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EVALUATION OF PERFORMANCE AND GENE ACTION OF QUANTITATIVE CHARACTERS IN SOME LOCAL AND EXOTIC TOMATO GENOTYPES
I. MORPHLOGICAL AND PHYSIOLOGICAL TRAITS.

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ABSTRACT: **Six tomato (*Lycopersicon esculentum* Mill.) genotypes were used in the present work to study the genetic behavior of morphological and physiological characters and to obtain information from the crosses about relative magnitude of gene effects involved in the inheritance of these characters and the components of genetic variance and gene action in both parents and their F_1 hybrids. This study was caried out in both the Experimental Farm and the Biotechnology Lab., El-Kassassein Horticulyure Research Station , A.R.C.,during the winer seasons 2001 /2002 and 2002 /2003 .**

Significant variances among all genotypes indicated the presence of either additive or non-additive genetic variations for all these characters.

The mean square values for the parents, the hybrids and the interaction between parents and hybrids showed highly significant and significant for almost all the studied characters.

A considerable portion of non-additive genetic variation which due to allelic interaction are present in all genotypes for number of branches, number of leaves and leaf area. However, rest of the

characters are 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 leaves par plant .

Additive gene effects is important in controlling the number of branches per plant, leaf area and chlorophyll A. Almost all morphological and physiological, charactes are largely-determined by genes with dominant effects, except for number of branches per plant which determined largely with additive gene effects and non-additive gene interaction. Both additive and dominance gene effects are involved in controlling almost all characters. However, dry leaves weight, number of leaves per plant, plant height, plant growth rate and chlorophyll B suggested to be mainly controlled by dominance gene effects. h_2 estimates, which express the dominance effects, indicate the existence of more positive genes controlling all characters except leaf area and carotenoids content. Over-dominance was found to control all morphological and physiological charactes.

Some sort of asymmetry ($\mu i \neq vi$) at loci showing dominance was observed for almost all the characters except for growth rate and chlorophyll A and B contents which had nearly equal proportions of both positive and negative genes controlling these charcters.

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

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) 2n=12 is one of the most important vegetable crops grown in Egypt and throughout the world for both fresh fruit market and the processed food industries.

Improvement of developmental and physiolgical chracters in tomato are desirable to offer better opportunities for having higher yield. However , not only the mean performance of these characters is of great importance to identify the best genotypes which could be bred to increase yield but also the information on the inheritance and the nature of gene action either additive or non-additive (Bhuiyan, 1986; Natarajan, 1990) in these characters are essential to plan and organize a breeding prog-ramme and in turn to develop hybrids and or varieties of desired developmental characters.

Therefore, the object of most recent works were to obtain some tomato hybrids through intervarietal crosses, which require studies on the genetic behaviour of the important quantitative traits. There are many special aspects to be considered to improve any quantitative trait of economic usefulness. 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 present work was achived to study the genetic behavior of morphological and physiological, characters and to obtain information from the crosses both the about relative magnitude of gene effects involved in the inheritance of these characters and the components of genetic variance and gene action in both parents and their F_1 hybrids .

MATERIALS AND METHODS

The present investigation was carried out at the Experi-mental 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 the Horticulture 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 Introduc-tion 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.

Crosses were adopted by emasculation of flowers of the female parents in the afternoon just a day prior to anthesis. Artificial pollination was practiced between 7-9 am at the following morning by a gentle rubbing of the stigma with a glass slide covered with pollens from male parent flowers. Female flowers were coverd with craft paper bags after pollination and a tag was hanged on the pedicle 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 fermentation method.

Evaluation Experiment:

Seeds of fifteen hybrids and six parents were sown in October 2002to 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 transplanted 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 replicate, Each replicate form a plot of 12 meters long and 120cm width. Plants were 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.

Experimental Data:

I. Morphological and physiological characters:

Data of these characters were recorded on five randomly chosen plants of each replicate. The characters recorded were, plant height (cm), number of branches per plant, number of leaves per plant, plant growth rate (cm/day), leaf area (cm^2), dry stem weight per plant (gm), dry leaves weight per plant (gm), chlorophyll A (mg/g fresh weight), chlorophyll B (mg/g fresh weight) and carotenoids (mg/g fresh weight).

Chlorophyll A, chlorophyll B and carotenoids, were recorded according the methods described by Fadell, A.A. (1962).

Diallel analysis:

The statistical analysis performed in the present investigation 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) was applied. 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:

For the performance of parental and their F_1 genotypes data on ten morphological and physiological characters showed that, the parental line 93 (P_6) was found to have the highest mean values for number of branches, number of leaves, leaf area and stem dry weight per plant. In addition Money Maker (P_5) had the highest value for plant growth rate. In the mean time, Super Marmand (P_3) showed to have the lowest values, among the parental genotypes for all the ten characters except in plant growth rate and leaf area where it had the second lowest values. The estimates of mean values for hybrid combinations showed that the F_1 (P_3 x P_6); Super Marmand X line 93 was found to have the highest mean values for five out of the ten characters. It had the second highest score for the contents of chlorophyll A and B. In addition, it had a considerable mean performance for the rest characters; plant growth rate, leaf area and carotenoids content. Meanwhile, the F_1 (P_5XP_6); Money Maker X line 93 had the highest mean values for plant growth rate and chlorophyll B content, but the hybrid (P_2 X P_3); Isogenic line 80 X Super Marmand showed to have the lowest values among F_1 hybrids in number of branches per plant, number of leaves per plant and leaf area. Meanwhile the F_1 (P_1XP_2) Isogenic line 83 X Isogenic line 80 had the lowest values for dry stem weight per plant and dry leaves weight per plant and the F_1 (P_4XP_6); Pretchard X Line 93 had the lowest values for plant height and plant growth rate and the F_1 (P_3XP_5); Super Marmand X Money Maker had the least scores for the content of both chlorophyll B and carotenoids. . The F_1 (P_2XP_6); Isogenic line 80 X Line 93 had the lowest value for chlorophyll A (Table 1).Similar

Table 1: Mean values for ten morphological and physiological characters of 6x6 diallel crosses in tomato (*Lycopersicon esculentum* Mill.).

Genotypes	Plant height (cm)	No. of branches per plant	No. of leaves per plant	Plant growth rate (cm/day)	Leaf area (cm^2)	Dry stem weight per plant (gm)	Dry leaves weight per plant (gm)	Chlorophyll (A) (mg/g fresh weight)	Chlorophyll (B) (mg/g fresh weight)	Carotenoids (mg/g fresh weight)
P_1	90.6	10.1	130.7	1.00	78.3	78.7	47.0	0.87	0.97	0.248
P_2	75.9	8.1	102.3	0.74	75.6	48.1	28.2	0.71	0.77	0.218
P_3	64.9	6.6	85.0	0.77	73.3	35.8	26.2	0.65	0.68	0.178
P_4	63.4	10.2	131.7	0.84	94.5	66.7	61.1	0.81	0.82	0.222
P_5	88.3	10.6	113.0	1.14	71.9	76.0	43.5	0.81	0.82	0.223
P_6	69.3	20.6	214.0	1.02	98.0	81.2	59.7	0.78	0.78	0.224
P_1xP_2	86.1	9.3	147.3	0.74	69.1	71.1	35.6	0.83	1.02	0.223
P_1xP_3	98.1	9.4	156.8	1.02	77.2	73.8	47.7	0.83	1.00	0.231
P_1xP_4	97.9	11.4	219.7	1.03	92.1	103.2	82.5	0.87	1.04	0.236
P_1xP_5	113.7	12.4	196.0	1.23	67.0	114.8	64.8	1.00	1.20	0.258
P_1xP_6	111.6	18.0	311.0	1.16	62.0	155.9	105.4	0.91	1.14	0.262
P_2xP_3	96.2	9.2	141.0	0.86	58.4	72.0	42.1	0.88	1.07	0.240
P_2xP_4	121.8	17.0	284.3	1.25	79.9	162.8	141.7	0.88	1.04	0.221
P_2xP_5	100.9	11.6	171.7	1.18	77.2	83.3	51.0	0.80	1.01	0.212
P_2xP_6	109.0	17.0	233.2	1.20	66.1	118.8	67.5	0.66	0.86	0.202
P_3xP_4	115.4	19.8	304.0	0.95	78.2	146.7	125.5	0.91	1.11	0.248
$P_3 x P_5$	108.3	13.4	203.0	1.07	67.2	103.2	73.9	0.65	0.78	0.184
$P_3 x P_6$	138.5	33.2	499.8	1.09	67.6	227.7	183.5	0.95	1.17	0.246
P_4xP_5	121.1	16.0	259.5	0.98	78.9	160.6	107.1	0.75	0.94	0.224
P_4xP_6	84.2	20.8	229.5	0.73	115.1	125.5	117.7	0.89	1.08	0.226
P_5xP_6	121.3	15.2	279.7	1.33	81.9	141.1	92.7	0.94	1.22	0.238

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.

findings were reperted by Singh and Singh (1993).

II. Gene Action in Quanti-tative Characters:

a. Analysis of Variance:

From the analysis of variance, it might be seen that the variances among all genotypes were 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 number of branches per plant and showed just significant values for plant height, chlorophyll A and carotenoids content. Rest of the morphological and physiological characters were non-significant (Table 2).

For hybrids, the mean square values were highly signi-ficant for all morphological and physiological characters while the content of chlorophyll B was just significant but the content of carotenoids was non-significant (Table 2). The interaction between parents and hybrids showed highly significant values for all morphological and physiological characters except for plant growth rate which was just significant but leaf area while carotenoids content was non-significant (Table 2). Many investigators reported the presence of additive and non-additive gene effects for different tomato traits. Additive and non-additive genetic variations for plant height and number of branches were reported by Natarajan (1990)

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 morphological and physio-logical characters .

The components of variation showed that the additive (D) component was highly significant for dry stem weight per plant and just significant for carotenoids content. However, positive con-siderable but non-significant D values were observed for number of branches per plant, leaf area, chlorophyll A.This might suggest that these characters are controlled to some extent with additive gene effects, (Table 3). These results are in concordance with those obtained by Natarajan (1990) for leaf area.The dominance component (H_1) of genetic variance was positive and significant for most morphological and physiological characters except number of branches per plant which had positive considerable but non-significant H_1 value, indicating

Table2: Mean square values for ten morphological and physiological characters of 6x6 diallel crosses in tomato genotypes.

Source of variation	d.f	M.S.									
		Plant height	No. of branches per plant	No. of leaves per plant	Plant growth rate	Leaf area	Dry stem weight per plant	Dry leaves weight per plant	Chlorophyll A	Chlorophyll B	Carotenoids
Replications	2	834.8*	52.5*	19010.7**	0.108	365.1	11077.7**	9835.4**	0.027	0.141	0.106*
Gennotypes	20	1248.5**	111.6**	26877.1**	0.099**	530.5**	6454.8**	5066.3**	0.304**	0.633**	0.053*
-Parents	5	412.3*	72.7*	6082.1	0.076	386.7	1026.4	669.9	0.207*	0.274	0.066*
- Hybrids	14	644.2**	114.3**	24499.4**	0.097**	584.8**	5588.6**	5143.7**	0.302**	0.345*	0.048
-P. x H.	1	13889.6**	266.7**	164140.6**	0.234*	489.0	45722.4**	25964**	0.817**	6.465**	0.061
Error	40	157.0	10.1	2526.9	0.032	148.4	1100.8	970.2	0.069	0.135	0.022

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

that almost all characters studied are largely determined by genes with dominant effects (Table 3).

It is worthy to mention that, all characters had either significant or positive considera-ble D value suggesting that they might to be controlled by both additive and dominance gene effects. However, plant height, number of leaves, plant growth rate, dry leaves weight and chlorophyll B, which had negli-gible 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 plant height (Bhuiyan *et al.,* 1986; Natarajan, 1990).

The estimates of average value of dominance in loci having unequal positive and negative allelic frequencies (H_2) were significant in cases of all the morphological and, physiological characters except for number of branches per plant and leaf area 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 for number of branches per plant and leaf area (Table 3). This suggests that dominance with asymmetrical gene distribution might be present also for these characters in the concerning parental genotypes. Wang-Lei *et al.* (1998) and Govindarasu *et al.* (1982) reported asymmetrical gene distribution for plant height.

The h2 estimates, which express the dominance effects, were significant and positive for all morphological and physiological characters except for leaf area and carotenoids content. These estimates indicates the existence of more positive genes controlling these characters (Table 3). Positive genes were also obtained by Srivastava *et al.* (1995).

The significant environmental component of variation was only observed for four out of the ten characters studied; leaf area, dry stem weight per plant, chlorophyll B and carotenoids content. This clearly indicated that these characters are more likely to be affected by the environmental effects than other characters (Table 3). Overdominance was found to control such allelic relationship in loci expressing dominance effects for all morphological and physiological characters (Table 4).

Table 3: Components of genetic variation and their standard errors for ten morphological and physiological characters of 6x6 diallel crosses in tomato genotypes.

Component	Plant height	No. of branches per plant	No. of leaves per plant	Plant growth rate	Leaf area	Dry stem weight per plant	Dry leaves weight per plant	Chlorophyll A	Chlorophyll B	Carotenoids
D	81.0	21.0	1202.8	0.014	76.0	105**	92.3	0.047	0.046	0.014*
F	175.9	-8.4	-2761.5	-0.010	-110.5	-229.5	-545.8	0.011	0.0003	0.01
H_1	1512.8**	89.3	27660.5*	0.075*	305.2*	7359.3**	5395.4**	0.33**	0.619**	0.042**
H_2	1372.2**	74.4	25098*	0.078*	285.5	6466.8**	4524*	0.325**	0.624**	0.037**
h^2	179803**	336.4**	2123135**	0.044*	76.3	591386**	335839**	0.164**	1.37**	0.008
E	56.5	3.2	824.6	0.012	52.9*	237.2**	131.0	0.022	0.045*	0.009**

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

Ghosh *et al.* (1996) found that over-dominance control such allelic relationship in loci expressing dominance effects for plant height and number of branches per plant. Meanwhile Natarjan (1990) showed overdominance for shoot dry weight. The parameter ($H_2/4H_1$) which measures the proportion of positive genes x proportion of negative genes over all arrays "µivi" was found to be the highest, 0.26 for plant growth rate and 0.25 for chlorophyll B contents. Meanwhile, it was the lowest (0.208) for number of branches per plant. Considering the various estimates of $H_2/4H_1$ for all characters, they suggest some sort of asymmetry (µi≠vi) at loci showing dominance for almost all the characters studied except for growth rate, chlorophyll A and B contents which had almost equal proportions of both positive and negative genes controlling these characters (Table 4).

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 for number of branches per plant, number of leaves per plant, plant growth rate, leaf area, dry stem weight per plant and dry leaves weight per plant (Table 4) indicating that recessive genes were higher in frequency than dominant ones in the parents for these characters. However, the rest characters had higher estimates (dom./rec.) 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 plant height, number of branches per plant, number of leaves per plant, dry stem weight per plant, dry leaves weight per plant, are controlled by the largest number of dominant gene groups, 13,5, 9, 9 and 8, respectively. Meanwhile, leaf area and carotenoids content were controlled by the least number of dominant gene groups (Table 4).

The narrow sense heritability estimates showed that, number of branches per plant, number of leaves per plant, leaf area, dry stem-weight per plant and dry leaves weight per plant characters had moderate to high heritability estimates except chlorophyll B which had the least narrow-sense heritability estimate; 0.09 (Table 4).

High heritability estimates were reported by Kryuchkov *et al.* (1992) for plant height and by Saranga *et al.* (1992) for number of branches per plant.

Table 4: Parameters of genetic variation for ten morphological and physiological characters of 6x6 diallel crosses in tomato genotypes.

Parameters	Plant height	No. of branches per plant	No. of leaves per plant	Plant growth rate	Leaf area	Dry stem weight per plant	Dry leaves weight per plant	Chlorophyll A	Chlorophyll B	Carotenoids
$(H_1/D)^{1/2}$	4.32	2.06	4.8	2.35	2.0	8.37	7.65	2.66	3.67	1.77
$(H_2/4H_1)$	0.227	0.208	0.227	0.250	0.234	0.22	0.209	0.246	0.250	0.221
$(4DH)^{1/2}+F/(4DH)^{1/2}-F$	1.67	0.823	0.614	0.723	0.468	0.769	0.442	1.1	1.00	1.52
h^2/H_2	13.1	4.52	8.46	0.563	0.267	9.14	7.42	0.505	2.2	0.224
h^2(n.s)	0.288	0.872	0.798	0.244	0.453	0.721	0.852	0.163	0.091	0.191

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تقييم الأداء والفعل الجيني للصفات الكمية في بعض التراكيب الوراثية المحلية والأجنبية في الطماطم
١- الصفات المورفولوجية والفسيولوجية

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استخدم في هذا العمل ستة تراكيب وراثية كآباء من الطماطم والهجن الناتجة عنها بغرض دراسة السلوك الوراثى لكل من الصفات المورفولوجيه و الفسيولوجية للحصول على معلومات عن المقدار النسبى لتأثيرات الجينات فى وراثة تلك الصفات و عن مكونات التباين الوراثى والفعل الجينى فى كل من الاباء والهجن الناتجة منها .

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. وقد أجريت هذه الدراسة في كل من المزرعة البحثية ومعمل التقنية الحيوية بمحطة بحوث البساتين بالقصاصين اثناء الموسمين ٢٠٠١ /٢٠٠٢ ، ٢٠٠٢ /٢٠٠٣ .

وجد أن قيم متوسط مربعات الانحرافات لكل من الآباء والهجن والتفاعل بين الآبـاء أظهر معنوية عالية في معظم الصفات المدروسة.

التأثير الجيني الغير مضيف والذي يرجع الى التفاعلات الآليلية ظهر في كـل الطـرز الوراثية المدروسة في الصفات التالية: وعدد أفرع النبات وعدد الأوراق ومساحة الورقـة لكن باقي الصفات المدروسة يتحكم فيها الفعل الجيني السائد.

التأثير الجيني المضيف يتحكم بصورة ظاهرة في كل مـن عـدد الأفـرع ومسـاحة الورقةوكمية الكلوروفيل A، كما وجد ان معظم الصفات المورفولوجية والفسيولوجية يتحكم فيه بصورة واضحة فعل الجينات السائدة ماعدا صفة عـدد الأفـرع والتـي يـتحكم فيهـا بصورتواضحة الفعل الجيني المضيف، ووجد ان كلا من التأثير الجيني المضيف والسـيادي يتحكما بصورة واضحة في معظم الصفات المدروسة لكن التأثير الجيني السيادي يتحكم في باقي الصفات، أوضحت تقديرات h_2 أن الجينات الموجبة التأثير لها دور هـام فـي معظـم الصفات، و قد ظهرت سيادة الفعـل الجينـي الفـائق فـي كـل الصـفات المورفولوجيـة والفسيولوجية.

ووجد ان نسب الجينات السائدة إلى الجينات المتنحية قد أظهـرت التـأثير السـيادي لمعظم الصفات المدروسة فيما عدا صفات معدل النمو ومحتوى كلور فيـل أ ، ب والتـى وضح انهما يتمتعان بنسب متساوية من كل من الجينات السالبه والموجبة التى تحكم كـلا منهما.