

BREEDING FOR DEVELOPING NEW INDETERMINATE LINES OF TOMATO (*SOLANUM LYCOPERSICUM* L.) BY SELECTION

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ABSTRACT: *Twenty new lines of indeterminate tomato (F₆) were selected from two F₂ generations, which exhibited high homogeneity based on estimated CV% values for plant height, number of leaves/plant, fruit length, fruit diameter and TSS% content during successive six seasons from 2012/2013 to 2017/2018 at the Experimental Farm, Faculty of Environmental Agricultural Sciences, Arish University, North Sinai under greenhouse conditions. The experimental work was conducted using a Randomized Complete Blocks Design with three replications. A highly significant differences were observed among the selected lines for all studied characters. Lines that showed the most vigorous growth were VL-4-1, VL-4-4, VL-5-1, VL-2-3, VL-7-4 and IR-44-2 and for total yield were VR-6, VR-6-40, IRS-43-2, IR-44-1 and IR44-2. The estimated genetic parameters revealed low differences between phenotypic and genotypic coefficient of variations for all studied traits indicating low environmental effects, and the phenotypic selection was effective and suitable for improvement the tomato. High GCV / PCV % ratios were detected for most studied traits, which suggest that the genetic improvement through selection is possible. The high estimates of heritability in broad sense which ranged from 82.44 to 99.63% support the possibility of using selection programme. The importance of selection was also supported by the estimated high heritability coupled with high genetic advance as percent of mean for all studied traits.*

Key words: *Tomato, indeterminate lines, homogeneity, genetic variability, heritability, genetic advance, selection.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops in Egypt and worldwide. Their fruits have important nutritive value and health benefits, so it is consumed fresh or in multiple processed forms. It cultivated in open field or under greenhouse conditions. Consequently, there is a need to develop new indeterminate lines or cultivars suitable for cultivation under greenhouse with high yield and fruit quality. This aim could be achieved by breeding programs such selection through the segregating generations.

Breeders hope to find desired plants in the F₂ and advanced generations. Genetic variability in tomato was studied

by many investigators in different countries using various genotypes. Under Egyptian conditions, Kansouh (2002) developed 24 promising lines of tomato from three F₂ populations by selection, these lines were highly homogenous and suitable for cultivation at Middle Delta Region. In India, Sharanappa and Mogali (2014) studied the genetic variability in 284 F₂ tomato plants derived from one cross, they found that both phenotypic and genotypic (PCV& GCV) coefficient of variability were high for average fruit weight and total yield/plant, while they were low for plant height and days to first anthesis of 50% of plants. Genetic variability among 19 indeterminate tomato genotypes was studied by Meena

et al. (2015), they found highly significant differences among all genotypes, and PCV was higher than GCV for all studied traits. The study of Lekshmi and Celine (2017) on forty tomato genotypes under greenhouse showed wide range of variability among the genotypes, indicating that selection for superior genotypes suitable for greenhouse conditions could be achieved. They also reported that GCV/PCV ratio was high for plant height, average fruit weight and yield/plant. It is necessary to know the extent and magnitude of additive and non additive gene effects, heritability and genetic gain of traits. The traits which have high values of GCV have high scope of improvement through selection (Patel *et al.*, 2015; Lekshmi and Celine, 2017). High heritability accompanied with high genetic advance as percentage of mean were recorded for most studied traits in tomato, suggesting that these traits were controlled by additive gene effects and that the straight selection is very important and more effective in tomato improvement (Kumar *et al.*, 2013; Sharanappa and Mogali, 2014; Rai *et al.*, 2016; Singh *et al.*, 2017).

In Egypt, few studies have been carried out for developing indeterminate tomato lines. Therefore, this study aimed to develop some indeterminate new lines by selection from two F₂ populations resulted from two commercial F₁ hybrids under El-Arish conditions, in addition to estimate the magnitude of variability, heritability and genetic advance.

MATERIALS AND METHODS

A field experimental work was carried out at the Experimental Farm, Faculty of Environmental Agricultural Sciences, Arish University, North Sinai, under greenhouse, during six successive seasons from 2012/2013 to 2017/2018 to develop some new indeterminate tomato lines for high vegetative growth vigour, high yield and fruit quality traits. The

program was started with seeds of two F₂ populations which were obtained from two different commercial F₁ hybrids, i.e., "V59-48" with obovate fruits (Tezier Co.) and "Izmir" with globe fruits (Syngenta Co.).

In the first season (2012/2013), 1200 plants from each F₂ population were planted under two plastic greenhouses (9mx60m), and thirty five plants were selected from the 2400 plants and their seeds were separately collected to form F₃ populations. In 2nd season (2013/2014), 65 plants from each of the 35 selected plants were grown as F₃ and the selection between and within F₃ populations was done for taller main stem, higher number of leaves, shorter time to achieve first flower as well as plants that produced higher early and total yield, selection also included fruit quality. Six populations were eliminated and seeds of the remained 29 families were separately collected as F₄ populations.

The selection was continued during the third season (2014/2015) to choose plants that had the desired characters to develop 29 families of F₅ populations concerning the mentioned traits. In the 4th season (2015/2016), the 29 families of F₅ were grown to produce F₆ populations. In the 5th season (2016/2017), the 29 genotypes (F₆) as well as, two check cultivars (CLN 1462A) brought from the Asian Vegetable Research and Development Center (AVRDC) and F₁ hybrid Myla from (Syngenta Co.) were used as control to determine the degree of homogeneity in the 29 families based on the estimated coefficient of variation (CV%) for some traits i.e., plant height, number of leaves/plant, fruit length, fruit diameter and TSS%. At the same season data were recorded, on yield and some fruit characteristics. Based on degree of homogeneity, nine families were excluded which showed high

heterogeneity and the remaining 20 ones were evaluated under two plastic greenhouses in the six season (2017/2018) with the same check cultivars.

During all seasons seeds were sown in speedling trays at the second week of October and transplanted at the first week of December. In the latter two seasons, a randomized complete blocks design (RCBD) with three replications was used, each replicate contained 22 genotypes (20 F₆ populations and 2 checks). The plot area was 13.5 m² (9m length x1.5m width). Drip irrigation system was used, each plot had two dripper lines and the distance between the double dripper lines centers was 150 cm and plants were set 50 cm apart. The chemical analysis of irrigation water over two seasons had EC 5.85 dSm⁻¹ and pH 7.17. The experimental soil was sandy loam while PH 8.06, EC 1.0 dSm⁻¹, organic matter 0.16% and Ca(Co₃)₂ 22.53% (average of two seasons).The Irrigation and fertilization regimes, pest control as well as plant pruning were applied as commonly recommended in El-Arish Region.

Data recorded: Five plants from each plot were chosen and labled after 90 days from transplanting to determine plant height (cm) and number of leaves/plant. All plants (36) /plot were harvested tell the end of the experiment and early yield /plant (kg) which was yield of the first three harvesting, total yield/plant (kg) and average fruit weight (g) were then determined. Five fruits/plot were taken randomly in the third harvest for measuring, pericarp thickness (mm) and counting number of loculs/fruit. Fruit shape index was calculated by (fruit length cm (L)/fruit diameter cm (D)) and described according to UPOV Guide (2013). Total soluble solids percentage (TSS%) was determined by a hand

refractometer. Vitamin C content (mg/100 g fresh weight) was determined by titration with 2, 6 Dichlorophenolindophenol as described in A.O.A.C. (1990).

Statistical analysis: the combined data over the two seasons (2016/2017 and 2017/2018) were calculated and subjected to statistical analysis of variance according to Snedecor and Cochran (1980) and means separation was done according to Duncan (1955). Genotypic (GCV) and phenotypic coefficient of variation (PCV) were calculated according to Burton and Devane (1953). Heritability in broad sense was estimated according to Allard (1999). Genetic advance and genetic advance as percent of mean were calculated using the formula of Johnson *et al.* (1955).

RESULTS AND DISCUSSION

Degree of homogeneity was determined by estimated coefficient of variance (CV %) as shown in Table (1). For plant height, it ranged from 3.86 to 17.39% for the selected genotypes. Twenty genotypes showed lower CV% values than those of the check cultivars, indicating high homogeneity for this trait, while the remaining ones (9 genotypes) showed higher CV% values than those of the check cvs. Regarding number of leaves/plant, most genotypes showed high homogeneity, since they gave the lowest CV% values, they were close to those check cvs. in this respect. The genotypes VR-6, VL-3-4, VL-7-4, IRS-43-2 and IR-43-3 recorded the lowest CV% values (4.28, 4.58, 4.41, 3.03 and 4.92, respectively), indicating that they were the most uniformity. Concerning days to first flower, most breeding lines showed low CV% values compared with the check cultivars. Only seven lines were slightly higher than the control in this respect.

Table 1: Estimation of coefficient of variance (CV%) for six characters in the selected genotypes of tomato crop.

Genotypes	Plant height	Number of leaves/plant	Days to 1st flower	Fruit length	Fruit diameter	TSS%
VR-1-2	7.95	10.19	11.14	10.56	9.27	10.94
VR-2-4	14.95	10.61	12.44	9.48	9.07	6.53
VR-3-1	9.59	10.14	8.59	12.84	11.91	7.71
VR-4-4	12.06	14.41	10.26	10.58	11.60	10.94
VR-4-3	7.39	5.04	3.28	5.06	6.69	2.94
VR-6	3.86	4.28	2.70	3.82	4.36	3.64
VR-6-40	4.89	5.12	4.45	3.36	5.96	2.59
VL-4-1	5.23	5.88	3.85	5.85	4.59	3.18
VL-4-4	5.71	5.35	4.97	4.51	6.01	4.51
VL-5-1	4.86	5.71	5.23	4.06	5.42	4.18
VL-5-4	5.27	5.52	3.57	5.07	4.87	3.23
VR-5-50	16.68	11.84	9.54	10.10	8.93	7.21
VR-7-1-1	15.45	12.39	10.86	9.69	8.32	7.84
VL-6-3	6.94	5.45	2.91	5.55	5.09	3.70
VL-6-4	17.39	12.89	10.14	10.08	12.83	10.07
VL-2-4	7.60	5.12	6.58	3.91	5.37	2.70
VR-2-5	5.52	6.52	3.95	4.27	4.35	3.11
VR-7-22	6.04	5.33	4.57	5.01	5.60	5.71
VL-2-3	4.64	6.71	3.55	3.79	4.17	3.17
VL-2-5	13.06	10.95	9.44	9.22	8.65	7.19
VL-3-4	4.04	4.58	4.38	4.44	3.20	5.47
VL-7-4	4.77	4.41	3.67	4.33	4.54	3.61
IR-43-1	6.15	5.51	2.07	4.88	4.29	2.32
IRS-43-2	4.30	3.03	2.20	3.14	3.35	2.54
IR-43-2	6.68	6.00	4.57	5.47	4.72	3.23
IR-43-3	4.34	4.92	2.25	4.64	3.08	4.47
IR-43-5	9.99	10.07	10.00	9.03	8.69	6.83
IR-44-1	5.61	5.12	4.45	3.91	4.42	2.49
IR-44-2	4.36	5.36	2.94	6.16	5.78	4.86
CLN1462A	8.41	9.38	8.54	8.79	7.34	6.52
Myla F ₁	7.89	6.82	6.96	6.32	7.47	5.19

Estimated coefficient of variances for both fruit length and diameter (Table 1) ranged from 3.14 to 12.84% and from 3.08 to 12.83%, respectively. From the selected 29 genotypes, 20 ones were highly homogenous in both traits, since they showed low CV% values, indicating that they were more homogenous among all genotypes. The genotypes VR-6, VR-6-40, VL-2-4, VL-2-3, IRS-43-2 and IR-44-1 recorded the lowest values for fruit length (3.82, 3.36, 3.91, 3.79, 3.14 and 3.91%, respectively). While the breeding lines VL-3-4, IRS-43-2 and IR-43-3 showed the lowest values (3.20, 3.35 and 3.08) for fruit diameter.

Regarding total soluble solids (TSS%), most selected lines showed high homogeneity, since they showed the lowest CV% values.

In general, the estimated (CV%) was varied among the genotypes in the same trait and from character to another in the same genotype. From the 29 selected genotypes, 20 ones were high homogenous in most traits under the conditions of this study compared with those of check genotypes. Therefore, these breeding lines could be considered as new homogenous lines for studying and evaluation. These results confirmed with those of Kansouh (2002) and Ahmed *et al.* (2017), who developed new local lines of tomato by selection from F₂ generations and the selected lines were enough homogenous for most traits since they exhibited low CV% values.

Mean performance of the new lines

Analysis of variance (Table 2) showed highly significant differences among all studied genotypes in all traits, indicating that the developed lines exhibited adequate genetic variability and considerable scope for selection of the best materials for crop improvement. Similar results were previously reported

by other workers (Rukhsar and Sharma, 2011; Sharanappa and Mogali, 2014; Taiana *et al.*, 2015; Lekshmi and Celine, 2017). Data of mean performance for all studied traits are presented in Table (3). The plant height in the selected lines ranged from 186.01 in VR-6-40 to 270.0cm in VL-5-4 lines with grand average of 221.17cm. Only six breeding lines significantly exceeded the highest check CLN1462A (230.0cm). However most obtained breeding lines showed plant height over 2.0 m. Regarding number of leaves per plant, it was ranged from 22.5 to 34.7 for the lines IR-43.1 and VL-5-1, respectively. The Breeding lines VR-6, VL-4-1, VL-4-4, VL-5-1, VL-2-3, VL-7-4 and IR-44-2 produced the highest leaf number with insignificant differences among them and could be considered as high vigorous lines. Many researchers found significant differences among the tomato genotypes for plant height (Osekita and Ademiluyi, 2014; Reddy *et al.*, 2014; Patel *et al.*, 2015) and for number of leaves/plant (Kansouh, 2002; Meena *et al.*, 2015). Days to first flower ranged from 31.0 to 45.0 with a mean of 36.88 day. Line IR-44-2 was the earliest in flowering (31.0 day) followed by both VL-4-4 and VL-5-1(33.0 day). Most selected lines significantly decreased or were similar to the earliest check Myla F₁(37.7).

Early yield for the selected lines ranged from 1.8 to 2.7 kg/plant with an average of 2.23 kg/plant. Seven lines (VR-6-40, VL-7-4, IRS-43-2, IR-43-2, IR-43-3, IR-44-1 and IR-44-2) significantly exceeded the highest yielded check CLN1462A (2.4kg/plant), also the line IR-43-1 did not significantly differ from the same check in early yield. For total yield/plant, data in Table (3) revealed that five selected lines (VR-6, VR-6-40, IRS-43-2, IR-44-1 and IR44-2) significantly surpassed the best check CLN1462A (6.6kg/plant). The lowest yield (4.2 kg/plant) was reflected by the line VL-6-3. However, all evaluated

breeding lines, except 7 ones exceeded or equaled to the lowest yielded check (6.0kg/plant). So, it could be concluded that most developed lines had higher early and total yield compared with the check cvs and may be used in commercial production under greenhouse after further evaluation and as a source in breeding programs for improvement the fruit productivity in tomato. The results are confirmed by those of Kumar *et al.* (2013), Meena *et al.* (2015), Patel *et al.* (2015) and Ahmed *et al.* (2017), who found highly significant differences for early and total yield among the evaluated tomato lines.

Average means of some fruit characteristics are shown in Table (4). Average fruit weight ranged from 52.7 to 119.0g with a mean of 85.48g. Among, 20 bred lines, three ones (IRS-43-2, IR-43-2 and IR-43-3) were significantly heavier fruits than the heaviest check cultivar (100.4g). While, the lightest fruits (52.7g) was recorded by the line VR-7-22. Rukhsar and Sharma (2011), Taiana *et al.*, (2015) and Singh *et al.*, (2017) found wide

range of variability among evaluated tomato lines regarding average fruit weight. Concerning pericarp thickness, it ranged from 0.58 to 0.96 cm with a mean of 0.75cm. Four lines (VR-4-3, IR-43-1, IRS-43-2 and IR44-2) significantly exceeded the check CLN1462A in pericarp thickness (0.73cm). However, ten lines were significantly similar to this check cultivar. Number of locules/fruit in the selected genotypes ranged from 2.03 to 4.00 with average of 2.73. Two lines (IRS-43-2 and IR-43-2) had the larger number, while the lowest number was obtained by lines VL-3-4 and VL7-4. Moreover, six selected breeding lines (about 30% of all genotypes) did not significantly differ among them and from CLN1462A and Myla F₁ as check cvs in this respect. Some researchers confirmed these results such as Kumar *et al.* (2013) for pericarp thickness, Patel *et al.* (2015) for number of locules, Rai *et al.* (2016) and Singh *et al.* (2017) for pericarp thickness and number of locules.

Table 2: Analysis of variance for all studied traits of tomato crop.

Characters	Mean sum of squares		
	Replication (d.f 2)	Genotypes (d.f 21)	Error (d.f 42)
Plant height (cm)	19.64 ^{ns}	1875.64 ^{**}	26.03
No. leaves/plant	1.28 ^{ns}	53.55 ^{**}	3.55
Days to 1 st flower	3.29 ^{ns}	33.32 ^{**}	1.03
Early yield/plant(kg)	0.001 ^{ns}	0.320 ^{**}	0.020
Total yield/plant(kg)	0.043 ^{ns}	1.867 ^{**}	0.034
Average fruit weight(g)	22.094 ^{ns}	950.655 ^{**}	48.254
Pericarp thickness(cm)	0.004 ^{ns}	0.030 ^{**}	0.001
No. locules/fruit	0.002 ^{ns}	1.106 ^{**}	0.004
Fruit shape index	0.002 ^{ns}	0.801 ^{**}	0.001
Vit.c content(mg/100g fresh weight)	0.517 ^{ns}	23.464 ^{**}	0.550
TSS percentage(%)	0.014 ^{ns}	1.746 ^{**}	0.008

ns, **: non significant and significant at the 0.01 levels of probability, respectively

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Table 3: Mean performance of the evaluated breeding lines of tomato for plant height, number of leaves/plant, days to first flower, early and total yield /plant.

Lines	Plant height (cm.)	No. leaves/ plant	Days to 1 st flower	Early yield/plant (kg)	Total yield/plant (kg)
VR-4-3	199.3k	25.3def	39.3c	2.1fgh	6.1de
VR-6	210.7j	33.1a	35.7fgh	2.3def	7.0a
VR-6-40	186.0l	24.1f	37.0def	2.6abc	7.1a
VL-4-1	249.7c	33.7a	43.3a	1.9hi	5.3fg
VL-4-4	246.3cd	33.3a	33.0i	1.9ghi	6.0de
VL-5-1	259.0b	34.7a	33.0i	1.9hi	5.0hi
VL-5-4	270.0a	29.3bc	37.0def	2.2ef	5.4f
VL-6-3	240.0de	29.7bc	45.0a	1.8i	4.2j
VL-2-4	213.1ij	24.1f	37.3c-f	1.8i	5.1gh
VR-2-5	231.4ef	28.2bcd	38.0cde	1.8i	5.6f
VR-7-22	209.7j	27.8cde	36.0e-h	1.8i	4.6i
VL-2-3	247.1cd	34.6a	34.3hi	2.1efg	5.9e
VL-3-4	233.7ef	29.8bc	37.7c-f	2.3def	6.1de
VL-7-4	231.9ef	34.0a	34.0hi	2.6abc	5.9e
IR-43-1	187.0l	22.5f	38.3cd	2.4cde	6.3cd
IRS-43-2	208.5j	27.8cde	34.7ghi	2.7ab	7.0a
IR-43-2	186.3l	23.3f	37.0def	2.7a	6.1de
IR-43-3	196.7k	24.8def	34.0hi	2.7ab	6.2de
IR-44-1	186.2l	24.5ef	36.7d-g	2.5abc	6.8ab
IR-44-2	220.7hi	34.2a	31.0j	2.5bcd	6.9ab
CLN1462A	230.0fg	31.6ab	41.3b	2.4cde	6.6bc
Myla F ₁	222.4gh	24.8def	37.7c-f	2.2efg	6.0e
Mean	221.17	28.87	36.88	2.23	5.96

- Means followed by the same alphabetical letter (s) within each column are not significantly different at 5% level according to Duncan's Multiple Range Test.

Table 4: Mean performance of the evaluated breeding lines of tomato for average fruit weight, pericarp thickness, number of locules/fruit, fruit shape index, Vit. C and TSS% contents.

Lines	Average fruit weight (g)	Pericarp thickness (cm)	No. locules /fruit	Fruit shape index	Vit.C content (mg/100g fresh weight)	TSS (%)
VR-4-3	94.8cd	0.91a	3.10b	0.92j	26.7de	6.60ij
VR-6	92.9cd	0.67d-g	3.07bc	1.23i	29.7bc	6.60ij
VR-6-40	80.0ef	0.73b-e	3.05bcd	1.20i	24.0ghi	5.80m
VL-4-1	68.9fg	0.58h	2.15f	1.80e	25.2fg	8.20c
VL-4-4	68.4fg	0.66g	2.13f	1.73f	24.7fgh	7.30e
VL-5-1	71.2fg	0.66fg	2.07f	1.83e	21.9j	6.80g
VL-5-4	69.9fg	0.72b-f	2.97cd	1.90d	22.2j	6.40k
VL-6-3	65.5g	0.69c-g	2.07f	1.80e	21.7j	7.50d
VL-2-4	76.2efg	0.69c-g	2.10f	1.40g	26.0ef	6.60ij
VR-2-5	63.9gh	0.75b	3.08bc	1.30h	23.7hi	8.33b
VR-7-22	52.7h	0.75b	2.96cd	1.30h	23.0ij	8.27bc
VL-2-3	87.3de	0.70b-g	2.07f	1.97c	30.3ab	6.37k
VL-3-4	85.8de	0.73bcd	2.03f	2.13b	24.7fgh	6.43jk
VL-7-4	93.8cd	0.74bc	2.03f	2.50a	22.9ij	8.53a
IR-43-1	94.9cd	0.96a	2.93d	0.83kl	25.3fg	7.07f
IRS-43-2	118.8a	0.95a	4.00a	0.80l	31.0a	7.37de
IR-43-2	108.3ab	0.71b-g	4.00a	0.80l	24.6gh	6.33k
IR-43-3	119.0a	0.75bc	3.03bcd	0.70m	25.0fgh	6.63hi
IR-44-1	80.0ef	0.73bcd	3.00bcd	0.87jk	29.3bc	6.73gh
IR-44-2	102.2bc	0.92a	2.97cd	0.90j	27.0de	6.77gh
CLN1462A	100.4bc	0.73b-e	3.00bcd	0.87jk	29.0c	7.07f
Myla F ₁	85.7de	0.67efg	2.27e	1.43g	27.3d	6.07l
Mean	85.48	0.75	2.73	1.37	25.68	6.98

- Means followed by the same alphabetical letter (s) within each column are not significantly different at 5% level according to Duncan's Multiple Range Test.

Data of fruit shape index revealed that there were highly significant differences among the breeding lines in this respect. Three lines (VR-4-3, IR-44-1 and IR-44-2) produced globe fruits with shape index values of 0.92, 0.87 and 0.90, respectively. While, the lines IR-6 and VR-6-40 had oblong fruits (1.23 and 1.20, respectively). Six ones (VL-4-1, VL-4-4, VL-5-1, VL-5-4, VL-6-3 and VL-2-3) gave cylindrical fruits since the values of L/D were more than 1.5. Long-date shape was observed in both lines VL-3-4 (2.13) and VL-7-4 (2.50). However, the lines IR-43-1, IR-43-2, IR-43-2, IR-43-3 gave oblate fruits, whereas L/D values ranged from 0.70 to 0.83. The remaining lines, viz., VL-2-4, VR-2-5 and VR-7-22 produced obovate fruits with index values of 1.40, 1.30 and 1.30, respectively. It is obvious that the differences among selected lines for fruit shape index may be due to high genetic distance in this trait between the parents of the commercial hybrids (V59-48 and Izmir).

For vitamin C content in fruits of recent breeding lines ranged from 21.7 to 31.0 mg/100g fresh weight with average of 25.68 mg. Four breeding lines (IR-43-2, VL-2-3, VR-6 and IR-44-1) significantly exceeded CLN1462A line (29.0 mg/100g). For total soluble solids (TSS%), it exhibited that fruits of the lines VL-4-1, VL-2-5, VR-7-22 and VL-7-4 contained the highest values of TSS (more than 8.0 %) and significantly exceeded the remaining lines and check cvs. On the other hand, the line VR-6-40 recorded the lowest value (5.80%). These results confirmed by Kansouh (2002), Rukhsar and Sharma (2011), Kumar *et al.* (2013) and Meena *et al.* (2015) who detected high genetic differences among genotypes in vitamin C and TSS% contents in tomato fruits.

Component of variances

The estimated genetic parameters are shown in Table (5). The coefficient of

variance (CV %) was ranged from 1.25 to 8.13%. The highest values were recorded in average fruit weight, number of leaves/plant and early yield/plant. While, the lowest values were given by total soluble solids (1.25%), number of locules/fruit (2.25%) and plant height (2.31%).

The estimates of genotypic (σ^2_g) and phenotypic (σ^2_p) variances revealed that the genetic variances contributed with large portion of total variation in all studied traits, since the differences between σ^2_g and σ^2_p were small. These results are confirmed by those of Shashikanth *et al.* (2010), Mohamed *et al.* (2012) and Meena *et al.* (2015) for plant height, average fruit weight and TSS%. Phenotypic (PCV %) and genotypic (GCV %) coefficient of variations are very important in studying the extent and nature of genetic variability to design suitable breeding program for improving any character(s). PCV% values were slightly higher than the GCV% ones for all studied traits, indicating that the genetic variance plays the main role in expression of the character. This fact make the simple selection could be used for genetically improvement of crops. Similar conclusion were reported by many investigators among them Rukhsar and Sharma (2011), Kumar *et al.* (2013), Patel *et al.* (2015) and Singh *et al.* (2017).

Heritability estimates were high for all studied traits (>75%), it ranged from 82.44 for days to 1st flower to 99.63% for fruit shape index, indicating minor environmental effects on the expression of these traits. Therefore, selection based on phenotypic observation as individual plant is effective for improvement these characters. This result is in agreement with those of Meena *et al.* (2015) for most growth and productivity, Patel *et al.* (2015) for plant height and total yield, Rai *et al.* (2016) for plant height, average fruit weight, total yield, pericarp thickness and

Table 5: Estimation of some genetic parameters for all studied traits of tomato crop.

Characters	CV%	Variance			GCV%	PCV%	GCV/PCV%	BSH	ΔG	$\Delta G\%$
		Genetic σ^2_g	Environment σ^2_e	Phenotypi $c\sigma^2_p$						
Plant height	2.31	616.537	26.030	642.567	11.23	11.46	97.9	95.95	50.103	22.65
No. leaves/plant	6.53	16.667	3.550	20.217	14.14	15.57	90.8	82.44	7.636	26.45
Days to 1 st flower	3.1	10.673	1.03	11.973	8.86	9.38	94.5	89.14	6.354	17.23
Early yield/plant(kg)	5.63	0.100	0.020	0.116	14.18	15.27	92.9	86.17	0.604	27.11
Total yield/plant(kg)	3.04	0.611	0.034	0.645	13.11	13.47	97.3	94.73	1.567	26.28
Average fruit weight (g)	8.13	300.800	48.254	349.054	20.29	21.86	92.8	86.18	33.166	38.80
Pericarp thickness(cm)	4.97	0.010	0.001	0.011	13.18	13.85	95.2	90.63	0.193	25.85
No. locules /fruit	2.25	0.367	0.004	0.371	22.20	22.32	99.5	98.63	1.242	45.48
Fruit shape index	2.67	0.267	0.001	0.268	37.68	37.76	99.8	99.63	1.062	77.49
Vit.C content (mg/100g fresh weight)	2.89	7.638	0.550	8.188	10.76	11.14	96.6	93.28	5.499	21.41
TSS percentage (%)	1.25	0.579	0.008	0.587	10.91	10.98	99.4	98.64	1.557	22.32

number of locules/fruit and Singh *et al.* (2017) for all traits.

The values of genetic advance (ΔG) ranged from 0.193 for pericarp thickness to 50.103 for plant height. However, genetic advance as percent of mean ($\Delta G\%$) was high (>20) for all traits. The high genetic advance help the plant breeder for predict genetic gain that obtained in the late generation of breeding program. High heritability linked with high genetic advance as percent is more useful than heritability alone for prediction of the results and effect of selection. In the present experiment, high heritability coupled with high genetic advance as percent were noted for all studied traits, indicating that the additive gene action played a predominant role in the inheritance of these characters and therefore, the selection is more effective for tomato improvement. Many workers reported that the most traits are controlled by the additive genes, among them Rukhsar and Sharma (2011) for Vit.C content and average fruit weight, Kumar *et al.* (2013) for total yield, Sharanappa and Mogali (2014) for average fruit weight, Reddy *et al.* (2014) for plant height, total yield and average fruit weight, Meena *et al.* (2015) for plant height, average fruit weight, total yield, TSS% and Vit.C content and Rai *et al.* (2016) for plant height, total yield, average fruit weight, pericarp thickness and number of locules.

In conclusion, single selection is effective as a breeding method during F_2 and advanced generations for developing new superior indeterminate tomato lines. These new lines could be used for commercial production under greenhouses and as parents in breeding programs of tomato.

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تربيته سلالات جديدة من الطماطم الغير محدودة النمو بواسطة الانتخاب

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الملخص العربى

تم انتخاب عشرون سلالة جديدة من الطماطم الغير محدودة النمو بواسطة الانتخاب داخل عشيرتين من الجيل الثاني لاثنتين من الهجن التجارية المنزعة داخل الصوب البلاستيكية- واستمر الانتخاب لصفات ارتفاع النبات, عدد الأوراق/نبات, طول وقطر الثمرة, ونسبه المواد الصلبة الذائبة الكلية خلال الفترة من ٢٠١٣/٢٠١٢ و ٢٠١٣/٢٠١٤ و ٢٠١٤/٢٠١٥ و ٢٠١٥/٢٠١٦ حتى الوصول إلى الجيل السادس (F₆). ثم أجرى التقييم داخل الصوب البلاستيكية فى الموسم الشتوى لعامى ٢٠١٦/٢٠١٧ و ٢٠١٧/٢٠١٨ بالمزرعة البحثية بكلية العلوم الزراعية البيئية, جامعه العريش, شمال سيناء. واستخدام فى تنفيذ التجربة تصميم القطاعات كاملة العشوائية فى ثلاث مكررات. وسجلت البيانات على الصفات تحت الدراسة لكلا موسمى التجربة , وتم تحليلها بالطرق الإحصائية المناسبة .

أوضحت النتائج أن السلالات فى الجيل السادس على درجة عالية من التجانس المظهري, كما وجدت اختلافات معنوية بين السلالات فى جميع الصفات , وقد أعطت بعض السلالات مثل فى إل-٤-١, فى إل-٤-٤, فى إل-٥-١, فى إل-٢-٣, فى إل-٧-٤, و اى أر-٤-٤-٢ تفوق في قوه النمو في حين أعطت السلالات فى أر-٦, فى أر-٦-٤٠, اى أر اس-٣-٤, اى أر-٤-٤-١, و اى أر-٤-٤-٢ تفوق فى المحصول الكلى.

أظهرت تقديرات الاختلافات الوراثية وجود فروق قليلة بين معاملا الاختلاف المظهري وبين معاملا الإختلاف الوراثي مما يدل على التأثير القليل للعوامل البيئية على الصفات المدروسة وبالتالي يكون الانتخاب على أساس الشكل المظهري فعال ومناسب لتحسين هذه الصفات. وكانت اعلي القيم المقدرة لمعامل الاختلاف الوراثي والمظهري لصفات متوسط وزن الثمرة, وعدد المساكن/ثمره, و شكل الثمرة مما يدل على توفر الاختلافات الوراثية بهذه الصفات وأن الانتخاب هو الأفضل لتحسينها وراثيا. وكذلك كانت قيم درجة التوريث عاليه لجميع الصفات المدروسة وتراوحت من ٨٢,٤٤ إلى ٩٩,٦٣ % لذا فان التحسين الوراثي لهذه الصفات من خلال الانتخاب المظهري للنبات الفردي يكون أكثر فاعليه. أيضا ارتبطت القيم العالية لدرجات التوريث بالقيم العالية للتقدم الوراثي (كنسبه مئوية من المتوسط) في جميع الصفات تحت الدراسة, عدا صفه عدد الأيام حتى تفتح أول زهره مما يدل على تحكم الفعل الجيني المضيف في توريثها ولذا فان الانتخاب على أساس الأداء المظهري يكون مناسب وفعال للتحسين.

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