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GENE ACTION AND HERITABILITY FOR SOME CHARACTERISTICS OF TOMATO FRUIT (*LYCOPERSICON ESCULENTUM* MILL)

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ABSTRACT

The aim of the present study was to estimate different types of gene action affecting some characteristics of tomato fruit. for this purpose , six tomato cultivars were used in this investigation. These cultivars were: (1) Super Marmand (France) (2) Peto 86 from France (3) Castel Rock (4) Super strain B, Flora data (5) and Advanced (6) from America. The varieties were crossed by using complete diallel crosses mating design, in order to produce 30 different hybrids. These parental varieties and their 30 hybrids were evaluated during two seasons for some fruit characteristics. The obtained data were subjected to biometrical analysis and the obtained results revealed that, the mean squares of entries were highly significant for the studied traits, leading to the further partition of genetic variance to its components.. The additive genetic variances were higher than their corresponding values of dominance genetic variances for locules number, fruit firmness, pericarp thickness, total soluble solids, ascorbic acid and lycopene content. The combined data over the two seasons showed that heritability in broad sense (h^2b) were 88.8% for locules number of the fruit, 87.3% for fruit firmness, and 78.2% for pericarp thickness, 3.5% for TSS, 95.77% for ascorbic acid, 92.5% for lycopene content. However, heritability estimates in narrow sense (h^2n %) were more less than the corresponding values in most of studied traits, indicating that the role of non-additive genetic variance in the genetic expression of these traits are non-negligible. Therefore, the suitable breeding program for improving these traits is recurrent selection programme.

INTRODUCTION

Tomato is one of the most consumed and widely grown vegetable crops in the world including Egypt. It is a popular vegetable/fruit and an important source of vitamins and minerals. Fruit quality is one the most important traits in a breeding program. Quality involves several traits such as fruit-firmness (FF), total soluble solids (TSS %), number of locules per-fruit (NLF), fruit thickness, ascorbic acid and lycopene content. In this respect, the determination of suitable breeding program for improvement of these traits is an important aim in tomato. The presence of a relatively high non-additive gene action indicates that the production of F1 hybrids should be considered as a result of the direct relationship between the non-additive gene and heterosis. Choice of parents for use in a plant breeding program is one of the most important decisions that a breeder makes (Borem and Miranda, 2005). Additive and non-additive genetic effects could be determined from the estimates of general combining ability (GCA) and specific combining ability (SCA), respectively. In this manner, Dod and Kale (1992) found on tomato that the higher magnitude of GCA compared with SCA for number of locules and fruit wall thickness indicated a predominant role for additive gene action. El-Sharkawy *et al.* (1997) reported, on tomato, that heritability estimates in broad and narrow sense for T.S.S were ranged from (49.04 to 63.97) and (21.92 to 41.82). respectively. On the other hand Kumar et al (2013) found highly significant variation due to GCA as well as SCA indicated the Importance of the additive as well as the non additive variation all the fruit quality character like T.S.S ascorbic acid content, and lycopene content governed by non additive

Therefore, these estimates were of great values in establishing the most promising approach. Thus, the present investigation was aimed to obtaining estimates for the different types of gene action in terms of general combining ability and specific combining ability by evaluating the diallel crosses mating design. By Determination of heterosis and maternal effect were also investigated in this study.

MATERIALS AND METHODS

The genetic materials used in the present study included six tomato varieties. These varieties were: Super Marmand and Peto 86 from France in addition to Castel Rock from American, all were a large fruit size, growth habit is determinate and maturity is medium. Super strain B and Flora data are American, these two varieties are characterized by a large fruit size, growth habit is semi determinate and maturity is late. Advanced is also Amirecan and characterized by a small fruit size, growth habit is semi determinate and maturity is early and Resistant . to bacterial Speck and tolerant of early blight. All six varieties are belonging to the species *Lycopersicon* . Individual plants from each variety were self pollinated for three generations to end up with an inbred line from each variety. This work was carried out during three successive generations at the Experimental station, Faculty of Agriculture, Mansoura University .

Selfed seeds from each variety were planted during the summer season of 2009 at the Experimental station, Faculty of Agriculture, Mansoura University. At the flowering time, all single crosses including reciprocals were made among these varieties according to a complete diallel mating design to produce 15F_1 hybrids and 15 F_{1r} reciprocal hybrids.

Therefore, the genetic materials used in this study were 6 parents, 30 F_1 hybrids (15 F_1 & 15 $F1_r$). All 30 entries were evaluated in a field trial at the experimental station, faculty of agriculture, Mansoura University, during the winter season of 2009 and summer season of 2010.

Data were recorded on ten guarded and labeled randomly chosen plants per plot for all entries in the two growing seasons .locules number ,fruit firmness ,pericarp thickness, T.S.S ,Ascorbic acid content and lycopene content were the measured characters .

The obtained data for these traits from each season and the combined data over both two seasons were subjected to biometrical analysis using the procedures described by Griffings Method III (1956) and outlined by Sing and Chaudary (1985).

The covariance of relative was translated into appropriate genetic components of variance as outlined by Matzinger and Kempthorne (1956) and Cocherham (1963). Therefore, additive genetic variance was estimated as following :-

$(\sigma^2 g) = 1/2\ (\sigma^2 A)$ or $(\sigma^2 A) = 2\ \sigma^2 g$

$\sigma^2 D = \sigma^2 s$

In addition , the dominance degree ratio as well as the heritabilities were determined using the following equations :-

Dominance degree ratio (Dd) :

$$Dd = \sqrt{\frac{\sigma^2 D}{\sigma^2 A}}$$

The heritability values were estimated as follows:-

1. **From single season:**

Broad sense heritability :-

$$h^2_b = \frac{\sigma^2 A + \sigma^2 D}{\sigma^2 A + \sigma^2 D + \sigma^2 r + \frac{\sigma^2 e}{k}} \times 100$$

Narrow sense heritability :-

$$h^2_n = \frac{\sigma^2 A}{\sigma^2 A + \sigma^2 D + \sigma^2 r + \frac{\sigma^2 e}{k}} \times 100$$

2. **From combined data over year:**

Broad sense heritability :-

$$h^2_b = \frac{\sigma^2 A + \sigma^2 D}{\sigma^2 A + \sigma^2 D + \sigma^2 r + \frac{\sigma^2 AY}{Y} + \frac{\sigma^2 DY}{Y} + \frac{\sigma^2 rY}{Y} + \frac{\sigma^2 e}{kY}} \times 100$$

Narrow sense heritability :-

$$h^2_n = \frac{\sigma^2 A}{\sigma^2 A + \sigma^2 D + \sigma^2 r + \frac{\sigma^2 AY}{Y} + \frac{\sigma^2 DY}{Y} + \frac{\sigma^2 rY}{Y} + \frac{\sigma^2 e}{kY}} \times 100$$

RESULTS AND DISCUSSION

The results of the analysis of combining ability for fruit characteristics with respect to each season and their combined data are shown in Table 1. The results revealed that the mean squares of entries were highly significant for the studied traits, indicating that the further partition of genetic variance to its components are valid. Therefore, the results of (GCA), (SCA) and (RE) mean squares were highly significant for locules number and pericarp thickness. In addition, the mean squares of GCA were significant in the cases of second seasons and the combined data over both seasons and non-significant for SCA and RE with respect to fruit firmness. This finding indicates that additive gene action may play the major role in the genetic expression of these characteristics. On the other hand, mean squares of the interaction between (GCA), (SCA) and (Res) with seasons were not significant for locules number, pericarp thickness and fruit firmness characters in most of occasions, indicating that, these parameters are highly stable with different environmental conditions with respect to the studied fruit characteristics. In this manner, many investigators reached the same results, among them, Dod *et al.* (1992), Alice *et al.* (2001) and Sekhar *et al.* (2010).

The results of analysis of combining ability for T.S.S , ascorbic acid , and lycopene content are presented in Table 2. The results of mean squares revealed that mean square of general combining ability (GCA) was highly significant and higher in magnitudes than the corresponding values of SCA and reciprocal effect mean squares with respect to the three traits (T.S.S, ascorbic acid content and lycopene content),this indicates to the major role of additive genetic variance in the inheritance of these traits. On the other hand, the results showed that GCA, SCA and RE interacted significantly with seasons in the case of T.S.S, revealing that these parameters are unstable on different environmental conditions, but highly stable in the cases of ascorbic acid content and lycopene content. Similar results were obtained by Abdel Raheem (1989), Seama *et al.* (2005) and Santosh and Sharma (2011) whom found the magnitude of variance due to GCA was greater than the variance due to SCA for lycopene content.

Table1: Analysis of combining ability and mean squares estimates for fruit characteristics at each season and the combined data over the two seasons

S.V	DF		Locules number			Fruit firmness			Pericarp thickness		
	Single	comb	S1	S2	Comb	S1	S2	comb	S1	S2	Comb
Entries	29	29	4.34**	5.18**	9.372**	0.91**	0.904**	8.12 **	0.148**	0.138**	0.276**
GCA	5	5	6.0204**	6.967 **	12.956**	1.088	1.1069**	2.14**	0.149 **	0.0905**	0.227 **
SCA	9	9	0.326 **	0.324 **	0.613**	0.1789	0.22	0.325	0.024 **	0.37 **	0.058 **
RE	15	15	0.679 **	0.806 **	1.4317*	0.11922	0.186	0.274	0.030 **	0.032 **	0.06**
Entr x S		29			0.158**			7.103**			0.0106**
GCA x S		5			0.03107			0.052			0.0118**
SCA x S		9			0.037			0.075			0.004
RE x S		15			0.054*			0.030			0.0028
Error	58	116	0.039	0.019	0.029	0.0197	0.0202	0.03	0.0028	0.0032	0.00307

*** and , ** significant at 5% and 1% levels of probability , respectively .**

Table 2 : Analysis of combining ability and mean squares estimates for physiological traits

S.V	DF		T.SS			Ascorbic acid %			Lycopene		
	Single	comb	S1	S2	Comb	S1	S2	Comb	S1	S2	Comb
Entries	29	29	2.77**	2.29**	2.734**	46.5**	28.76**	64.87**	5.04**	6.83**	11.26**
GCA	5	5	3.97**	0.264 **	1.85 **	63.62 **	41.69 **	101.5 **	7.57**	10.705 **	18.06 **
SCA	9	9	0.111**	0.313 **	0.24 **	4.4 **	2.6*	4.2 *	0.211*	0.27	0.31 *
RE	15	15	0.34**	1.14 **	0.96 **	4.34	2.02	3.74	0.505 **	0.56**	0.932 **
Entr x S		29			2.33 **			10.47**			0.594**
GCA x S		5			2.388 **			3.79			0.214
SCA x S		9			0.183 **			2.7			0.17
RE x S		15			0.516 **			2.62			0.141
Error	58	116	0.0234	0.0105	0.017	3.066	1.34	2.204	0.108	0.156	0.132

*** and , ** significant at 5% and 1% levels of probability , respectively .**

The results of genetic parameters and heritability estimated for fruit traits for both seasons and combined data are presented in **Table 3.** The results revealed that the magnitude of additive genetic variances (σ^2A) were larger than their corresponding of non -additive genetic variances including dominance (σ^2D) for all studied traits (locules number, fruit firmness and Pericarp thickness). These results could be confirmed by the dominance degree ratio, which was less than one for the three studied traits at the first season, second season and combined data respectively. Therefore, the heritability in broad sense (h^2b %) were high and close to heritability in narrow sense estimates for these traits and these values were 89.3%, 89.6% and 88.8% for locules number of the fruit, 90.6%, 85.7% and 87.3%) for fruit firmness, and 82.9%, 73.02% and 78.2% for pericarp thickness with respect to first season, second season, and combined data, respectively. However, heritability estimates in narrow sense (h^2n %) were 85.6%, 85.7% and 84.8% for locales number of the fruit, 77.1%, 69.8% and 76.8% for fruit firmness and 70.5%, 44.1% and 58.49% for pericarp thickness with respect to first season, second season, and combined data, respectively. This finding indicated the predominance of additive genetic variance in fruit characteristic and recommended the selection breeding programe for improving these quality traits. Also, the results indicate that the interaction between the genotypic parameters and seasons (σ^2Axs) (σ^2Dxs) and (σ^2rxs) were very low for the fruit characters traits indicating that these traits were less affected by environmental components with different degrees. Similar results obtained by Sonone *et al.* (1986), Dod and Kale (1992) Dodhol *et al.* (1999) Salib (1999)

Table 3: Estimates of genetic parameters and heritability in broad and narrow sense for fruit characteristics

	Locules number			Fruit firmness.			Pericarp thickness		
	S1	S2	Comb	S1	S2	Comb	S1	S2	Comb
ó²A	2.8	3.32	4.1	0.454	0.44	0.612	0.062	0.026	0.053
ó²D	0.143	0.1528	0.19	0 .0796	0.1002	0.083	0.011	0.017	0.0179
ó²r	0.319	0.393	0.46	0.049	0.083	0.0814	0.014	0.0148	0.0194
D d	0.23	0.21	0.215	0.41	0.47	0.36	0.42	0.81	0.266
ó²A x s	-	-	0.00	-	-	0.00	-	-	0.0038
ó²D x s	-	-	0.004	-	-	0.0269	-	-	0.00
ó²r x s	-	-	0.012	-	-	0.0052	-	-	0.00
h²b %	89.8	89.6	88.8	90.6	85.7	87.3	82.9	73.02	78.2
h²n %	85.6	85.7	84.8	77.1	69.8	76.8	70.5	44.1	58.49

Different genetic parameters and heritability were estimated for some tomato physiological traits which included T.S.S, ascorbic acid content and lycopene content traits for both seasons and combined data, the results are presented in Table 4. The results indicated that the estimates of the additive variance (σ^2A) were higher than the corresponding non-additive and reciprocal effect variance with respect the three studied traits as physiological traits. These results were emphasized by dominance degree ratio which were less than one in all occasion for T.S.S, ascorbic acid content and lycopene content traits. In addition, the heritability in narrow sense estimates were high and close to the corresponding values of heritability in broad sense in most of occasions with respect to the three traits. This finding insure the predominance of additive genetic variance of the physiological traits and the selection breeding program is recommended for improvement. Furthermore, the variance due to the interaction between additive gene action and seasons were negative, which considered equal zero in the cases of T.S.S and fruit firmness, and the corresponding magnitudes of non-additive and reciprocal effect with seasons variances were positive in the two traits. This finding indicated that the additive gene action is more stable with different environmental conditions. On the other hand, in the case of lycopene content trait, the additive by season interaction was positive, while the non-additive and reciprocal effect by seasons interaction variances were negative indicating that non-additive and reciprocal effect are more stable than additive gene action on different environmental conditions. In this respect, similar results were obtained by Bhutani *et al.* (1983) Hannan *et al* (2007) and Garg *et al.* (2008) for T.S.S ,lycopene content for ascorbic acid content,respectively.

Table4: Estimates of genetic parameters and heritability in broad and narrow sense for physiological traits at each season and the combined data over two seasons

	T.S.S			Ascorbic acid			Lycopene		
	S1	**S2**	**Comb**	**S1**	**S2**	**Comb**	**S1**	**S2**	**Comb**
ó^{2}A	1.88	-0.128	-0.21	24.12	18.6	31.76	3.61	5.12	5.86
ó^{2}D	0.08	0.255	0.031	2.139	1.5	0.795	0.122	0.143	0.151
ó^{2}r	0.16	0.565	0.15	0.638	0.34	0.373	0.1986	0.205	0.26
D d	0.21	0.0	0.0	0.29	0.06	0.16	0.18	0.17	0.16
ó^{2}A x s	-	-	1.04	-	-	-0.428	-	-	-0.034
ó^{2}D x s	-	-	0.144	-	-	1.22	-	-	0.075
ó^{2}r x s	-	-	0.249	-	-	0.2106	-	-	0.004
h^{2}b %	92.14	36.29	3.5	84.78	95.2	95.77	94.2	95.4	92.5
h^{2}n %	88.38	0.0	0.0	77.8	88.1	93.4	91.16	92.8	90.14

In conclusion, due to the previous results, which confirmed the role of both additive and non-additive genetic variance in the inheritance of studied fruit characteristic and physiological traits with different levels, the suggested suitable breeding program for improving these traits is recurrent selection programme.

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الفعل الجينى ودرجة التوريث لبعض مواصفات ثمار الطماطم

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اجريت هذه الدراسة بغرض تحديد طبيعة الفعل الجيني ودرجة التوريث لبعض خصائص ثمار الطماطم ,ولهذا السبب فقد أستخدم في هذه الدراسة ستة أصناف مختلفة من الطماطم وهى ١- سوبر مارماند, ٢- بيتو ٨٦ ,٣- كاسل روك ٤- سوبر سترين بى ٥- فلوراديد ٦- ادفانسيد . وتم تهجين هذه الأصناف من خلال نظام التزاوج الدائرى الكامل بغرض الحصول على ١٥ هجين و١٥ هجين عكسى. تم تقييم الإباء (٦) والهجن الناتجة (٣٠) في قطاعات كاملة العشوائية فيموسمين متتاليين، وذلك لمواصفات الثمار وبعض الصفات الفسيولوجية. وتم تحليل البيانات المتحصل عليها من كل موسم وكذلك البيانات التجميعية لكلا الموسمين. ومن أهم النتائج المتحصل عليها هي أن متوسط المربعات للتراكيب الوراثية كانت عالية المعنوية مما يشير أنه من المتاح تقسيم التباين الوراثى الى مكوناته. ولذلك تم تحليل التباين للقدرة على التيآلف للحصول على مكونات التباين من القدرة العامة والقدرة الخاصة على التآلف بالإضافة الى التباين الراجع للهجن العكسية.

وكان التباين الاضافى كان اعلى من التباين السيادى لكل من الصفات التالية عدد المساكن فى الثمرة ,درجة صلابة الثمرة, سمك جدار الثمرة, المواد الصلبة الذائبة ,المحتوى من فيتامين ج ومقدار صبغة الليكوبين ز كما واوضحت البيانات المجمعة على مدار موسمين ان درجة التوريث فى المدى الواسع كانت 92.5%95%.77%,3.5%,78.2% (87.3% بينما كانت فى المدى الضيق اقل من مثيلاتها فى المدي الواسع 90.14%,93.4%,0.0%,84.8%,58.49%,76.8% لصفات عدد المساكن فى الثمرة ,درجة صلابة الثمرة, سمك جدار الثمرة, المواد الصلبة الذائبة ,المحتوى من فيتامين ج ومقدار صبغة الليكوبين على الترتيبمما يشير الى أن الفعل الجينى السيادى له دورا في توريث هذه الصفات لايجب إهمالة. ولذلك نسبة الى هذه النتائج يمكن أن يكون برنامج التربية المفضل لتحسين مثل هذه الصفات هو الإنتخاب المتكرر العكسى.

قام بتحكيم البحث

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