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EVALUATION OF PERFORMANCE AND GENE ACTION OF QUANTITATIVE CHARACTERS IN SOME LOCAL AND EXOTIC TOMATO GENOTYPES

II. YIELD AND QUALITY TRAITS

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ABSTRACT: Six tomato (*Lycopersicon esculentum* Mill.) genotypes and their F1 hybrids, were used in the present work to study the genetic behavior of quality and yield characters and to obtain information about the relative magnitude of gene effects involved in the inheritance of these characters. This study was carried out in the Experimental Farm and the Biotechnology Lab., El-Kassasein Horticulture Research Station, during the winter seasons of 2001 / 2002 and 2002 / 2003.

Significant variances among all genotypes for all characters, indicated the presence of either additive or non-additive genetic variations among these genotypes. Aconsiderable portion of non-additive genetic variation which due to allelic interaction are present in all genotypes for number of locules per fruit, fruit shape index, total soluble solids and average fruit weight. Rest of the characters is characterized with minimum portion of variation due to dominance gene effects in relation to the whole non-additive genetic variation. However, considerable portion of non-allelic interaction was suggested to be involved in the non-additive gene effects controlling

number of fruits per plant. Additive gene effects is important in controlling the fruit shape index, number of locules, pericarp thickness, ascorbic acid, average fruit weight, number of fruits per plant. Both additive and dominance gene effects are involved in controlling almost all characters. However, titratable acidity, total fruits weight, suggested to be mainly controlled by dominance gene effects.

The presence of dominance with asymmetrical gene distribution, in the parental genotypes, were observed for all quality and yield characters even for fruit shape index and average fruit weight.

Estimates, of h_2 indicate the existence of more positive genes controlling five out of the nine characters. Partial dominance due to dominance gene effects was assigned for fruit shape index, pericarp thickness ascorbic acid and average fruit weight. However, over-dominance was found to control total soluble solids, titratable acidity, number of fruits per plant and total fruits weight per plant.

Some sort of asymmetry ($\mu i \neq vi$) at loci showing dominance was observed for almost all the characters.

Key words: **Gene action – *Lycopersicom esculentum* - Morphological- Performance- Physiological- Quality- Quantitative – Tomato – Yield.**

INTRODUCTION

Improving yield in any vegetable crop depends mainly not only on the availability of genetic variations but also on the nature of gene action in losi controlling the expression of yield and its related and quality characters for this crop. However, performance is critical to identify the best genotypes which could be used in different types of breeding programs to increase yield (Singh *et al.,* 1999). However, there is no commercial local hybrids show high yielding ability and good fruit characteristics until now. So, the increasing of the productivity together, with high quality are the major objectives of many plant breeders. In this respect, intervarietal crosses of tomato are very important to plant breeding before trying other breeding strategy programs to produce productive hybrids with high fruit quality.

Most recent works aimed to obtain some tomato hybrids through intervarietal crosses, which require studies on the genetic behaviour of the important quantitative traits (Omara *et al.*, 1988 and Ramos *et al.*, 1993). Information about the nature of gene action of these traits as well as the estimates of heritability in narrow sense should be investigated (Asins *et al.*, 1993). The magnitude of additive and non-additive genetic effects could be determined and the role of the dominant gene effects, the non-allelic interaction and the genetic divergence also could be determined (Mather and Jinks, 1971).

In the present study an attempt was made to throw some light on the genetic behaviour of yield characters and to study the genetic behavior of quality and yield characters and to obtain information about the relative magnitude of gene effects involved in the inheritance of these characters; and the components of genetic variance and gene action in parents and their F_1 hybrids.

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm of El-Kassasien Horticultural Research Station, Horticultural Research Institute, Agricultural Research Center, during the winter seasons of 2001-2002 and 2002–2003.

Six tomato (*Lycopersicon esculentum* Mill.) genotypes were used in this investigation. These include the two isogenic lines 83 (P_1) and 80 (P_2) which were kindly obtained from Horti-culture Department, Iowa State University, Ames, Iowa, USA, the commercial sherry tomato; line 93 (P_6) which was kindly obtained from the North Central Regional Plant Introduction Station, ARS, Ames, IA, USA and another three varieties namely Super Marmand (P_3), Pretchard (P_4) and Money Maker (P_5) which were obtained from the Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.

In the winter season of 2001-2002, seeds of the six parental tomato varieties were sown. Twenty seedlings of each parent were transplanted to represent the plant material for achieving the half diallel crosses for the 6x6 combinations without reciprocals.

Emasculation of flowers of the female parents was achieved in the afternoon just a day prior to anthesis. Crossing was carried out between 7-9 am at the following morning of emascula-tion. Artificial pollination was practiced by a gentle rubbing of the stigma with a glass slide covered with pollens from male parent flowers. Craft paper bags were used for covering female flowers after pollination and a tag was hanged on the pedicel of each pollinated bud. From the last week of February till the end of May in the same season, hybrid seeds from mature set fruits were harvested and extracted by fermintation method.

Evaluation Experiment:

Seeds of fifteen hybrids and six parents were sown in October 2002 to produce the transplants. Each of the twenty-one genotypes was sown in thirty pots; ten pots per replicate. Two seeds were sown in each pot. Usual and similar agricultural practices were applied to keep transplants healthy. Measurement were collected from the three replications of both parental and F_1 hybrid genotypes.

The seedlings were trans-planted in Nov., 2002 under low tunnel conditions in the Experimental Farm of El-Kassasien Horticulture Research Station. Each tunnel represents fifteen of each of parental and F_1 hybrid plants in each of the three replicates. Each replicate form a plot of 12 m. long and 1.2m width. Plants were sown at 40cm apart. Normal field practices and recommended quantitities of fertilizers were applied during the entire growing season until maturity. Control of diseases, insects and pests was practiced according to the recommendation of Ministry of Agriculture.

The genetic behaviour of the characters of each genotype was studied on ten randomly chosen plants in each replica-tion.

Experimental Data:

I. Fruit quality characters:

Data for the six characters were recorded on twenty-five fruits, randomly chosen from the yield of five randomly chosen plants from each replicate.

They were fruit shape index, number of locules per fruit, pericarp thickness (mm) and total soluble solids (T.S S.); which was determined as an average of five refracto-meter readings (Brix %) using juice drops from each of five fruits.

Titratable acidity (%) was calculated using the titration method according to the method described by A.O.A.C (1990).

Ascorbic acid (Vitamin C) content was determined using 2,6 dichloro-phenol indophenol method as described by A.O.A.C. (1990).

II. Yield and it's Compo-nents:

Total yield, was evaluated as total number of fruits per plant, it was evaluated as average number of fruits per plant in all harvests of ten randomly chosen plants for each genotype in each replication.

Total fruits weight per plant (Kg) was estimated as average weight of fruit yield in all harvests over ten plants for each genotype in each replicate.

Average fruit weight (gm) was evaluated as average weight of fruit per plant of each genotype in each replication.

Diallel analysis:

The statistical analysis was performed in the present investi-gation involved the Hayman's approach, the theory of diallel developed by Haymen (1954a,b) using Mather's concept of D,H components of variation and described in detail by Mather and Jinks (1971). The calculation of different genetic estimates were made after Singh and Chaudhary (1977).

RESULTS AND DISCUSSION

I. Performance of Parental and F_1 hybrid Genotypes:

Data of the mean values for nine quality and yield characters (Table 1), showed that the Isogenic line 83 (P_1) was found to have the highest mean values for fruit shape index, pericarp thickness and average fruit weight. Moreover, line 93(P_6) was found to have the highest mean values for titeratabl acidity and number of fruits per plant. Money Maker (P_5) had the highest values for total fruits weight and ascorbic acid content. On the other hand, the, line 93 (P_6) had the least value for average fruit weight, while Isogenic line 80(P_2) had the second lowest score for number of fruits per plant. Moreover, no single F_1 hybrid was charcterized with the highest mean value for more than one character atmost. The highest mean value for

Table1: Mean values for nine quality and yield characters of 6x6 half- diallel crosses in tomato (*Lycopersicon esculentum* Mill.).

Genotypes	Fruit shope Index %	No. of locules per fruit	Pericarp thickness (m.m)	Total soluble solids %	Titera -table acidity %	Ascorbic acid Mg/100g	No. of fruit Per plant	Total fruit weight/plant (kg)	Avg. fruit Weight (gm)
P_1	0.97	4.4	0.62	6.1	1.31	1.44	35.7	1.54	42.5
P_2	0.95	4.0	0.58	7.2	1.18	2.16	31.3	1.11	34.7
P_3	0.67	10.0	0.48	5.5	1.31	1.35	24.7	1.05	42.4
P_4	0.89	5.5	0.47	9.2	1.34	1.44	24.7	0.77	32.4
P_5	0.92	2.5	0.49	6.8	1.28	2.48	74.0	1.59	21.6
P_6	0.91	2.6	0.33	7.1	1.47	2.16	109.3	1.12	10.3
P_1xP_2	0.93	4.1	0.56	6.5	0.99	1.35	44.0	1.42	34.7
P_1xP_3	0.83	4.5	0.51	6.2	1.15	1.58	49.5	1.70	38.7
P_1xP_4	0.87	4.6	0.46	5.0	1.07	1.68	60.3	2.33	38.6
P_1xP_5	0.92	2.8	0.51	5.3	1.05	1.91	81.0	3.02	35.3
P_1xP_6	0.88	4.1	0.40	7.0	1.41	2.09	143.8	2.28	15.5
P_2xP_3	0.83	4.9	0.57	6.3	1.24	1.76	63.7	2.16	32.9
P_2xP_4	0.91	4.2	0.55	6.8	0.99	1.71	67.7	2.68	38.5
P_2xP_5	0.91	3.3	0.59	7.9	0.90	2.25	84.7	2.75	32.7
P_2xP_6	0.90	3.4	0.43	6.5	1.26	1.71	72.8	1.35	18.2
P_3xP_4	0.80	4.7	0.51	5.8	1.12	1.51	88.3	3.15	36.4
$P_3 x P_5$	0.91	2.9	0.54	6.4	1.18	1.71	104.0	2.84	26.6
$P_3 x P_6$	0.90	3.0	0.37	7.0	1.55	1.71	196.5	2.48	12.5
P_4xP_5	0.91	2.5	0.48	5.3	1.14	1.67	137.5	3.77	27.6
P_4xP_6	0.79	4.2	0.38	4.7	1.52	2.15	126.3	2.52	22.2
P_5xP_6	0.92	2.5	0.49	5.2	1.22	2.32	132.7	2.63	20.0

P_1 = Isogenic line 83, P_2= Isogenic line 80, P_3= Super Marmand, P_4= Pretchard, P_5= Money Maker and P_6= Line 93.

total yield was scored by the F_1 (P_4XP_5); Pretchard X Money Maker. It is worthy to mention that both the parental genotype P_5 and his F_1 hybrid (P_4XP_5) had the highest mean values for total yield per plant 3.77Kg. In addition Money Maker (P_5) had the highest value for plant growth rate. The highest value of number of fruits per plant was scored by the F_1 (P_3XP_6); Super Marmand X Line 93 which had also the highest value for titeratable acidity. The F_1 (P_2XP_6); Isogenic line 80 X Line 93 had the lowest value for total yield per plant (Table 1). Singh and Singh (1993) stated that, the highest value for total fruit weight per plant was 1200 gm.

II. Gene Action in Quantita-tive Characters:

a. Analysis of Variance:

From the analysis of variance, it might be seen that the variances among the twenty-one genotypes were highly significant for all characters. This clearly, indicates the presence of either additive or non-additive genetic variations among these genotypes. The mean squares for the parents were highly significant for most yield characters. Meanwhile, titeratable acidity and weight of total yield were non-significant. For hybrids, the mean square values were highly significant for all the quality and yield characters except for fruit shape index which was just significant.

The interaction mean square values were highly significant for number of locules per fruit, total soluble solids, titerable acidity, number and weight of fruits per plant. Meanwhile, the rest quality and yield characters were non-significant, (Table 2). Many investigators reported the presence of additive and non-additive gene effects for different tomato traits. Singh *et al.* (1999) showed that additive and non-additive genetic variations were important for average fruit weight, marketable yield and total yield and Rai *et al.* (1997a) showed their presence for yield and yield components.

b. Components of Genetic Variance and Gene Action:

The relative estimates of the genetic components of variation due to additive and dominant genes are given in Table (3) for both quality and yield characters.

The components of variation showed that the additive (D) component was highly significant for fruit shape index, number of

Table 2: Mean square values for nine quality and yield characters of 6x6 half- diallel crosses in tomato genotypes.

Source of variation	d.f.	M.S.								
		Fruit shape index	No. of locules per fruit	Pericarp thickness	Total soluble solids	Titratable acidity	Ascorbic acid	No. of fruits per plant	Total fruits weight per plant	Avg. fruit weight
Replications	2	0.002	0.08	0.011	0.79	0.54*	0.13	8884.4**	8.18**	99.0*
Gennotypes	20	0.135**	7.97**	0.017**	4.40**	0.65**	1.55**	6109.3**	1.99**	291.6**
-Parents	5	0.369**	22.8**	0.030**	5.91**	0.16	3.16**	3560.3**	0.30	475.1**
- Hybrids	14	0.060*	2.09**	0.014**	3.31**	0.76**	1.08**	5435.1**	1.25**	243.4**
-P. x H.	1	0.001	16.0**	0.001	12.2**	1.51**	0.01	28294.1**	20.8**	49.2
Error	40	0.026	0.34	0.003	0.51	0.08	0.15	678.1	0.44	23.0

*,** Significant at 5% and 1% levels, respectively.

locules per fruit, pericarp thickness, ascorbic acid and average fruit weight, and significant for total soluble solids. This indicates that additive gene effects are important in controlling all these characters. Similar conclusion was obtained by Dod *et al.* (1995) for number of lecules, total soluble solids and pericarp thickness; Rai *et al.* (1997b) for pericarp thickness and Perera and Liyanaarachchi (1993) for average fruit weight. However, positive considerable but non-significant D values were observed for number of fruits per plant. This might suggest that these characters are controlled to some extent with additive gene effects, (Table 3). These results are in con-cordance with those obtained by Perera and Liyanaarachchi (1993) for number of fruits per plant.

The dominance component (H_1) of genetic variance was positive and significant for all the quality and yield characters, indicating that all these characters are largely determined by genes with dominant effects (Table 3).

It is worthy to mention that, seven out of the nine characters had either significant or positive considerable D values suggest-ing that they might be controlled by both additive and dominance gene effects. However, titratable acidity, total fruits weight, which had negligible D values but significant H_1 values are suggested to be mainly controlled by dominance gene effects, (Table 3). In this concern, both additive and non-additive gene effects were observed to be important in controlling, number of fruits and average fruit weight (Omara *et al.*, 1988), mean fruit weight (Vallejo-Cobrera and Estrada, 1993), number of lecules (Amerol-Junior *et al.*, 1996) and yield and yield components (Rai *et al.*, 1997a; Singh *et al.*, 1999).

The estimates of average value of dominance in loci having unequal positive and negative allelic frequencies (H_2) were significant in all the studied yield and quality characters except, fruits shape index and average fruit weight indicating the presence of dominance with asymmetrical gene distribution among the parents for these characters. However, H_2 values were insignificant but positive and were considerable, in respect to other components and for fruit shape index and average fruit weight. This suggests that dominance with asymmetrical gene distribution might be present also for these characters in the

Table 3: Components of genetic variation and their standard errors for nine quality and yield characters of 6x6 half diallel crosses in tomato genotypes.

Component	Fruit shape index	No. of locules per fruit	Pericarp thickness	Total soluble solids	Titratable acidity	Ascorbic acid	No. of fruits per plant	Total fruits weight per plant	Avg. fruits weight
D	0.115**	7.5**	0.009**	1.8*	0.021	1.01**	1065.6	0.099	149.5**
F	0.097**	7.3**	0.0009	3.61*	-0.18	0.48*	-777.7	0.149	0.679
H_1	0.074*	5.6**	0.004**	6.96**	0.434**	0.748**	4413.9**	2.32**	69.1*
H_2	0.047	3.3**	0.003**	4.7**	0.296**	0.629**	3814*	1.84**	48.4
h2	-0.004	20.7**	0.00008	2.53*	0.307**	-0.025	36627.2**	27.0	5.7
E	0.008	0.15	0.0009**	0.18	0.033**	0.048	121.0	0.0004	8.9*

*,** Significant at 5% and 1% levels, respectively.

concerning parental genotypes (Table 3). Wang-Lei *et al.* (1998) also, reported the presence of dominance with asymmetrical gene distribution for plant yield and total soluble solids.

The h2 estimates, which express the dominance effects, were significant and positive for four out of the nine yield and quality characters; number of locules per fruit, total soluble solids, titratable acidity and number of fruits per plant indicating the existence of more positive genes controlling these characters (Table 3). Positive genes were also obtained by Srivastava *et al.* (1995) for yield per plant; Saranga *et al.* (1992) for total soluble solids, titratable acidity and number of locules and Yadav *et al.* (1991) for pericarp thickness.

The significant environmental component of variation was only observed for three out of the nine characters studied; pericarp thickness, titratable acidity and average fruit weight. This clearly indicated that these characters are more likely to be affected by the environmental effects than other characters (Table 3). The mean degree of dominance $(H_1/D)^{1/2}$ estimates were less than one for fruit shape index, number of locules, pericarp thickness, ascorbic acid and average fruit weight (Table 4). This clearly suggests that partial dominance is controlling the allelic interaction in all loci of dominance gene effects for these characters. These results are in agreement with those obtained by Ramos *et al.* (1993) and Lopez-Rivares and Cuartero (1985) for average fruit weight. However, overdominance was found to control such allelic relationship in loci expressing dominance effects for total soluble solids, titratable acidity, number of fruits per plant and total fruits weight per plant.

The parameter $(H_2/4H_1)$ which measures the proportion of positive genes x proportion of negative genes over all arrays "$\mu i v i$" was found to be the highest value (0.216) for number of fruits per plant. Meanwhile, it was the lowest (0.15) for number of locules per fruit. Considering the various estimates of $H_2/4H_1$, they suggest some sort of asymmetry ($\mu i \neq v i$) at loci showing dominance for almost all the nine characters.

The values "$(4DH_1)^{1/2} + F/(4DH_1)^{1/2}-F$" which reflect the proportion of dominant and recessive genes (dom./rec.) were less than one only for titratable acidity and number of fruits per plant (Table 4) indicating that

Table 4: Parameters of genetic variation for nine quality and yield characters of 6x6 half diallel crosses in tomato genotypes.

Parameters	Fruit shape index	No.of locules per fruit	Pericarp thickness	Total soluble solids	Titratable acidity	Ascorbic acid	No. of fruits per plant	Total fruits weight per plant	Avg. fruit weight
$(H_1/D)^{1/2}$	0.8	0.863	0.688	1.97	4.59	0.863	2.04	4.84	0.680
$(H_2/4H_1)$	0.161	0.15	0.151	0.169	0.17	0.21	0.216	0.198	0.175
$(4DH)^{1/2}+F/$ $(4DH)^{1/2}-F$	3.23	3.61	1.18	3.09	0.03	1.77	0.696	1.37	1.01
$h2/H_2$	-0.093	6.20	0.03	0.538	1.04	-0.039	9.6	14.7	0.118
h^2(n.s)	0.523	0.892	0.849	0.142	0.610	0.61	0.91	0.998	0.802

recessive genes were higher in frequency than dominant ones in the parents for these characters. However, the rest of the nine characters had estimates for (dom./rec.) higher than 1 with positive values of F (Table 3), thus showing that more dominant genes are controlling these characters.

Estimates of number of gene groups controlling the characters and exhibit dominance ($h2/H_2$) showed that number of locules, number of fruits per plant and total fruits weight are controlled by the largest number of dominant gene groups, 6, 10 and 15, respectively. Meanwhile, leaf area, caro-tenoids content, fruit shape index, pericarp thickness and ascorbic acid content were controlled by the least number of dominant gene groups (Table 4).

The narrow sense herita-bility estimates show that, all quality and yield characters had moderate to high herita-bility estimates except total soluble solids, which had the least narrow-sense heritability estimate; 0.14 in (Table 4). Similar high heritability estimates results were also observed in tomato for yield per plant by Padmalatha and Reddy (1990).

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تقييم الأداء والفعل الجيني للصفات الكمية في بعض التراكيب الوراثية المحلية والأجنبية في الطماطم
٢ – صفات المحصول والجودة.

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استخدم في هذا العمل ستة تراكيب وراثية من الطماطم والهجن الناتجة عنها:

لدراسة السلوك الوراثى لصفات المحصول والجودة وللحصول على معلومات عن المقدار النسبى للتأثيرات الجينية التى تساهم فى وراثة تلك الصفات. وقد أجريت هذه الدراسة في كل من المزرعة البحثية ومعمل التقنية الحيوية بمحطة بحوث البساتين بالقصاصين أثناء الموسمين الشتويين ٢٠٠١/٢٠٠٢ ، ٢٠٠٢ / ٢٠٠٣.

أظهر تحليل التباين وجود تباين معنوي في كل الصفات الكمية المدروسة على مستوى كل الطرز الوراثية وهذا يوضح وجود التباين الوراثي الراجع للإضافة والغير إضافي في كل الطرز الوراثية. التأثير الجيني الغير مضيف والذي يرجع الى التفاعلات الآليلية ظهر في كل الطرز الوراثية المدروسة في الصفات التالية: عدد الحجرات داخل الثمرة وشكل الثمرة والأملاح الكلية الذائبة ومتوسط وزن الثمرة، لكن باقي الصفات المدروسة فيتحكم فيها الفعل الجيني السائد. التأثير الجيني المضيف يتحكم بصورة ظاهرة في كل من شكل الثمرة وعدد الحجرات في الثمرة وسمك اللحم وفيتامين ج ومتوسط وزن الثمرة وعدد الثمار لكل نبات. معظم صفات الجودة والإنتاج يتحكم فيه بصورة واضحة فعل الجينات السائدة. كلا التأثير الجيني المضيف والسيادي يتحكما بصورة واضحة في معظم الصفات المدروسة لكن التأثير الجيني السيادي يتحكم في باقي الصفات.

ثبت أن التأثير الجيني السيادي في المواقع التي تشتمل على تكرارات غير متساوية من الأليلات الموجبة والسالبة موجود في كل التراكيب الوراثية الأبوية في معظم الصفات.

أوضحت تقديرات h_2 أن الجينات الموجبة التأثير لها دور هام في خمس من بين التسع صفات.

ظهرت سيادة الفعل الجيني الجزئي في صفات شكل الثمرة وسمك اللحم وفيتامين ج ومتوسط وزن الثمرة بينما ظهر سيادة الفعل الجيني الفائق في الأملاح الكلية الذائبة والحموضة المعايرة وعدد ثمار النبات والوزن الكلي للثمار لكل نبات.

و قد أظهرت نسب الجينات السائدة إلى الجينات المتنحية ان تأثيرات السياده فى كل الصفات المدروسة تغلب على نظيرتها المتنحية.