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TES HETEROSIS AND GENETIC PARAMETERS AFFECTING INHERITANCE in IMPORTANT TRAITS OF TOMATOES (*Lycopersicon esculentum*, Mill)

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ABSTRACT

Tomatoes is one of the most important vegetable crop not only in Egypt, but also all over the world. Therefore, there are many different continues effort to produce superior hybrids and varieties. In this respect, the present investigation was directed to exploit the amounts of heterosis that could be obtained from the hybrids and determine the nature of gene action associated with it using Mather and Jinks (1982) scaling test. For this purpose, four varieties were used. These varieties were: Edkawy (P_1), Super streen B (P_2), Peto 86 (P_3) and Flourdade (P_4). Three hybrids were obtain during 2009 growing season by crossing Edkawy with each of the other three varieties to produce three different hybrids. In the growing season of 2010, each hybrid was used to generate six populations which included(P_1, P_2,F_1,F_2, BC_1 and BC_2). Amounts of heterosis from mid – parent were 100.3 and 62.3% for the hybrid (P_1 X P_2) indicating that it had the heaviest fruit weight per plant and No. of fruits/plant. The hybrid (P_1 X P_4) gave (16%), for shape index. The hybrid (P_1 X P_3)gave (43.2%), for hardness in kg.

For chemical traits, the hybrid (P_1 X P_4) gave 17.09 for total soluble soileds .The best hybrid for lycopene and ascorbic acid were the hybrid (P_1 X P_2) which gave 129.2 and 15.7% , respectively.

Proportion amounts of heterosis from better -parent were ٦٤.٤ and ٣٨.٤ for the hybrid (P_1 X P_2) indicating that it had the heaviest fruit weight per plant and No. of fruits/plant.The hybrid (P_1 X P_4)gave 25%, for hardness in kg.

For chemical traits, the hybrid (P_1 X P_4) gave 14.0 %for total soluble soiled .The best hybrid for lycopene and ascorbic acid was the hybrid (P_1 X P_2) which gave 75.6 and -19.0% , respectively. In the same time , all the F_2 generations showed inbreeding depression.

The six population were setup in scaling test analyses to determine the nature of gene action and to test the adequacy of additive dominance model.

Keywords: Scaling test, Heterosis,and Inbreeding depression.

INTRODUCTION

Hybridization of tomato has been known to produce superior F_1 hybrid which perform better than its two parents.

The amount of heterosis varied where some traits showed large amounts and others showed modest amount of heterosis. In this respect, Zanata (1994),and El-Sharkawy *et al.*, (1997) studied six parameter model on three tomatoes hybrids. They found that all studied hybrids showed heterosis relative to the better parent. For plant height and number of branches per plant with values of 6.7 to13.7 % ,respectively. Metwally *et al.*, (1990); Gustavo *et al*., (2006); Mahmoud *et al*., (2007); Sekhar (2007) and Khoja *et al.*, (2008) found heterosis for plant height of 72.5,while fruit weight and fruit length showed 15.9 and 12.2%, respectively. Dordevic and Zecevic (2010); Rahmani Gul *et al*., (2010) and Sekhar *et al.*, (2010). and Kansouh and Zakher (2011). reported that the amounts of heterosis for these two traits were 48 and 45%, respectively. They also indicated that heterosis for yield per plant over the mid-parent was 34.9 %.

With respect to gene action, Garg *et al.*, (2008) indicated that additive gene effects predominated total yield per plant especially number of fruits and fruit weight .On the other hand, Saleem *et al.*, (2009) indicated that non additive genetic variances were important. They also found that heritability in narrow sense was low for most traits. Haydar *et al.*, (2007); Abd El-Haleem *et al.*, (2010); Arora *et al.*, (2010);Aykuttonk *et al.*, (2011)and Sher *et al.*, (2012) indicated that scaling test cleared that additive – dominance model was adequate to explain the nature of gene action for the most studied traits of tomatoes.

Therefore, the objectives of this study were directed to estimate heterosis ,inbreeding depression and nature of gene action using scaling test analyses.

MATERIALS AND METHODS

The present study was carried out during the period of 2009, 2010 and 2011 growing seasons in two lucations, the frist at El-Tawheed Nursery, Gamasa Road, Dakhlia Governorate and the second in Experimental Station, Faculty of Agriculture, Mansoura University, Egypt. Four varieties were used for this study namely; Edkawy (P_1), Super streen B (P_2), Peto 86 (P_3) and Flourdade (P_4). From these varieties, three hybrids were obtained during 2009 season by crossing Edkawy with each of the other three varieties . In the 2010 growing season, some F_1 plants were selfed to produce F_2 generation seeds. The F_1 plants were also back crossed to their parents to obtain BC_1 and BC_2 seeds. The inheritance mode of all traits was determined using Mather and Jinks (1982) scaling test of the six population for all the different three hybrids (P_1, P_2, F_1, F_2, BC_1, BC_2) were evaluated during 2011 growing season. Data were recorded on individual plants for day to first flower; total fruits weight/plant (kg); number of fruits/plant; shape index; hardness ; total soluble solid (TSS %); lycopene and vitamin C.

Statistical and genetic analysis:

Analysis of variance was done for all The six populations (P_1, P_2, F_1, F_2, BC_1, and BC_2) within each hybrid with respect to all studied traits. They were planted in Randomized Complete Blocks Design (RCBD) with three replications.

Heterosis and inbreeding depression

The amount of heterosis was determined as the percentage increase of the F_1 mean over the average of its two parents or above its better parent. Therefore, the values of heterosis could be estimated as follow:

- Heterosis over the mid-parent: H (M.P%) = $\frac{\overline{F}_1 - M.P}{M.P} \times 100$.
- Heterosis over the better parent: H (M.P%) = $\frac{\overline{F}_1 - B.P}{B.P} \times 100$.

- Inbreeding depression (I.D%): It was measured as a percentage deviation of F_2 generation than their corresponding to F_1 hybrids from the following equation:
- I.D% = $\frac{\bar{F}_1 - \bar{F}_2}{\bar{F}_1} \times 100$

The scaling test (A, B and C)parameters were determined according to **Mather and Jinks, (1982**) for testing deviations of segregation from the additive and dominance model of gene effects:

Scaling test	Variance
$A = 2\bar{B}C_1 - \bar{P}_1 - \bar{F}_1$	$VA = 4V\bar{B}C_1 - V\bar{P}_1 - V\bar{F}_1$
$B = 2\bar{B}C_2 - \bar{P}_2 - \bar{F}_1$	$VB = V\bar{B}C_2 - V\bar{P}_2 - V\bar{F}_1$
$C = 4\bar{F}_2 - 2\bar{F}_1 - \bar{P}_1 - \bar{P}_2$	$VC = 16V\bar{F}_2 - 4\overline{V\square}_1 - V\bar{P}_1 - V\bar{P}_2$

The standard errors are equal to the square roots of the corresponding variance:

Types of gene action:

The six-parameter modules m, a, d, aa, ad and dd, which stand for mean effects, additive, dominance, additive x additive, additive x dominance and dominance x dominance gene effects, respectively, would be estimated according the following formula:

m = mean of $\bar{F}_2$

$a = \bar{B}C_1 - \bar{B}C_2$

$d = \bar{F}_1 - 4\bar{F}_2 - (1/2)\bar{P}_1 - (1/2)\bar{P}_2 + 2\bar{B}C_1 + 2\bar{B}C_2$

$aa = 2\bar{B}C_1 + 2\bar{B}C_2 - 4\bar{F}_2$

$ad = \bar{B}C_1 + (1/2)\bar{P}_1 - \bar{B}C_2 + (1/2)\bar{P}_2$

$dd = \bar{P}_1 + \bar{P}_2 + 2\bar{F}_1 - 4\bar{F}_2 - 4\bar{B}C_1 - 4\bar{B}C_2$

The variance, standard error and calculated "t" values for various genetic components are obtained as follows:

	Variance (V)	(S.E)	t value
m	$V\overline{F}_2$	$(Vm)^{1/2}$	m/S.D (m)
a	$V\,\overline{B}C_1 + V\overline{B}C_2$	$(Va)^{1/2}$	d/S.E. (d)
d	$V\overline{F}_1 + 16V\overline{F}_2 + ¼\,V\overline{P}_1 + ¼\,V\overline{P}_2 + 4V\overline{B}C_1$ $V\overline{B}$	$(Vd)^{1/2}$	d/S.E.(d)
aa	$4V\overline{B}C_1 + 4\,V\overline{B}C_2 + 16V\overline{F}_2$	$(Vaa)^{1/2}$	aa/S.E.(aa)
ad	$V\overline{B}C_1 + ¼\,V\overline{P}_1 + V\overline{B}C_2 + ¼\,V\overline{P}_2$	$(Vad)^{1/2}$	ad/S.E.(ad)
dd	$V\overline{P}_1 + V\overline{P}_2 + 4\,V\overline{F}_1 + 16V\overline{F}_2 + 16V\overline{B}C_1$ $V\overline{B}$	$(Vdd)^{1/2}$	dd/S.E.(dd)

In the absence of non-allelic interaction, the additive dominance model is adequate and the following formulae were applied.

$m = ½\,\overline{P}_1 + 1/2\,\overline{P}_2 + 4\,\overline{F}_2 - 2\overline{B}C_1 - 2\overline{B}C_2$

$a = ½\,\overline{P}_1 - 1/2\,\overline{P}_2$

$d = 6\overline{B}C_1 + 6\overline{B}C_2 - 8\overline{F}_2 - \overline{F}_1 - (3/2)\overline{P}_1 - (3/2)\overline{P}_2$

Their variances have been computed using following formula:

$Vm = ¼\,\overline{P}_1 + 1/4\,\overline{P}_2 + 16\,\overline{F}_2 + 4\overline{B}C_1 + 4\overline{B}C_2$

$Va = ¼\,\overline{P}_1 + 1/4\,\overline{P}_2$

$Vd = 36\overline{B}C_1 + 36\overline{B}C_2 + 64\overline{F}_2 + \overline{F}_1 + (9/4)\overline{P}_1 + (9/4)\overline{P}_2$

Heritability in broad sense (h^2_b %):

Heritability in broad sense is referred to as the ratio of heritable variance to total variance. Heritable variance: (VG) includes additive(δ^2_A), dominance(δ^2_D), and epistatic genetic variances(δ^2_F). The total variance (VP) includes these genetic variances in addition to environmental variance(δ^2_E). Therefore, heritability in broad sense would calculated using the following equation:

$$h^2_b\,\% = \frac{VG}{VP} X100$$

Where:

$VG = \delta^2_A + \delta^2_D + \delta^2_I$

$$VP = \delta^2_A + \delta^2_D + \delta^2_I + \delta^2_E$$

Heritability in narrow sense (h^2_n%):

Heritability in narrow sense was estimated by the following formula:

$$h^2_n \% = \frac{VA}{VP} X100$$

RESULTS AND DISCUSSION

I- The significance of variation among the six generations.

The results of the analyses of variance of the six generations of the three hybrids were obtained and the results are presents in Tables 1. The mean squares of genotypes No. of days to first flower trait were highly significant for the three hybrids The same was true for yield and yield component traits except the hybrid No.3 which showed significant values for shape index and hardness traits . All chemical traits, were traits significant and highly significant with the exception of TSS trait which was insignificant for the H_1 .

The significance of genotypes indicated the presence of large differences between the six generations which obtained for the three different hybrids and indicated that the comparisons between the means of all genotypes would be possible.

II- The performance of the F_1 hybrids and their related generations:

In this study, the means the three F_1 hybrids were evaluated along with their relative generations which included the two parents, the F_1 hybrids, the F_2 generations and the two back crosses are presented in Table 2. It appeared that the F_1 hybrids significantly exceeded their parents, the two back crosses and the F_2 ; for all traits, except days to the first flower. This later trait showed smaller mean but it was an indications of earliness. Inbreeding depression was clear for all traits. However the F_2 generation, and the two back crosses were better than their two parents for all studied traits. Therefor, the results indicated that heterosis was clearly present for the three groups of the studied traits. It should indicated that the parental variety Edkawy only exceeded the F_1hybrid for vitamin C. Although, inbreeding depression was present, the F_2 still better than both parents.

III-The general magnitudes of heterosis and inbreeding depression in the three hybrids of tomatoes.

It has been indicated earlier that the three F_1 hybrids exceeded all related generations for all studied traits. Therefore, it would be useful to determine and estimate the amount of heterosis and inbreeding depression that took place in the three hybrids. The estimated amounts of heterosis and inbreeding depression were obtained for all studied traits and the results are presented in Table 3.

The estimated mounts of heterosis from mid - parent were 100.3 and 62.3% for the hybrid (P_1 X P_2) indicating that it had the heaviest yield as weight and number per plant and of No. of fruits/plant. The hybrid (P_1 X P_4) gave 16%, for shape index.

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The hybrid (P_1 X P_3)gave 43.2%, for hardness in kg. For chemical traits, the hybrid (P_1 X P_4) gave 17.09% for total soluble soileds .The best hybrid for lycopene and ascorbic acid was the hybrid (P_1 X P_2) which gave 129.2 and 15.7% , respectively.

Proportion amounts of heterosis from better - parent were ٦٤.٤ and ٣٨.٤ %for the hybrid (P_1 X P_2) indicating that it had the heaviest fruit yield as weight and number per plant and of No. of fruits/plant. The hybrid (P_1 X P_2) gave 3%, for shape index. The hybrid (P_1 X P_4)gave 25%, for hardness in kg.

For chemical traits, the hybrid (P_1 X P_4) gave 14.0% for total soluble soileds .The best hybrid for lycopene and ascorbic acid was the hybrid (P_1 X P_2) which gave 75.6 and -19.0% , respectively.

Negative estimate of heterosis from the mid-parent was obtained for days to first flower for the three hybrid,The best hybrid (P_1 X P_2) gave -17.11%. This indicated that the hybrids were earlier than their parents.

Negative estimate of heterosis from the better -parent was obtained for days to first flower for the three hybrids, The best hybrid (P_1 X P_2) gave -13.4%.

The performances at the F_2 generations were lower than the F_1 hybrids for all studied traits. However, the magnitudes of the F_2 generation appeared to be higher than the mid-parent for all studied traits. The inbreeding depression was present for all studied traits where the F_2 generation values were lower than their corresponding values of the F_1 hybrid.

The amounts of heterosis from the better parent were present but less than that were obtained from the of mid-parent. It should be indicated that heterosis for vitamin C was not present in F_1 hybrid where it was higher in the parents. Lycopene showed high value of heterosis in the F_1, while it was in the F_2 generation.

IV- The estimated amount of genetic parameters for the three hybrids.

The estimated amounts of genetic parameters were obtain for the different three hybrid for all traits and the results are presented in Table 4.

The additive genetic variance δ^2A and the dominance genetic variance δ^2D were obtained. Where, it appeared that the magnitudes of dominance genetic variances were larger than their corresponding estimates of additive genetic variance for some traits. But it, was vice verses for some other traits.

The estimated amount of heritability in narrow sense and broad sense indicated that the magnitudes of narrow sense heritability which were smaller than those of broad sense. In general, the estimated amounts of heritability in narrow sense was 32% for day to first flower for H_2. The magnitudes of abroad sense heritability ranged from 91.2% for days of first flower. The larger estimates of heritability for some traits indicated that selection would be possible for there traits.

Yield traits which had also large estimates of narrow sense heritability would be improved through selection.

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V – The scaling test for the validity of additive – dominance model

The scaling test which including the A, B, and C parameters which test the validity of additive, dominance model and their corresponding variances were obtain for all traits, and the results are presented in Table 5.

In their respect, the means , additive, dominance, and all epestatic effects are presented in Table 6.

The scaling test: A, B, and C were insignificant because they were smaller than their stander error. This results indicated that additive, dominance model is valid and adequate to explain the natural of gene action for all traits. The other components indicated that the magnitudes of the dominance (h) were larger than their corresponding estimates of additive effect (d) the other epestatic effects variances which included additive by additive (i) additive by dominance (j) and dominance by dominance (l) were insignificant. indicating the validity of the model Similar results were obtained by Whab-Allah(1995) ; Salib (1999) ; Amin *et al*., (2001); and Abd El-Haleem *et al.*, (2010) Arora *et al.*, (2010); Aykuttonk *et al.*, (2011); Adeyanju *et al.*,(2012) and Sher *et al.* (2012). who indicated the validity of additive – dominance model to explain the inheritance of most traits.

In general, the results of this investigation indicated the presents of significant amount of heterosis from the mid and patter parent for all traits. The F_2 generation were lower in their performances than there corresponding F_1 hybrids for all traits indicating the presents of inbreeding depression, although the F_2 generations still higher than the mid parent.

The estimated values of heritability indicated that broad sense heritability's were larger than those of narrow sense for most traits, indicating that there were non-additive genetic variances affected the heritance of all studied traits.

Scaling test revealed that the ‘magnitudes of: A, B, and C the parameters indicated the validity and adequacy of additive - dominance model and indicated the absence of the epstatic variances. Therefore, the results of this study suggest that plant breeders would use hybrid tomatoes in order to increased both yield and quality.

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قياس قوة الهجين والثوابت الوراثية التي تؤثر في توريث الصفات الهامة في الطماطم

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تعتبر الطماطم من محاصيل الخضر الهامة ليس فقط في مصر ولكن في جميع دول العالم . وعلى ذلك إستمرت المحاولات لإنتاج هجن أو أصناف عالية المحصول وعلى ذلك فان هذه الدراسة كان الغرض منها دراسة قوة الهجين التي يمكن الحصول عليها من بعض الهجن وتقدير طبيعة فعل الجين المصاحب لها .

خلال موسم النمو ٢٠٠٩ تم إستخدام أربعة أصناف هي إدكاوى (P_1) و سوبر استرين بى (P_2) ، وبيتو ٨٦ (P_3) ، وفلوريدا(P_4) ومنها تم إنتاج ثلاث هجن حيث تم إستخدام الصنف الأول إدكاوى كأب للأصناف الثلاثة الآخرين التى إستخدمت كأمهات .

وفى عام ٢٠١٠ تم الحصول لكل هجين من الهجن الثلاثة على ستة أجيال هي : الأب الأول ، والأب الثاني ، والجيل الأول ، والجيل الثاني ، والهجين الرجعى للأب الأول ، والهجين الرجعى للأب الثاني. ولقد تم تقييم العشائر الستة لكل هجين لعدد من الصفات الخضرية وصفات المحصول ومكوناته والصفات الكيماوية حيث تم تقدير الإنخفاض الراجع للتربية الداخلية باستخدام طريقة(١٩٨٢) Mather and Jinks التي تفترض أن التأثير الوراثي راجع للتأثير التجميعي والسيادي فقط مع غياب أنواع التأثيرات التفاعلية المختلفة

وأسفرت أهم النتائج على،الحصول على قيم مرتفعة لقوة الهجين لمتوسط الآباء ولقد تم الحصول على قوة هجين تعادل% 100.2 و٦٢.٣ لصفات وزن الثمرة وعدد الثمار لكل نبات على الترتيب بالنسبة للهجين (P_1X P_2) كما أعطى الهجين (P_1 X P_4) قوة هجين قدرها١٥.٢% لمعامل شكل الثمرة .

أما الهجين (P_1 X P_3) فقد أعطى قوة هجين قدرها ٤٣.٢% لصفة الصلابة مقاسه بالكيلو جرام. وكذلك تفوق الهجين(P_1 X P_2) لصفة المواد الذائبة الكلية وفى نسبة الليكوبين بنسبة ١٢٥.٢-١٥.٧ على الترتيب

أما بالنسبة لقوة الهجين مقارنة بأفضل الآباء فقد تم الحصول على قوة هجين تعادل%٦٤.٤-٣٨.٤ لصفات وزن الثمرة وعدد الثمار لكل نبات على الترتيب بالنسبة للهجين (P_1X P_2) كما أعطى الهجين (P_1 X P_2) قوة هجين قدرها٣.٠%لمعامل شكل الثمرة .

أما الهجين (P_1 X P_4) فقد أعطى قوة هجين قدرها 25.0% لصفة الصلابة مقاسه بالكيلو جرام. وكان الهجين (P_1 X P_2) متفوق في المواد الذائبة الكلية وفى نسبة الليكوبين فكانت النسبة ٧٥.٦%.

ولقد إتضح من النتائج أن الجيل الثاني أظهر إنخفاضا كبيرا عن الجيل الأول بجميع الصفات ولقد إتضح من إستخدام طريقة Mather and Jinks لتحديد طريقة فعل الجين إن كل من التأثير التجميعي والسيادي هو المتحكم في توريث معظم الصفات مرجحا غياب جميع التأثيرات الراجعة لجميع التفاعلات الغير أليلية .

قام بتحكيم البحث

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Table 1: Analyses of variance of the six populations for the important traits of the three hybrids.

S.V.	Hybrids	d.f.	Vegetative traits	Yield and its component trait				Chemical traits		
			Day to first flower	Total fruits weight /plant (kg)	No. of fruits/ plant	Shape index	Hardness (kg)	TSS%	Lycopene	Vit. C
Replications	H_1	2	0.1	2.40	11.70	0.99	0.13	0.004	494.1	1.1
	H_2	2	4.6	127.8	57.4*	0.13	0.12	0.06	78.7	0.07
	H_3	2	3.3	75.4	3.2	0.27	0.05	0.04	312.5	0.84
Genotypes	H_1	5	44**	2521**	318**	3.7**	0.97**	0.17	38778**	35.3**
	H_2	5	44**	1428**	328**	6.3**	1.7**	0.16*	2789.9**	35.6**
	H_3	5	50**	2052.6**	444.3**	3.09*	0.76*	0.39**	1803.8**	26.7**
Error	H_1	10	2.6	5.1	20.4	0.45	0.14	0.07	312.4	1.4
	H_2	10	4.9	44.4	14	0.4	0.10.1	0.03	33.3	0.47
	H_3	10	1.6	21.4	5.5	0.3	0.05	0.03	159.7	0.86

Where: H_1 = Edkawy X Super streen B , H_2 = Edkawy X Peto 86 and H_3 = Edkawy X Flourdade.
***, ** Significant at 0.05 and 0.01 levels of probability , respectively.**

Table 2: The mean performances of the six generations for the important traits of the three hybrids.

Six populations	Genotypes	Vegetative traits	Yield and its component traits				Chemical traits		
		Days to first flower	Total fruits weight /plant (kg)	No. of fruits/ plant	Shape index	Hardness (kg)	TSS	Lycopene	Vit. C
Parents	P_1(Edkawy)	79.07	5.65	32.6	0.6	1.6	5.0	284.9	15.9
	P_2(Super streen B)	86.13	3.61	45.8	1.2	2.9	5.2	151.8	6.2
	P_3 (Peto 86)	74.2	4.3	54.2	1.0	3.3	5.3	329.5	5.3
	P_4 (Flourdade)	76.67	4.3	32.5	0.9	2.4	5.3	315.1	6.8
F_1	P_1 X P_2	68.47	9.29	63.7	1.0	3.3	5.6	500.6	12.8
	P_1 X P_3	67.6	8.33	64.5	1.02	3.5	5.5	340.0	12.9
	P_1 X P_4	67.2	9.07	64.5	0.9	2.5	5.7	335.5	12.9
BC_1	P_1 X P_2	78.2	7.12	40.1	0.93	2.7	5.3	258.3	12.2
	P_1 X P_3	75.2	7.06	48.2	0.96	2.7	5.6	302.0	11.1
	P_1 X P_4	75.8	7.2	47.3	0.9	3.2	5.3	354.0	13.2
BC_2	P_1 X P_2	78.93	6.72	44.8	0.95	3.0	5.4	322.4	11.9
	P_1 X P_3	76.07	7.25	46.6	0.87	3.6	5.3	358.3	12.5
	P_1 X P_4	73.67	7.81	47.1	0.8	2.6	5.4	342.8	11.5
F_2	P_1 X P_2	76.73	7.81	47.6	0.92	2.8	5.5	308.9	10.9
	P_1 X P_3	75.93	7.49	52.2	0.88	2.6	5.1	360.5	11.2
	P_1 X P_4	76.2	8.07	52.2	0.9	2.4	5.2	318.7	11.9

Where: H_1 = Edkawy X Super streen B , H_2 = Edkawy X Peto 86 and H_3 = Edkawy X Flourdade .

Table 3: The amounts of heterosis from mid – parent (M.P %) and better parent (B.P %) and inbreeding depression I.D % for the important traits of the three hybrids.

Heterosis and inbreeding depression	Hybrids		Vegetative traits	Yield and its component traits				Chemical traits		
			Days to first flower	Total fruits weight /plant (kg)	No. of fruits/ plant	Shap index	Hardness (kg)	TSS	Lycopene	Vit. C
M.P	H_1	P_1 X P_2	82.6	4.63	39.2	0.89	2.29	5.12	218.4	11.1
	H_2	P_1 X P_3	76.63	4.98	43.3	0.86	2.5	5.15	307.2	10.6
	H_3	P_1 X P_4	77.87	4.98	32.6	0.78	2.03	4.88	300.1	11.38
B.P	H_1	P_1 X P_2	79	5.65	46	1-0	2.9	5.2	285	16
	H_2	P_1 X P_3	74.2	5.65	43.3	1.0	3.3	5.3	330	16
	H_3	P_1 X P_4	77	5.65	34	0.9	2.0	5.0	315	16
F_1	H_1	P_1 X P_2	68.47	9.29	63.7	1.03	3.33	5.67	500.6	12.82
	H_2	P_1 X P_3	67.6	8.33	64.5	1.02	3.6	5.5	340	12.1
	H_3	P_1 X P_4	67.2	9.07	64.5	0.91	2.5	5.71	335.5	12.9
H (M.P) %	H_1	P_1 X P_2	-17.11	100.3	62.3	15.7	45.77	10.88	129.2	15.7
	H_2	P_1 X P_3	-11.79	67.4	48.9	18.6	43.2	7.4	10.65	13.6
	H_3	P_1 X P_4	-13.7	82.15	97.75	16.0	23.1	17.09	11.82	13.47
H (B.P) %	H_1	P_1 X P_2	-13.4	64.4	38.4	3.00	13.7	7.6	75.6	-19.٠
	H_2	P_1 X P_3	-8.8	47.4	43.3	2.00	9.00	3.7	3.2	-24.3
	H_3	P_1 X P_4	-12.3	60.33	89.7	1.10	25.0	14.0	6.47	-19.37
I.D.%	H_1	P_1 X P_2	-12.07	15.9	25.8	10.02	18.6	2.23	38.3	14.1
	H_2	P_1 X P_3	-12.33	10.1	25.3	5.12	24.02	-2.17	11.23	7.87
	H_3	P_1 X P_4	-13.39	11.07	26.58	0.00	-10.8	6.43	-5.5	-1.91

Where: H_1 = Edkawy X Super streen B , H_2 = Edkawy X Peto 86 and H_3 = Edkawy X Flourdade .

Table 4: The estimates of genetic variance including additive (δ^2A), dominance (δ^2D) and heritability (h^2_n % and h^2_b %) for the important traits of the three hybrids.

Genetic parameters	hybrids		Vegetative traits	Yield and its component traits				Chemical traits		
			Days to first flower	Total fruits weight /plant (kg)	No. of fruits/plant	Shap index	Hardness (kg)	TSS	Lycopene	Vit. C
δ^2_A	H_1	P_1 X P_2	37.78	210.7	128.3	0.076	0.94	0.22	2641	14.46
	H_2	P_1 X P_3	25.8	341.8	62.6	0.034	0.8	2.4	716.8	15.6
	H_3	P_1 X P_4	69.8	35.6	184.6	0.020	1.20	0.76	138	0.6
δ^2_D	H_1	P_1 X P_2	2.84	25.9	58.4	0	0.52	0.8	90.8	0.72
	H_2	P_1 X P_3	52.4	99.2	448.4	0	4.2	1.2	137.6	0.4
	H_3	P_1 X P_4	3.04	212.4	170.0	0.036	1.44	0.12	1516	11.96
h^2_n %	H_1	P_1 X P_2	85.2	86.6	66.8	0	81	17.3	99.4	86.8
	H_2	P_1 X P_3	32	76.2	12.1	91.8	15.8	63.0	81.6	91.2
	H_3	P_1 X P_4	91.2	13.8	51.4	35.0	44.0	70.3	8.2	4.4
h^2_b %	H_1	P_1 X P_2	91.2	97.3	97.3	0	125	80.3	96.1	104
	H_2	P_1 X P_3	97.2	98.4	99.1	91.9	99.0	94.7	97.3	93.5
	H_3	P_1 X P_4	95.2	96.6	98.8	98.2	98.5	81.4	99.3	93.2

Where: H_1 = Edkawy X Super streen B , H_2 = Edkawy X Peto 86 and H_3 = Edkawy X Flourdade .

Table 5: The scaling test of the adequacy of the additive dominance model (A, B and C) with their standard devition. for the important traits of the three hybrids.

Scaling test parameter	Hybrids		Vegetative traits	Yield and its Component traits				Chemical traits		
			Days to first flower	Fruits weight /plant (kg)	No. of fruits/ plant	Shap index	Hardness (kg)	TSS	Lycopene	Vit. C
A	H_1	P_1 X P_2	8.87±9.2	-10.6±15	-16.3±16.7	0.18±0.2	1.07±1.32	0.15±1.2	-268.8±70.1	-4.21±5.1
	H_2	P_1 X P_3	3.73±8.77	2.07±20.1	-4.0±23.3	0.08±0.2	2.03±2.1	0.2±1.4	91.7±32.9	-2.93±4.8
	H_3	P_1 X P_4	5.33±11.1	-5.1±19.4	-1.8±18.6	0.12±0.31	1.13±1.54	0.21±1.4	65.2±21.0	-5.91±4.2
B	H_1	P_1 X P_2	3.27±6.5	8.2±17.8	-20±12.5	-0.26±0.2	-0.73±1.54	-0.04±1.8	-7.51±26.8	10.82±4.66
	H_2	P_1 X P_3	10.3±10.3	28.1±23.5	-14.1±22.9	-0.31±0.24	-1.71±2.41	-0.45±1.6	51.52±30.3	4.86±4.6
	H_3	P_1 X P_4	3.47±8.17	33.8±14.9	7.0±20.3	0.14±0.14	-0.01±1.8	0.7±1.4	-13.1±54.7	4.18±4.2
C	H_1	P_1 X P_2	4.8±19.7	50.9±43.8	-16.9±37.1	-0.13±0.7	-0.39±3.44	0.61±3.22	-202±147.6	-3.73±12.3
	H_2	P_1 X P_3	15.2±21.5	50.3±57.3	-22.9±48.8	0.11±0.56	-1.28±4.94	1.25±3.92	-87.25±82.7	-0.9±12.2
	H_3	P_1 X P_4	14.67±25	62.5±3.64	-4.8±47.4	0.38±0.57	3.78±4.04	0.19±3.3	144.7±86.0	4.05±13.16

Where: S.D. is the standard deviation.

Table 6: The estimates of the mean and all epestatic variance with their standard deviation for the important traits of the three hybrids.

Mean and all epestatic variance	Hybrids		Vegetative traits	Yield and its component traits				Chemical traits		
			Days to first flower	Fruits weight /plant (kg)	No. of fruits/ plant	Shap index	Hardness (kg)	TSS	Lycopene	Vit. C
m	H_1	P_1 X P_2	76.73±4.8	7.81±0.72	47.3±9.1	0.9±0.17	2.7±0.83	5.6±0.74	308.9±39.8	11.02±2.97
	H_2	P_1 X P_3	75.93±5.3	7.49±0.95	48.2±12.1	0.97±0.14	2.72±1.2	5.65±0.93	301.7±20.3	11.1±2.9
	H_3	P_1 X P_4	76.2±6.2	8.07±0.59	185.1±11.7	0.93±0.14	3.23±1.0	5.34±0.78	353.9±21.4	13.16±2.05
d	H_1	P_1 X P_2	-0.73±5.2	5.9±11.4	-4.7±10.1	-0.03±0.2	0.3±0.95	-0.02±0.98	-64.12±37.3	-2.66±3.2
	H_2	P_1 X P_3	-0.87±6.5	-2.87±233	-5.6±16.2	-0.02±0.14	1.04±1.6	0.17±1.0	-2.18±21.7	1.41±3.1
	H_3	P_1 X P_4	2.13±6.6	-9.27±11.8	4.47±13.6	0.00±0.17	0.21±1.17	-0.12±0.91	24.1±29.1	-0.5±2.8
h	H_1	P_1 X P_2	-6.8±22.1	16.4±49.1	5.1±42.0	0.19±0.81	1.77±3.8	0.06±3.6	208.27±165.3	12.08±13.6
	H_2	P_1 X P_3	-10.2±25.0	30.2±64.7	26.0±58.5	-0.18±0.64	2.68±5.8	-1.11±4.3	263.1±92.7	2.28±13.6
	H_3	P_1 X P_4	-16.5±28.4	27.6±43.0	67.0±54.5	-0.29±0.66	-2.15±4.64	1.55±3.6	-57.2±103.6	-4.25±10.0
i	H_1	P_1 X P_2	7.3±22.0	-53.3±49	-19.3±41.9	0.05±0.8	0.72±3.8	-0.49±3.5	-73.97±165.2	10.34±13.6
	H_2	P_1 X P_3	-1.2±24.9	-20.1±64.6	4.8±58.4	-0.34±0.64	1.6±5.8	-1.49±4.2	230.5±29.2	2.83±13.5
	H_3	P_1 X P_4	-5.87±28.3	-33.7±42.8	6.0±54.4	-0.41±0.66	-2.65±4.64	0.72±3.6	-92.6±103.6	-5.79±9.9
j	H_1	P_1 X P_2	2.8±5.5	-9.4±11.5	1.9±10.2	0.22±0.2	0.9±0.97	0.1±1.0	-130.6±37.4	-7.51±3.35
	H_2	P_1 X P_3	-3.3±6.7	-13.0±15.3	5.07±16.3	0.19±0.14	1.87±3.4	0.32±1.0	20.1±21.9	-3.9±3.2
	H_3	P_1 X P_4	0.93±6.7	-19.4±12.0	14.07±13.6	0.13±0.17	0.57±1.1	-0.24±0.96	39.1±29.2	-5.04±2.9
l	H_1	P_1 X P_2	-19.5±28.9	55.7±63.3	55.6±55.1	0.03±1.0	-1.05±5.1	0.4±3.3	350.4±210.0	-16.95±17.8
	H_2	P_1 X P_3	-12.8±34.0	-10.0±83.7	13.3±81.2	0.58±0.84	-1.92±8.12	1.74±5.6	-373.6±120	-4.75±17.7
	H_3	P_1 X P_4	-2.93±36.7	5.0±59.8	-52.4±72.2	0.43±0.88	1.53±6.1	-1.63±1.46	40.5±144.8	7.52±14.2

Where: S.D. is the standard deviation.