

Genetic Analysis and Correlation Studies of Yield and Fruit Quality Traits in Tomato (*Solanum lycopersicum* L.)

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Abstract: Estimation of the existing variability in the available germplasm and knowledge about association of various traits is helpful for multiple trait selection and necessary to develop desirable genotypes of tomato. Keeping this in view, evaluation of genetic parameters and association studies were conducted in a set of 14 landraces of tomato for 8 quantitative traits over 2 seasons (2010/2011 – 2011/2012) at Dara'a Center of Scientific Agricultural Research, GSAR, Syria. Highly significant differences were found among the genotypes for all the traits studied, indicating wide range of variability and providing ample scope for selecting the desirable types. The phenotypic coefficient of variation (PCV) was greater than the respective genotypic coefficient of variation (GCV) for all the traits, denoting the environmental factors influencing their expression to some degree or other. High estimates of broad sense heritability (h^2) and genetic advance as percent over mean (GA %) were observed for plant height, number of locules/fruit and pericarp thickness which might be assigned to additive gene effects. Correlation studies indicated that days to maturity, number of locules/fruit and pericarp thickness were positively and significantly correlated with fruit yield at both genotypic and phenotypic levels, indicating the importance of these traits as selection criteria.

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1. Introduction

Although tremendous increase in national tomato production has been made by planting high yielding imported hybrid varieties during the recent years, yet the need to accelerate the efforts for breeding varieties to boost tomato production has become more acute than before. Plant breeders are continuously endeavoring to improve the genetic potential of yield and quality traits of tomato crop so as to meet the demands of an ever-increasing population. The approaches to make significant improvement in tomato production, require information regarding nature and magnitude of genetic variation in quantitative traits and their interrelationships in the available germplasm, which are important pre-requisites for a systematic breeding program. Several researchers *viz.*, Mohamed *et al.*, 2012; Dar & Sharma, 2011; Saeed *et al.*, 2007; Mohanty, 2003; Mohanty, 2002 have emphasized the utility of the estimates of genetic components such as coefficient of variation, heritability and expected genetic advance in the prediction of response quantitative traits to selection.

The present investigation was, therefore done to obtain some information on the extent of variability, heritability, genetic advance and association for eight traits in fourteen Syrian landraces of tomato, which could be useful in tomato improvement programs.

2. Materials and Methods

Fourteen Syrian landraces of tomato i.e., 20060, 20061, 20170, 20198, 20292, 20303, 20335, 20339, 20364, 20402, 20660, 20740, 20909 and 20992 were used for this study. These genotypes, selfed for several generations, were supplied by Bank of Plant Genetic Resources, General Commission of Scientific Agricultural Research (GCSAR).

The experiment was carried out in a randomized complete block design with three replications at the experimental field of Dara'a Center of Scientific Agricultural Research, GCSAR, Syria during summer seasons of 2010/2011 and 2011/2012. Six weeks old healthy seedlings of each genotype were transplanted during the second week of April every season in plots of single rows, each 8.8 m long and spaced 1.8 x 0.4 m. The days to maturity and fruit yield (kg. ha^{-1}) were recorded on a whole plot basis, whereas plant height (cm), number of locules/fruit, pericarp thickness (mm), fruit shape index, total sugar content (%) and total soluble solids content (%) were recorded from a random sample of ten plants in each plot.

Analysis of variance and means of genotypes over two seasons were determined for all the traits using MSTAT-C statistical program (Russell, 1991). The genotypic (GCV) and phenotypic coefficient of variation (PCV) were computed as suggested by Burton & Devane (1953) and classified according to

Sivasubramanian & Madhavamenon (1973). The heritability in broad sense (h^2) and genetic advance (GA) were determined as per Johnson *et al.* (1955) and categorized as demonstrated by Robinson *et al.* (1949). The correlation coefficients were worked out following Al-Jibouri *et al.* (1958) and the significance of correlation coefficients at both phenotypic and genotypic levels were done by t-test (Steel & Torrie, 1984) and standard errors (Reeve & Rao, 1981), respectively.

3. Results

Pooled analysis of variance revealed highly significant mean squares of genotypes for all the traits studied. The mean squares due to environments (seasons) were significant just for plant height, pericarp thickness, total sugar content and fruit yield. But, the mean squares due to genotype-environment interaction were significant only for days to maturity, number of locules/fruit, pericarp thickness and fruit yield. The mean values pooled over two seasons for the traits studied are presented in **Table 1**. The data pertaining to days to maturity revealed that genotypes 20170 and

20335 (102 days) were significantly the earliest. The highest height of plant was recorded in genotype 20335 (110.50 cm) followed by 20660 (107.83 cm) which differed significantly from majority of the genotypes. For number of locules/fruit, the genotype 20402 registered the maximum value (7.50) and the minimum value (2.00) of the genotypes 20170, 20335 and 20660. The pooled data regarding fruit shape index showed that the genotypes 20909 (1.08), 20060 (1.05) and 20364 (1.02) had the highest values of this trait. For total sugar content, it has been found that 20303 (3.32 %) was significantly higher over all other genotypes, while the genotype 20660 (3.25 %) was found at par. Regarding total soluble solids content, the highest content was recorded in genotype 20660 (5.98 %) followed by 20303 (5.70 %). Considerable variability was observed for fruit yield among the genotypes investigated, however, the data showed that the genotype 20060 registered the maximum yield (42908 kg. ha⁻¹) which differed significantly from all other genotypes, whereas the minimum fruit yield was recorded in 20660 (15907 kg. ha⁻¹).

Table 1: Means and pooled analysis of variance over two seasons for yield and fruit traits in 14 tomato genotypes.

Genotypes	Days to maturity	Plant height (cm)	Number of locules/fruit	Pericarp thickness (mm)	Fruit shape index	Total sugar (%)	Total soluble solids (%)	Fruit yield (kg. ha ⁻¹)
20060	113	87.50	6.17	5.50	1.05	2.67	4.49	42908
20061	117	91.83	8.33	5.17	0.68	3.06	4.88	33995
20170	102	103.17	2.00	3.67	0.86	3.01	5.59	20705
20198	109	75.17	3.17	5.17	0.89	2.76	4.79	37292
20292	109	79.17	5.33	4.67	0.71	2.71	4.45	32152
20303	111	79.67	4.33	4.83	0.97	3.32	5.70	36580
20335	102	110.50	2.00	2.33	0.82	2.92	5.55	28367
20339	112	80.33	4.50	3.17	0.78	2.72	4.51	25152
20364	116	86.50	6.50	5.00	1.02	2.78	4.65	34135
20402	110	85.50	7.50	4.83	0.64	2.62	4.36	36210
20660	105	107.83	2.00	2.50	0.90	3.25	5.98	15907
20740	114	78.50	2.67	6.00	0.94	2.60	4.73	31307
20909	112	89.83	3.33	6.00	1.08	2.74	4.66	30850
20992	113	105.50	3.00	3.33	0.68	2.82	4.70	28325
Grand mean	110	90.07	4.35	4.44	0.86	2.86	4.93	30992
Mean squares (G)	127.84**	855.52**	26.94**	8.94**	0.13**	0.30**	1.69**	296309049**
Mean squares (E)	2.10	168.40**	0.48	8.04**	0.007	0.05*	0.034	821672229**
Mean squares (G x E)	59.17**	7.55	0.42*	0.54**	0.00	0.02	0.03	259579440**
L.S.D. (p < 0.05)	2.89	6.45	0.60	0.69	0.12	0.12	0.14	4584

*, ** : significant at 0.05 and 0.01 probability levels, respectively.

Variance components, genotypic and phenotypic coefficient of variation, heritability in broad sense and genetic advance of the traits under study are presented in **Table 2**. The maximum genotypic and phenotypic variations were found for fruit yield and plant height, while the minimum ones were for total sugar content and fruit shape index. The genotypic (GCV) and phenotypic coefficient of variation (PCV) were high (> 20 %) for number of locules/fruit (48.28 % , 48.74 %) and pericarp thickness (26.65 % , 27.25 %), respectively. The PCV was higher than the respective GCV for all the traits evaluated. Wide difference between GCV and PCV was observed just for fruit yield, whereas narrow difference between them for the other traits. The broad sense heritability ranged from (18.42 %) for fruit yield to (99.41 %) for fruit shape index. High estimates of genetic advance as percent of mean (> 20 %) were obtained for number of locules/fruit (84.63 %), pericarp thickness (46.31 %), fruit shape index (30.52 %) and plant height (23.14 %).

The genotypic (r_g) and phenotypic correlation coefficients (r_{ph}) among the different pairs of traits studied are shown in **Table 3**. The data depicted in the table indicated in general that genotypic correlations were higher than the corresponding phenotypic ones for all the traits combinations. The genotypic and phenotypic associations of fruit yield were positive and

highly significant with days to maturity (0.586** , 0.479**), number of locules/fruit (0.625** , 0.589**) and pericarp thickness (0.747** , 0.643**), respectively. But, negative and significant with plant height (-0.636** , -0.569**), total sugar content (-0.366* , -0.320*) and total soluble solids content (-0.584** , -0.536**), respectively.

Table 2: Genetic parameters for yield and fruit traits in 14 tomato genotypes (combined across two seasons).

Traits	σ^2_g	σ^2_{ph}	GCV (%)	PCV (%)	h^2 (%)	GA	GA (%)
Days to maturity	11.45	18.47	3.08	3.91	61.99	4.69	4.27
Plant height	141.33	142.66	13.20	13.27	99.07	20.84	23.14
Number of locules/ fruit	4.42	4.48	48.28	48.74	98.66	3.68	84.63
Pericarp thickness	1.04	1.45	26.65	27.25	96.55	2.06	46.31
Fruit shape index	0.02200	0.02213	17.21	17.44	99.41	0.26	30.52
Total sugar	0.050	0.053	7.82	8.04	94.34	0.38	13.35
Total soluble solids	0.28	0.29	10.75	10.95	96.55	0.92	18.61
Fruit yield	6121602	33227571	7.98	18.60	18.42	1869	6.03

Table 3: Genotypic (r_g) and phenotypic correlation coefficients (r_{ph}) among the different pairs of traits in 14 tomato genotypes (pooled).

Traits	r	Plant height	Number of locules / fruit	Pericarp thickness	Fruit shape index	Total sugar	Total soluble solids	Fruit yield
Days to maturity	r_g	-0.523**	0.651**	0.675**	0.079	-0.323*	-0.642**	0.586**
	r_{ph}	-0.495**	0.607**	0.590**	0.079	-0.268	-0.601**	0.479**
Plant height	r_g		-0.415*	-0.730**	-0.148	0.432**	0.578**	-0.636
	r_{ph}		-0.405*	0.652**	-0.146	0.369*	0.536**	-0.569**
Number of locules/ fruit	r_g			0.549**	-0.279	-0.196	-0.572**	0.625**
	r_{ph}			0.506**	-0.239	-0.190	-0.565**	0.589**
Pericarp thickness	r_g				0.394*	-0.415*	-0.563**	0.747**
	r_{ph}				0.345*	-0.359*	-0.529**	0.643**
Fruit shape index	r_g					0.100	0.192	0.152
	r_{ph}					0.075	0.157	0.182
Total sugar	r_g						0.858**	-0.366*
	r_{ph}						0.846**	-0.320*
Total soluble solids	r_g							-0.584**
	r_{ph}							-0.536**

*, **: significant at 0.05 and 0.01 probability levels, respectively.

4. Discussion

The highly significant differences among the genotypes for all the traits indicate sufficient diversity among them. The significant mean squares due to environments (seasons) as well as genotype-environment interaction for pericarp thickness and fruit yield not only demonstrate the difference in seasons of cropping, but also reflect the different response of genotypes to environmental changes. Mean of genotypes varied greatly for most of the traits studied, indicating high magnitude of variability. These results corroborate the views of Ara *et al.* (2009); Singh *et al.* (2002).

The very low difference between the genotypic and phenotypic variance for plant height, number of locules/fruit, pericarp thickness, fruit shape index, total sugar content and total soluble solids content, implies that there is less influence of environment and consequently selection can be effective for these traits. Genotypic and phenotypic

variances are influenced by the units used for measuring the particular plant trait. Coefficient of variation will nullify such effects and comparisons can be made across the traits and across the findings. High GCV and PCV were observed for number of locules/fruit and pericarp thickness indicate existence of broad genetic base, which would be amenable for further selection. These findings were in conformity with Kumar *et al.* (2006); Veershetty (2004).

Very often, heritability in broad sense is not the true indicator of inheritance of traits. Since, only additive component of genetic variance is efficiently transferred from generation to another. Therefore, heritability may mislead in judging the effectiveness of selection for the trait. Considering heritability in broad sense along with genetic advance may reveal the prevalence of specific components (additive or non-additive) of genetic variance and thus helps in judging the response of selection for the trait more accurately.

High heritability accompanied with high genetic advance as percent over mean was observed for plant height, number of locules/fruit, pericarp thickness and fruit shape index indicating the prevalence of additive gene effects and hence selection would be effective for these traits. Low heritability with low genetic advance was recorded for fruit yield indicating that this trait is highly influenced by environmental effects and selection would be ineffective. Similar observations were made by Asati *et al.* (2008); Bhardwaj & Sharma (2005); Joshi *et al.* (2004).

Correlation studies pave way to know the association prevailing between highly heritable traits with the most of economic traits and give better understanding of the contribution of each trait in building up the genetic make up of the crop. The estimates of genotypic correlation (r_g) were generally higher than phenotypic correlation (r_{ph}) showing that masking effects of the environment was little and indicating the presence of inherent association between various traits.

It was observed that fruit yield had positive and highly significant correlation with days to maturity, number of locules/fruit and pericarp thickness indicating that selection based on these traits would bring about improvement in yield. The interrelationship between both of total sugar content and total soluble solids content with fruit yield depicted that if the quality traits would increase, the yield would decrease. In other words, it seems impossible to improve both of yield and quality traits simultaneously. On the contrary, days to maturity was proportional to fruit yield. Therefore, the most of early genotypes appeared to be low yielders as also reported earlier by Haydar *et al.* (2007); Kumar *et al.* (2006); Prashanth (2003); Sharma & Verma (2000); Narendrakumar & Arya (1995).

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