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Study of Genetic Parameters and Character Interrelationship of Yield and Some Yield Components in Tomato (*Solanum lycopersicum* L.)

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Abstract: Coefficients of variation, heritability, genetic advance, correlation coefficients and path coefficient analysis for yield and some its contributing characters in 14 landraces of tomato were done over 2 growing seasons 2010/2011 and 2011/2012 at Dara'a Center of Scientific Agricultural Research, General Commission of Scientific Agricultural Research (GCSAR), Syrian Arab Republic. The genotypes exhibited a wide range of variation for all the characters. Phenotypic coefficient of variation and genotypic coefficient of variation were the highest for number of fruits per plant whereas the lowest ones were for harvest index. High heritability coupled with high genetic advance as percentage over mean were observed for number of primary branches per plant, number of fruits per plant, number of fruits per cluster, average fruit weight and fruit yield per plant indicating that selection for these characters would give good response. Average fruit weight and harvest index had positive and highly significant correlation with fruit yield per plant at both phenotypic and genotypic levels. Path coefficient analysis revealed that number of fruits per plant and harvest index had the highest positive direct effects on fruit yield per plant suggesting their importance while imposing selection for amelioration of yield in tomato.

Key words: Additive Gene Action % Fruit Yield % Genetic Advance % Heritability % Tomato

INTRODUCTION

Tomato is one of the most important vegetable crops grown throughout the world. It is a rich source of vitamins and minerals and consumed as fresh or in processed forms [1]. World acreage of tomato is more than 4.5 million hectares and in Syrian Arab Republic is grown in about 18,500 hectares spreading over all the governorates [2].

Genetic variability is essentially the first step of plant breeding for crop improvement which is immediately available from germplasm which is considered as the reservoir of variability for different characters [3]. Since, most of the economic characters including yield are polygenically controlled and are much influenced by the environmental factors, an understanding of inheritance and study of association between yield and its components is necessary for planning an effective selection program in identifying high yielding genotypes. However, the inheritance of quantitative characters is often influenced by variation in other characters, which may be due to pleiotropy genetic linkage [4]. Hence, it is necessary to partition the observed overall phenotypic variation into heritable and non-heritable components using suitable design which enable us to know whether the superiority of selection is inherited by the progenies. Information regarding the genetic parameters such as variation coefficient, heritability, expected genetic advance, degree of association between the various characters, direct and indirect effects of characters contributing to total fruit yield are of permanent significance in formulating appropriate breeding strategy and exploiting the inherent variability of the experimental materials.

The present investigation was carried out to gather these information in a collection of some landraces of tomato which would be utilized for further improvement of tomato yield through an appropriate and sound breeding plan.

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MATERIALS AND METHODS

The experiment was laid out in a randomized complete block design with 3 replications at the experimental field of Dara'a Center of Scientific Agricultural Research, General Commission of Scientific Agricultural Research (GCSAR), Syrian Arab Republic during summer seasons of 2010/2011 and 2011/2012. Fourteen Syrian landraces of tomato viz., 20060, 20061, 20170, 20198, 20292, 20303, 20335, 20339, 20364, 20402, 20660, 20740, 20909 and 20992 were used for this study which selfed for several generations and supplied by Plant Genetic Resources Bank, GCSAR.

Six weeks old healthy seedlings of each genotype (landrace) were transplanted during the second week of April every year at a spacing of 1.8 m x 0.4 m in a plot of 8.8 m x 1.8 m. Standard cultural practices were adopted to raise the crop successfully. Ten plants were selected at random in each plot every year to record the observations on number of primary branches per plant, number of fruits per plant, number of fruits per cluster, average fruit weight (g), harvest index (%) and fruit yield per plant (kg). Progeny means, pooled over two years were analyzed to compute the phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), environmental coefficient of variation (ECV), heritability in broad sense, genetic advance as percentage over mean, genotypic (r_g) and phenotypic correlation coefficients (r_p) and path coefficients were calculated following the formula illustrated by Singh and Chaudhary [5].

RESULTS AND DISCUSSION

The statistical and genetic parameters estimated are shown in Table 1. The range of variation was maximum (20.13 - 184.97) for number of fruits per plant followed by average fruit weight (11.02 g - 130.26 g) and minimum (1.57 kg - 3.68 kg) for fruit yield per plant. The characters showing wide range of variation provide ample scope for selecting the desirable types, considering that range in mean values is not reliable since it includes genotypic, environmental and genotype-environment interactions. The characters which showed wider range were also characterized by higher magnitudes of PCV and GCV. Therefore, coefficient of variation is more reliable as it is the independent unit of measurement. The phenotypic (PCV) and genotypic coefficient of variation (GCV) were high for number of fruits per plant (92.67 %, 89.11 %), average fruit weight (52.62 %, 47.80 %), number of fruits per cluster (49.47 %, 47.25 %) which suggested existence of broad genetic base and would be amenable for further selection [6]. The estimates of PCV were generally higher than the respective GCV for all the characters under study denoting environmental factors influencing their expression to some degree or other. Wide differences between values of PCV and GCV for harvest index and fruit yield per plant implied its susceptibility to environmental fluctuation, whereas they were narrow for the other characters indicating that they were less influenced by environments and can be convinced by looking at low values of ECV. The works of Haydar *et al*. [7], Mohamed *et al*. [8] and Pradeepkumar *et al*. [9] support the present findings.

According to Johnson *et al*. [10] and Panse [11], estimates of genotypic coefficient of variation alone are not sufficient to assess the heritable variation, so for more reliable conclusion, the high estimates for both of heritability and genetic advance should be considered together indicating the heritable fraction of the variation which provides the base to plant breeder for selection on the basis of phenotypic performance. The heritability in broad sense ranged from (30.31 %) for harvest index to (95.83 %) for number of primary branches per plant. High values of heritability for almost all the characters clarified that they were least affected by environmental modification. The estimates of heritability alone fail to indicate the response to selection, therefore, heritability estimates appear to be more meaningful when accompanied by estimates of genetic advance [12]. The genetic advance as percentage over mean varied from (8.53 %) for harvest index to (150.81 %) for number of fruits per plant. High estimates of genetic advance were obtained for all the characters except harvest index which portrayed that they could be improved to a large extent through selection.

The high heritability coupled with high genetic advance was observed for all the studied characters studied except harvest index indicating predominance of additive gene effects and suggesting that effective selection may be done for these characters. Medium estimates of heritability accompanied by low GCV and genetic advance was observed for harvest index which may be attributed to non-additive gene effects controlling its expression and selection would not be rewarding. Similar results have also been reported by Prema *et al*. [13] for average fruit weight and fruit yield per plant, Revanasiddappa [14] and Sivaprasad [15] for number of primary branches per plant and number of fruits per plant, Saeed *et al*. [16] for fruit yield per plant and Purnanand [17] for number of fruits per cluster and average fruit weight.

Table 1: Statistical and genetic parameters for six quantitative characters of tomato (pooled)

Character	Range	Mean ± SE	PCV	GCV	ECV	Heritabil-ity (%)	GA as (% mean)
No. of primary branched per plant	3.27-6.63	4.83±0.04	22.69	22.2	3.58	95.83	38.3
No. of fruits per plant	20.13-184.97	62.45±1.43	92.67	89.11	18.67	92.47	150.81
No. of fruits per cluster	2.03-8.05	3.78±0.05	49.47	47.25	10.90	91.41	79.63
Average fruit weight (g)	11.02-130.26	79.71±2.43	52.62	47.8	10.97	83.16	77.02
Harvest index (%)	29.88-50.68	41.25±0.56	16	8.8	6.31	30.31	8.53
Fruit yield per plant (kg)	1.57-3.68	2.52±0.04	23.25	16.95	2.38	53.06	21.83

Table 2:Phenotypic (r_p) and genotypic (r_g) correlation coefficient for different pairs of characters in tomato (pooled)

Character		No. of fruits per plant	No. of fruits per cluster	Average fruit weight	Harvest index	Fruit yield per plant
No. of primary branched per plant	r_p	0.81^{**}	0.85^{**}	-0.85^{**}	-0.48^{**}	-0.53^{**}
	r_g	0.85^{**}	0.88^{**}	-0.91^{**}	-0.55^{**}	-0.57^{**}
No. of fruits per plant	r_p		0.94^{**}	-0.86^{**}	-0.51^{**}	-0.44^{**}
	r_g		0.98^{**}	-0.92^{**}	-0.60^{**}	-0.51^{**}
No. of fruits per cluster	r_p			-0.84^{**}	-0.52^{**}	-0.46^{**}
	r_g			-0.89^{**}	-0.58^{**}	-0.53^{**}
Average fruit weight	r_p				0.66^{**}	0.64^{**}
	r_g				0.76^{**}	0.72^{**}
Harvest index	r_p					0.84^{**}
	r_g					0.88^{**}

** - Significant at 0.01 probability level.

Table 3: Direct (diagonal) and indirect effects at phenotypic (P) and genotypic (G) levels of various component characters on yield of tomato (pooled)

Character		No. of primary branched per plant	No. of fruits per plant	No. of fruits per cluster	Average fruit weight	Harvest index	Correlation with yield
No. of primary branched per plant	P	-0.339	0.136	0.174	-0.131	-0.371	-0.53
	G	-0.220	2.193	-2.534	0.910	-0.920	-0.57
No. of fruits per plant	P	-0.274	0.168	0.193	-0.132	-0.394	-0.44
	G	-0.190	2.580	-2.823	0.920	-1.002	-0.51
No. of fruits per cluster	P	-0.288	0.158	0.205	-0.129	-0.402	-0.46
	G	-0.194	2.530	-2.880	0.980	-0.970	-0.53
Average fruit weight	P	0.288	-0.145	-0.170	0.154	0.510	0.64
	G	0.270	-2.380	2.560	-1.000	1.270	0.72
Harvest index	P	0.163	-0.086	-0.107	0.102	0.773	0.84
	G	0.120	-1.790	1.670	-0.790	1.670	0.88

Residual effect: p= 0.491; g = 0.300.

The estimates of phenotypic and genotypic correlation coefficients (Table 2) descried that the genotypic correlations were higher than the corresponding phenotypic ones for all the character combinations indicating predominant role of heritable factors. Also, narrow difference between phenotypic and genotypic correlation coefficient was noticed for almost all the pairs of characters studied showing that masking or modifying effects of the environment was little indicating the presence of an inherent association among these characters [18]. Fruit yield per plant had positive and highly significant correlation with average fruit weight (0.64, 0.72) and harvest index (0.84, 0.88) at both phenotypic and genotypic levels respectively, but negative and highly significant with number of primary branches per plant, number of fruits per plant and number of fruits per cluster. Number of fruits per plant expressed positive and highly significant relationships at both levels with number of primary branches per plant and number of fruits per cluster but negative and highly significant with average fruit weight showing component compensation effect and therefore, simultaneous improvement of these two characters should not be possible. These results corroborate the views of Mayavel *et al.* [19], Mohanty [20] and Prashanth [21].

The results of path coefficient analysis in Table 3 revealed that number of fruits per plant had the positive maximum direct effect on fruit yield per plant (0.168, 2.580) followed by harvest index (0.773, 1.670) at both phenotypic and genotypic levels, respectively. Number of fruits per plant manifested strong negative correlation with fruit yield per plant but its direct effect was positive and was diluted mainly due to negative indirect effects via number of primary branches per plant and harvest index.

Consequently, such anomalous situation suggested that a restricted simultaneous selection model could be followed to nullify the undesirable indirect effects to make proper use of the direct effect. These findings illustrated markedly that number of fruits per plant and harvest index were the important components in selection for higher yield of tomato. It could be noticed that most of the direct effects were less than one at the phenotypic level but more than one at the genotypic level indicating that inflation due to multicolinearity was minimal phenotypically whereas maximum genetically [22]. The unexplained variation in phenotypic and genotypic paths was 0.491 and 0.300, respectively which might be due to many reasons such as other characters not considered here, environmental factors and sampling errors [23]. The trend of these results was in accordance with Ghosh *et al.* [24], Mohanty [20], Revanasiddappa [14] and Venkataraman [25].

CONCLUSIONS

High estimates of heritability and genetic advance as percent over mean were noticed for number of branches per plant, number of fruits per plant, number of fruits per cluster and average fruit weight which might be assigned to additive gene effects governing their inheritance and phenotypic selection for their improvement could be achieved by simple breeding methods. According to path analysis, it was observed that number of fruits per plant had negative correlation with yield, but the direct effect is positive suggesting that a restricted simultaneous selection model is to be followed to nullify the undesirable indirect effects in order to make use of the direct effect.

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