحت النتائج ما يلى : –

١– كان هناك اختلاف معنوى جداً بين الطرز الوراثية فى جميع الصفات المورفولوجية والمحصولية وخصائص الثمار المدروسة.

٢– كان تباين الآباء مقابل الهجن معنويا لكل الصفات المدروسة مما يدل على وجود تأثيرات قوية لقوة الهجين.

٣– كانت قيم التباين الراجع إلى القدرة الخاصة على الائتلاف موجبة وعالية فى المقدار عن تلك الراجعة إلى القدرة العامة على الائتلاف لجميع الصفات ما عدا عدد الأيام اللازمة للتزهير وكذلك عدد وطول الثمرة.

٤– أثبت الصنف المستورد Peacock Improved أنه أحسن أب ذو قدرة عالية للائتلاف لصفة المحصول الكلى/نبات ، بينما الأب Charleston Gray لخصائص الثمرة.

٥– كانت الهجن Giza 1× peackock Improved, Giza 21 × Charleston Gray أحسن التراكيب الوراثية التى أظهرت تأثيرات خاصة معنوية لصفة المحصول.

٦– كانت تقديرات درجة التوريث بمعناها الضيق عالية بالنسبة لمحصول النبات وكذلك عدد الثمار/نبات ووزن الثمرة.

٧– أظهر تحليل الارتباط أن صفة كمية محصول الثمار فى النبات ترتبط ارتباطاً موجباً مع طول النبات وعدد الثمار ووزن الثمرة والمواد الصلبة الذائبة الكلية فى الثمرة بينما كان الارتباط بين عدد الأيام للتزهير وعدد الثمار ومحصول الثمار ارتباطاً سالباً.