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DEVELOPING NEW EGYPTIAN LOCAL LINES OF TOMATO (*SOLANUM LYCOPERSICUM* L.)

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ABSTRACT: *A study was conducted at Zifta district, Gharbia governorate, at middle delta region of Egypt during seven successive seasons of 2009-2015 to study the genetic variability and heritability for some plant and fruit characteristics in tomato. Fifteen F7 lines were selected from 4 F2 generations of six generations of selection. The estimated coefficient of variance (C.V %) values (degree of homogeneity) differed among the studied genotypes for the same character and from trait to another of the same genotype. The selected genotypes were enough homogenous for the studied traits and then it could be considered as new lines. A great diversity and significant differences were observed among the fifteen selected genotypes for all studied traits. The lines S.209, K.111-1, K.111-6, AL. 3-1-3 and EUR. 2-2 were considered the best lines for yield and fruit quality traits, and could be used in breeding programs to develop new local F1 hybrids of tomato.*

The results showed high values for genotypic coefficient of variation (G.C.V %) compared with the phenotypic coefficient of variation (P.C.V %) and high heritability in broad sense (h^2bs) for all studied traits. The G.V.C% vs P.C.V% and (h^2bs)values were 18.43 vs 22.08% and 0.70 for (days to 50% flowering), 20.09 vs 22.46 and 0.8(for plant height),22.94 vs 24.80 and 0.86(for number of branches),16.67 vs 17.26 and 0.93 (for early yield), 18.25 vs 18.53 and 0.94 (for total yield), 16.59 vs 19.22 and 0.75 (for fruit firmness),indicating small environmental effects and large additive genetic components of the phenotypic variation for these traits and can be improved through selection programs.

Key words: *Tomato breeding, genotypes, local varieties.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the most important vegetable crop grown for human consumption. Since the modern cultivars often have higher crop indices than the older outmoded ones (Holiday, 1976),attention must be given to development of new high yielding lines through breeding programs. The breeder hopes to find plants in F2 that combine the desired levels of expression. Maximum progress in improving a character would be expected with a carefully designed pedigree selection program, when the additive gene action is the main component of gene effects. Many studies reported that, the additive genetic variance was more important than non-additive ones for most tomatoe traits, among them were Metwally *et al.,* (1996), Thakur and Kohli, (2005), Saeed *et al.,* (2008), Shahabuddin *et al.,* (2009), Salib (2012), and Kansouh (2013 & 2014), for number of plant branches, average fruit weight and fruit firmness. According to Bhatt *et al.,* (2001), Hannan *et al.,* (2007) Singh *et al., (*2007), Sekhar *et al.,* (2010) and Kansouh (2013), the magnitude of additive and non-additive variance was significant and approximately play the same role in the inheritance of tomato early and total yield.

A close correspondence between genotypic coefficient of variation (G.C.V%) and phenotypic coefficient of variation (P.C.V%)varies with high values of broad sense heritability (h^2b) previously reported by Asati *et al.,* (2008), Anjum Ara *et al.,* (2009), Surma *et al.,* (2009), Kansouh and Zakher (2011), Ahirwar *et al.,* (2013), and Kansouh (2013), for plant height, number of branches, early and total yield, average fruit weight and total soluble solids (TSS%) content.

Selection is an important methods for improving characters, especially in self-pollinated crops, Berry and Rafique (1988), selected F3 and F4 lines of tomato adapted to high temperature from different origins. Kansouh (2002), developed high yielding lines of tomato by selection from 3 F2 populations. Also, Islam *et al.,* (2011), selected segregating tomato lines and evaluated them to develop high yield and virus resistant varieties. The main objective of this study was to develop a new promising local lines of tomato by selection and estimating the extent of variability and dividing that variabilities into heritable and non-heritable components in the selected lines.

MATERIALS AND METHODS

This study was carried out at the growing farmers of Zifta districts, Gharbia governorate, Middle delta region during the successive summer seasons of 2009 till 2015. Seeds of 4 F2 populations of tomato (*Solanum lycopersicum* L.) were developed and used for this study. In season of 2009, 300 plants from each of the four populations were grown, the best 28 plants were selected and seeds were separately collected. In the season of 2010, a number of 100 plants from the progeny of each selected plant were planted. Observations and selection were made between and within the F3 families, in order to select the best plants with the best fruit characters. Nine families were excluded according to preliminary observations, seeds of the best plant from each remained family were separately collected as F4. The planting, observation and selection were continued during the seasons of 2011 and 2012, in order to obtain seeds of the F6 generation. In the season of 2013, sixty plants with three replicates (20 plants/plot) of the F6 populations representing 19 selected genotypes were grown with the commercial cv. Super strain B and Allisa F1 Hybrid (as check cvs). The coefficient of Variance (C.V %) was estimated for all selected genotypes concerning some characters (days of flowering, plant height, fruit shape, fruit firmness and total soluble solids TSS% content) to determine the degree of its homogeneity. At the same time data for some plant and fruit characteristics were recorded. According to the obtained data, five populations were excluded due to their high heterogeneity (C.V %). The remaining 14 genotypes, in addition to the line S.2 (which chosen from a breeding program conducted by Kansouh 2002), were evaluated again with the check cultivar Supper strain B. the seedlings were transplanted on February 15th in all seasons of the experiments. A randomized complete block design with three replicates was used. The plants were spaced at 40 cm apart on rows, 125 cm wide between rows, and 500 cm long. Routine cultural practices were similar to farmers' conditions in tomato commercial production.

Data were recorded for the following characters, number of days from transplanting to flowering of 50 % of plants, plant height (cm) and number of primary branches /plant at the end of flowering stage, early yield (kg/plant) as yield of first three harvests, total yield (kg/plant) as total weight of all harvested fruits, average fruit weight , fruit firmness (g/cm) (measured by using a needle type pocket penetrometer), and fruit shape index (estimated by dividing fruit length on fruit diameter) and described to UPOV guide 1992). Analysis of variance, component of variance (coefficient of variance, C.V%, genotypic and phenotypic coefficient of variance, G.C.V% and P.C.V %) and broad sense heritability (h^2b) were estimated as reported by Singh and Chaudhary (1995).

RESULTS AND DISCUSSION

1. Degree of homogeneity:

Estimated coefficient of variance (C.V%) values for number of days from transplanting to 50% flowering of plants (Table 1) showed that , the selected genotypes PPP.1-2 , ROC.1,ROC.1-2-3 , SQ. 5, and DUS. 7-4-1 recorded C.V % values higher than those of the check cultivars Alissa F1 hybrid and supper strain B , indicating high heterogeneity (C.V% > 7.00), the remaining selected genotypes become higher homogenous for this trait , since they reflected C.V % values close to or lower than those of the check cvs. Supper strain B, and Alissa F1 hybrid. However, the genotype of EUR. 2-2, ROC.2 and GAP-16 showed the lowest C.V% values , i.e. 3.87, 3.91 and 3.87 % respectively , indicating that they are more uniform than other genotypes or check varieties.

Plant height, estimated coefficient of variance (C.V %) values (Table 1) ranged from 3.10, to 13.57% in the selected genotypes, compared with 5.12 and 7.33 in the check cultivars. (Super strain B and Alissa F1 hybrid). The genotypes PET-8, AL -3B, STA 12-10, SMA-12 and GAP-16 could be considered the highest homogenous for this trait, since they gave the lowest variation values (C.V % <5.00). On the other hand, the lowest homogeneity were observed in the genotypes ROC, 1-2-3 and DUS. 7-4-1, where they gave the highest C.V % values (11.65 and 13.75 %, respectively). However, except the four genotypes PPP.1-2, RDC.1, ROC.1-2-3 and DUS 7-4-1. All lines became high homogeneous in this trait , since they gave C.V % values close or lower than the commercial Super strain B and Alissa F1 hybrid .

Concerning fruit shape index, data listed in (Table 1), showed that, the highest homogeneity was observed in the genotypes, K111-6, and GAP-16, since they gave the lowest C.V % values (6.13 and 5.67 %, respectively), while, plants of the four genotypes ROC. 1, ROC. 1-2-3, SQ5 and DUS. 7-4-1 showed the highest heterogeneity, since they recorded the highest C.V% values (C.V% >10.00). However, except those previous four genotypes, the C.V % values of new breeding lines were lower than those of the check cultivars (Super strain B, and Alissa F1 hybrid), indicating high homogeneity for this trait,

Regarding fruit firmness, the genotypes ROC.1 and PET-8 could be considered the highest homogenous, since they reflected the lowest variation (C.V% were 4.01 and 3.67% respectively), while the highest heterogeneity was observed for the genotype ROC.1-2-3, (C.V% = 8.57%). However, except the five genotypes which showed C.V % more than 5%, all selected genotypes became highly homogeneous for this trait, since they reflected C.V % values lower than that of the check cultivar Supper strain B.

For total soluble solids content (TSS%), results showed that the lowest C.V % values, i.e., 8.15, 8.93 and 9.01% were recorded by the genotypes S.209 , ROC. 2 and GAP.16, respectively , indicating that they were more uniform than other genotypes. In this respect, except the five genotypes PPP1-2, ROC-1 ROC.1-2-3, SQ-5 and DUS. 7-4-1 which showed C.V % values higher than 12.00%(high heterogeneity)the remaining selected genotypes showed high homogeneity for this trait , since they reflected C.V% values close to or lower than those of check variety Super strain B , and Alissa F1 hybrid.

Generally, the degree of homogeneity (C.V %) differed among the studied genotypes for the same character and from trait to another in the same genotype. Also, obtained coefficient of variance (C.V%) values for studied traits showed that the genotypes PPP1-2, ROC.1, ROC1-2-3, SQ.5 and DUS 7-4-1 reflected the highest C.V % values compared to those given by the check cultivar Super strain B and Alissa

F1 hybrid for most traits, indicating high heterogeneity, so they were excluded. The remaining 14 selected genotypes are enough homogenous, since they showed C.V% values near or lower than those of the two check varieties , then it could be considered as new lines. These results are in agreement with those of Berry and Rafique (1988), Kansouh (2002), and Islam *et al.,* (2011), who selected many lines of tomato from F2, F3, and F4 generations and reported that the selected lines became higher in homogeneity after F6 generation.

Table (1): Estimated coefficient of variance (C.V %) values for five studied characters in the selected estimated genotypes.

Genotypes	Days of flowering	Plant height cm.	Fruit Shape index	Fruit Firmness g/cm.	TSS %
S.209	4.26	5.33	6.83	4.36	8.15
PPP.1-2	9.63	12.1	8.01	5.13	12.82
ROC-1	7.53	8.33	13.25	4.01	14.57
ROC. 1-2-3	7.67	11.65	12.86	8.57	13.86
S.Q-5	12.01	7.83	10.33	5.93	16.64
PET-8	5.12	4.11	7.51	3.67	10.33
END-1	6	6.67	8.01	4.19	9.81
K.111-1	4.36	5.4	7.6	4.37	10.01
K.111-6	5.67	5.37	6.13	5.00	9.67
AL.3B	4.73	3.1	6.81	4.12	10.33
AL. 3-1-3	5.2	6.25	7.46	4.83	10.46
EUR. 2-2	3.87	5.1	7.03	4.36	9.52
DUS.7-4-1	9.13	13.57	13.56	5.10	14.5
STA. 12-10	5.10	4.02	7.14	5.00	9.67
PO.16-3	4.37	6.16	6.72	5.17	10.13
L.2	6.01	5.93	6.83	4.3	9.51
ROC-2	3.91	5.67	7.46	4.56	8.93
SMA-12	4.16	4.33	8.63	4.67	9.63
GAP-16	3.87	4.83	5.67	4.11	9.01
Alissa-F1 hybrid	4.67	5.12	7.16	3.87	9.27
SSB*	5.83	7.33	8.67	4.63	10.13

SSB*: The commercial cultivar super strain B as check cv. (control)

II. Mean performance of the selected lines:

Highly significant differences were observed among the selected lines for all studied traits (Table 2). For number of days to 50% flowering, it's ranged from 23.17 to 47.5 with a mean of 38.61 days compared to 38.67 days in the check cultivar Super strain B. The line GAP-16 could be considered the earliest flowering, since it recorded 23.17 days to 50% flowering, followed by the lines PET-8, AL-3B, EUR2-2 and PO16-3 where they recorded less than 35.0 days. On the other hand, the latest flowering line were L-2, and ROC-2, since they showed 50% flowering at 44.28 and 47.5 days, respectively. However, except, the lines GAP-16 and ROC-2 no significant differences between the selected lines and the check cultivar Super strain B were recorded for this trait.

Regarding the plant height**,** highly significant differences among means of the evaluated lines were observed (Table 2). Their means ranged from 18.25 cm (for line GAP-16) to 150.33cm(for line L-2) with a mean of 61.92 cm. Compared to the check cultivar Super strain B , five lines (which showed plant height > 65.0 cm) significantly exceeded check cultivar by percentage ranged from 19.18% (in the line K-111-6 to 172.49 % for the line L2). However eight other lines were statistically similar to the control for this trait.

The highest number of branches per plant (more than 8.0 branches per plant) were recorded for the lines S-209, K-111-1, K 111-6 and L-2. They significantly exceeded the control by percentages of 26.34 %, 30.17%, 24.81% and 118.22 %, respectively. However, except the line GAP-16, which showed the lowest value (5.16), the remaining ten lines were statistically similar to the check cultivar Super strain B (Table 2).

High significant differences among early yield means of the evaluated lines were observed (Table 2). The recorded early yield ranged from 0.256 to 1.625 Kg /plant. The highest early yield (more than 1.40 kg/plant) were produced by the lines S-2, S.209, AL-3B, AL-3-1-3,EUR.2-2 and STA 12-10 , and significantly exceeded Super strain B (control) by values ranged from 7.78%(for line S.209)to 23.11% (for line AL 3-1-3).

Total yield reflected also a great variation among the selected lines evaluated (table 2). The six lines, S.209, K111-1, K111-6, AL 3-1-3, EUR 2-2 and L-2 were considered the best lines since they produced the highest total yield values (more than 6.00 Kg /plant).Also, they exceeded the check cultivar Super strain B by values ranged from 7.21 % (for line AL 3-1-3) to14.65 % (for the line L-2). On the other hand, the lowest yield value (0.410 Kg /plant) was observed for the line GAP- 16

Average fruit weight of the selected lines ranged from 15.32 gm to 165.67 gm, reflecting significant differences among the studied lines. The heaviest fruit weight (more than 140.0gm) was produced by the lines S.209, AL-3B and SMA- 12, while the lightest fruit weight was recorded for the line GAP-16 (15.32gm)

For fruit firmness (Table 2) lines S.209, PET-8, K111-1, K111-6, AL.3B and PO16-3 produced the firmest fruits (561.2 to 605.3 g/cm) and statistically similar to the check cultivar Super strain B (592.7g/cm), followed by the lines S.2 , AL3-1-3, EUR 2-2 and STA12-10 with values of 512.7 to 542.5 g/cm . On the other hand, fruits of the lines END-1, L-2, ROC.2, SMA-12, and GAP-16 recorded the lowest firmness values (less than 500g/cm).

Generally, According to data obtained, the lines S.209, K111-1, K-111-6, AL.313 and EUR 2-2 were considered the best lines, since they produced the highest total yield with good fruit traits compared to the commercial cultivar Super strain B. It also could be used in breeding programs to develop new local F1 tomato hybrids adapted to Egyptian environment. Also, our results showed that, pure line selection as a breeding method would be effective for improving yield and fruit characteristics of tomato in Egypt. These results are confirmed with the results obtained by Kansouh, (2002), Anjum Ara *et al.,* (2009), Islam *et al.,* (2011), and Patel *et al.,* (2013), who found significant differences among tomato lines and cultivars studied for the same traits.

Table (2): Mean performances of the evaluated breeding genotypes for some plant and fruit characteristics in tomato.

Genotypes		Days of 50% flowering	Plant height (cm.)	Number of branches/ plant	Early yield (kg/ plant)	Total yield (kg/plant)	Average fruit weight (g)	Fruit Firmness (g/cm.)	Fruit Shape
S.2		37.14	57.21	6.17	1.588	4.78	110.4	512.7	Cylindrical
S.209		35.86	65.81	8.25	1.42	6.176	142.17	581.6	Obovoid
PET-8		34.17	43.16	5.61	1.125	3.22	75.67	605.3	Ovoid
END-1		40.35	52.10	5.83	1.01	4.013	105.36	471.5	Round
K.111-1		40.11	68.13	8.5	1.315	6.445	135.72	572.1	Cylindrical
K.111-6		43.38	65.75	8.15	1.275	6.357	130.5	565.4	Cylindrical
AL.3B		34.67	54.16	6.16	1.573	5.718	140.13	561.2	Obovoid
AL 3-1-3		35.16	58.19	6.63	1.625	6.125	135.76	542.5	Obovoid
EUR.2-2		32.6	67.13	7.1	1.58	6.51	130.5	536.1	Obovoid
STA12-10		35.33	55.63	6.45	1.45	5.773	120.35	530.6	Cylindrical
PO.16-3		33.46	61.22	6.83	1.23	5.51	120.13	572.1	Obovoid
L.2		44.28	150.33	14.25	0.905	6.55	110.63	460.5	Round
ROC-2		47.5	63.75	6.35	1.13	4.813	135.25	482.7	Clyindrical
SMA-12		41.12	51.16	5.47	1.215	4.725	165.67	375.6	Round
GAP-16		23.17	18.25	5.16	0.256	0.41	15.32	410.4	Ovoid
Mean		38.61	61.92	7.11	1.21	5.21	129.4	510.1	
SSB*		38.67	55.17	6.53	1.32	5.713	135.63	592.7	Obovoid
L.S.D	5%	7.66	10.15	1.1	0.085	0.355	20.51	31.6	
	1%	10.18	13.5	1.46	0.113	0.473	27.28	42.03	

SSB*: The commercial cultivar Super strain B as Check cv. (control)

III Components of variance:

Estimations of coefficient of variation (C.V %) components of variance, i.e. environmental variance (σ^2e), genetic variance (σ^2g), phenotypic variance (σ^2p), geno- and phenotypic coefficient of variance (G.C.V%, P.C.V %), GCV/PCV ratio and broad sense heritability (h^2b) for the studied traits are listed in Table 3. The variance varied from trait to another , since the coefficient of variation (C.V%) ranged from 3.79% to 12.15%.The highest variation among the selected lines was detected for number of days to 50% flowering and plant height since, they recorded the highest C.V% values (12.15 and 10.04%, respectively). Respecting the order, the low variation among the lines was observed for fruit firmness character, while it showed C.V % value of 3.79%.

Regarding the genetic and phenotypic variances (σ^2 g and σ^2 p), estimated σ^2g vs σ^2p for the studied traits were 50.65 vs 72.65 for the character of days to 50% flowering, 154.78 vs 193.42 for plant height 2.66 vs 3.11 for number of branches, 0.041 vs 0.044 for early yield, 0.904 vs 0.952 for total yield, 460.98 vs 618.72 for average fruit weight and 1149.5 vs 1523.96 for fruit firmness. In this respect, the studied traits showed low values of difference between phenotypic and genotypic variance, indicating that, large portion of the phenotypic variance σ^2 p was due to the genetic variance σ^2 g and the observed significant differences among the selected lines are genetically controlled.

Table (3): Coefficient of variance (C.V %), component of variance (σ^2 g and σ^2 p), geno- and phenotypic coefficient of variation (G.C.V and P.C.V %) and broad sense (H^2BS) heritability for studied traits.

Genotypes	Days of 50% flowering	Plant height (cm)	Number of branches/ plant	Early yield (kg/ plant)	Total yield (kg/plant)	Average fruit weight (g)	Fruit firmness (g/cm.)
C.V%	12.15	10.04	9.43	4.51	4.21	9.71	3.79
σ^2 e	22	38.64	0.45	0.003	0.048	157.74	374.46
σ^2g	50.65	154.78	2.66	0.041	0.904	460.98	1149.5
σ^2 p	72.65	193.42	3.11	0.044	0.952	618.72	1523.96
H^2BS	0.70	0.8	0.86	0.93	0.94	0.75	0.75
G.C.V%	18.43	20.09	22.94	16.67	18.25	16.59	6.65
P.C.V%	22.08	22.46	24.8	16.26	18.53	19.22	7.65
gcv/pcv %	83	89	92	96	98	86	87

For geno- and phenotypic coefficient of variation (GCV% and PCV%), estimated GCV % vs PCV % values for the studied traits (table 3) were , 18.43 vs 22.08 for days to 50% flowering , 20.09 vs 22.46% for plant height , 22.94 vs 24.80 for number of branches , 16.67 vs 17.26 for early yield , 18.25 vs 18.53 for total yield , 16.59 vs 19.22 for average fruit weight and 6.65 vs 7.65 for fruit firmness. Also, obtained broad sense heritability (H^2BS) values for the traits ranged from 0.70 to 0.94, suggesting high values of heritability. Likewise, the GCV/PCV ratios showed high values, since ranged from 83 to 97%. Generally, smaller are the values of differences between pheno and genotypic coefficient of variations, the lesser will be the environmental effect on the character. In another term, the large portion of phenotypic variance (σ^2 p) was due to the genetic variance and significant differences among the studied breeding lines are genetically controlled with a small environmental effects. Therefore, these characters could be improved through selection based on phenotypic observations and selection for such cases would be effective in achieving superior lines through the early segregating generations in tomato. These results are in agreement with the findings of Asati *et al.,* (2008), Anjum Ara *et al.,* (2009), Suarma *et al.,* (2009), Kansouh and Zakher (2011), and Ahirwar *et al.,* (2013), who found a close correspondence between geno- and phenotypic coefficient of variation with high broad sense heritability values for the same traits studied in tomato and suggested selection for improving these traits.

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إستنباط سلالات جديدة مصرية من الطماطم محلياً

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الملخص العربي

أجريت هذ الدراسة بمركز زفتى غربية بإقليم وسط الدلتا خلال الفترة من ٢٠٠٩ إلى ٢٠١٥ لتقدير ودراسة التباين الوراثي والكفاءة الوراثية لبعض الصفات المرتبطة بالنبات والثمار في الطماطم. تم اختيار ١٥ سلالة جيل سابع منتجة من ٤ عشائر جيل ثاني بعد ٦ أجيال انتخابية.

أظهرت حسابات معامل الاختلاف ان السلالات المنتخبة اصبحت عالية التجانس وان اختلف المعامل من صفة لأخرى وأظهرت الدراسة وجود تنوع وفروق معنوية بين السلالات وبعضها في كل الصفات المدروسة. تعتبر السلالات أس ٢٠٩ و ك.١١١ – ١ و ك. ١١١ – ٦ و إيه أل ٣ –١ –٣ و إي يو أر. ٢–٢ أفضل السلالات في الصفات المحصولية والثمرية ويمكن استخدامها في برامج تربية لإنتاج هجن محلية.

أظهرت النتائج أيضًا قيم عالية لمعامل الاختلاف الراجع للتباين الوراثي مقابل معامل الاختلاف الراجع للتابين الظاهري وكذلك كفاءة وراثية عالية في كل الصفات. وكان معامل الاختلاف الراجع للتباين الوراثي مقابل الراجع للتباين الكلي (الظاهري) وكذلك الكفاءة الوراثية كالآتي: ١٨,٤٣ مقابل ٢٢,٠٨ % وكفاءة وراثية ٠,٧٠ لصفة عدد الأيام حتى تزهير ٥٠% من النباتات و٢٠,٠٩ مقابل ٢٢,٤٦ وكفاءة وراثية ٠,٨٠ لصفة طول النبات و٢٢,٩٤ مقابل ٢٤,٨٠ وكفاءة وراثية ٠,٨٦ لصفة عدد الفروع الأولية و١٦,٦٧ مقابل ١٧,٢٦ وكفاءة وراثية ٠,٩٣ لصفة المحصول المبكر و١٨,٢٥ مقابل ١٨,٥٣ وكفاءة وراثية ٠,٩٤ لصفة المحصول الكلي و ١٦,٥٩ مقابل ١٩,٢٢ وكفاءة وراثية ٠,٧٥ لصفة متوسط وزن الثمرة و ٦,٦٥ مقابل ٧,٦٥ وكفاءة وراثية ٠,٧٥ لصفة صلابة الثمار مما يدل على صغر تأثير البيئة على هذه الصفات وأن الجزء الأكبر من المكون الكلي (الظاهري) للتباين يرجع إلى المكونات الوراثية لعوامل الإضافة مما يجعل تحسين هذه الصفات ممكن خلال برامج الانتخاب.