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Full Length Research Article

Correlation and path coefficient analysis in tomato (*Lycopersicon esculentum* mill.)

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Abstract

Tomatoes are a good source of beta-carotene. Lycopene in tomato is a powerful antioxidant and reduces the risk of prostate cancer. Present study was conducted in the research area of Department of Plant Breeding and Genetics, University of Agriculture Faisalabad during the Rabi Season of 2011. Forty genotypes of tomato were evaluated for genetic variability and interrelationship of different traits with yield. The data was recorded on quantitative traits such as plant height, leaf area, branches per plant, clusters per plant, flowers per cluster, fruits per cluster, fruit setting %, fruit weight, fruit width, fruit length, and yield per plant and qualitative traits i-e fruit color and fruit shape. Genotype BL-1076 performed better for number of branches per plant, number of clusters per plant and fruit setting percentage. The genotypes BL-1174, LO-2840, LO-4379, LO-2831, CLN-519-93D4-1-0-3 were good in performance for different characters. Correlation analysis used to determine the relationship among yield and yield related traits and path coefficient analysis used to find out the direct and indirect effects of different traits on yield. Yield per plant was positively and significantly correlated with clusters per plant, fruits per cluster, fruit weight, fruit width, fruit length and leaf area. The trait fruit length showed highest positive direct effect on yield followed by plant height, leaf area, branches per plant and clusters per plant. Flowers per cluster had positive indirect effect on yield per plant via branches per plant, clusters per plant, fruit weight, fruit width, fruit length, plant height and leaf area. It is suggested that flowers per cluster, fruits per cluster and fruit length may be used in next breeding program for the selection of high yielding varieties of tomato.
Keywords: Tomato, Genetic variability, Correlation, Path analysis

Introduction

Vegetable crops have secondary importance in crop husbandry in Pakistan, so very little importance is given to their improvement. By improving production technologies and cultivation of high yielding varieties the vegetable production may be expanded by increasing area of their cultivation. Tomato (*Lycopersicon esculentum*) is one of the most important vegetable crops throughout the world. It belongs to family Solanaceae which is also known as nightshade family. Tomatoes are a good source of beta-carotene (Admas *et al*., 2005). Lycopene in tomato is a powerful antioxidant and reduces the risk of prostate cancer (Hossain *et al*., 2004). It represents a large portion of the agricultural industry and has become a dietary staple for human consumption in many parts of the world (Lugasi *et al*., 2003).

Due to lack of good varieties tomato seed is imported from different countries. To overcome this problem, we should develop such varieties with good yield potential. Genetic variability is very important source in the breeding programs (Sujatha *et al*., 2002). In the breeding programs genetic similarities and difference present in the genotypes are efficiently utilized as a genetic resource (Safavi *et al*., 2010). Magnitude and nature of genotypic and environmental variation in the morphological characters is the prerequisite for the progress of breeding program (Safavi *et al*., 2011).

Yield is a complex trait which is contributed by number of traits in tomato like plant height, number of fruits per cluster, fruit length and fruit width. For the improvement of tomato yield it is very important to determine the association between yield and its related traits. This may also be helpful in the identification of such traits which have direct and indirect effect on yield (Hladni *et al*., 2011). Correlation is an important genetic tool which provide information about all positively and negatively correlated characters with yield. Importance of correlation studies in selection program is appreciable when highly heritable characters are associated with the important character like yield. Simple correlations partitioned into genotypic and phenotypic correlations. Higher magnitude of genotypic correlation coefficients than phenotypic indicates the absence of environmental effects (Ashok *et al*., 2000). But it only determines the interrelationship among traits. So, there is another analysis i-e path coefficient analysis is helpful for the partitioning of the correlation into components due to direct and indirect effects and also permits critical examination of specific factors that provide a given correlation.

The objective of this study was to estimate the genetic variability among different genotypes of tomato for yield and its related traits. Another objective of this study to assess the relationship among yield and yield related traits. This will help in the development of selection criteria for high yielding types of tomato in breeding programs.

Materials and Methods

Experimental material

Forty tomato genotypes developed and maintained in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad were used in this experiment (Table 1).

Experimental layout

Experiment was conducted during Rabi Season 2011. Seeds of forty tomato genotypes were sown in the nursery and seedling were spaced at distance of 45cm from plant to plant and 75cm from row to row at one side of bed. Thirty days old seedlings were transplanted in the field by using randomized complete block design with three replications. Agronomic and plant protection practices were applied as per requirement to each replication.

Data recording

Five plants of each genotype were taken randomly from each replication and data were recorded on quantitative characters such as plant height (cm), leaf area (cm^2), number of branches per plant, number of clusters per plant, number of flowers per cluster, number of fruits per cluster, fruit setting percentage (%), fruit weight (g), fruit width (g), fruit length (g) and yield per plant (kg). Qualitative characters were also observed i-e fruit color and fruit shape at maturity.

Statistical analysis

The data were analyzed statistically to determine the genetic variability following Steel *et al*. (1997). Correlation analysis was used to find the strength of relationship among yield and its related traits (Kown and Torrie 1964). Path coefficient analysis was performed to examine the direct and indirect effects of morphological traits on yield proposed by Dewy and Lu (1957).

Results and Discussion

Quantitative characters

Genetic variability is very important tool for the improvement of yield in plant breeding. The mean squares of different characters from analysis of variance were presented in Table 2. Genotypes showed highly significant differences for all the traits. The mean comparisons of genotypes for different characters revealed that plant height ranged from 53.33cm to 166.27cm, leaf area from 4.65cm^2 to 24.24cm^2 number of branches per plant from 1.47 to 3.53, number of clusters per plant from 8.13 to 18.80, number of flowers per cluster from 2.59 to 6.59, number of fruits per cluster from 1.80 to 5.20, fruit setting percentage from 60.86% to 89.13%, fruit weight from 4.32g to 67.33g, fruit width from 1.55cm to 6.33cm, fruit length from 1.53cm to 5.16cm and yield per plant from 0.35kg to 3.77kg.

Qualitative characters

The differences among forty genotypes of tomato for fruit color were observed for red and orange fruits. Out of these forty genotypes fifteen genotypes showed red color. Five genotypes out of fifteen showed dark red color which were LA-0716, LA-1278, LA-1279, LA-2662, LA-2711. Remaining twenty-five genotypes showed orange color.

For fruit shape all the genotypes of tomato were different from each other. Fruit shapes which were observed round, oval and pear. Twenty-five genotypes produced round shape fruits and ten genotypes produced fruits which were oval shape. Only five genotypes LO-006233, LO-006235, 17863, 17865, 17867 which showed pear shape fruits.

Correlation and path coefficient analysis

Genotypic and phenotypic correlation coefficients among various traits are presented in Table 3. Clusters per plant, fruits per cluster, fruit weight, fruit width, fruit length and leaf area showed positive and significant correlation with yield per plant at both genotypic and phenotypic levels. Plant height had positively correlated with branches per plant at both levels but with fruit setting percentage and fruit weight only at genotypic level. Genotypic and phenotypic correlation of branches per plant, clusters per plant, fruit weight, fruit length and plant height were positive and significant with leaf area. Fruit length showed significant and positive association with fruit weight and fruit width at both levels. Fruit width had positive and significant correlation with fruit weight at both levels. Fruit setting percentage showed significant and positive correlation with branches per plant and clusters per plant at both genotypic and phenotypic levels. At both levels fruits per cluster showed positive and significant association with flowers per clusters. Clusters per plant had positive and significant association with branches per plant at both levels.

Path analysis presented direct and indirect effects of different traits on yield per plant (Table 4). Fruit length followed by plant height, leaf area, branches per plant and clusters per plant had positive direct effects on yield per plant. While other traits had negative direct effects on yield per plant. On the other hand, flowers per cluster exhibited positive indirect effect on yield per plant via branches per plant, clusters per plant, fruit weight, fruit width, fruit length, plant height and leaf area. Fruit width had positive indirect effect on yield through branches per plant, clusters per plant, flowers per cluster, fruits per cluster, fruit setting % and plant height. Branches per plant showed positive indirect effect on yield of tomato via clusters per plant, fruits per cluster, fruit setting %, plant height and leaf area. Plant height had positive indirect effect on yield through the traits like branches per plant, fruits per cluster, fruit setting%, fruit weight and leaf area.

Discussion

Tomato is an important vegetable crop from an economic point of view in most countries of the world. Among the germplasm significant variation showed the presence of genetic variability which suggests that this material can be used in the next breeding program. Genetic variability in tomato genotypes for different morphological traits had also been reported by many researchers (Hussain *et al.,* 2001; El-Hamady *et al.,* 2002; Nandan and Asati, 2008; Ibitoye *et al.,* 2009; Jiregna *et al.,* 2011; Dar and Sharma, 2011; Rajasekhar *et al.,* 2013 and Jilani *et al*., 2013). The comparison indicates that further improvement of these genotypes for different traits can be used in the selection of superior plants. Genotype BL-1076 showed good performance for number of branches per plant, number of clusters per plant and fruit setting percentage. Genotype LO-2576 performed better for number of flowers per cluster and number of fruits per cluster. The genotypes BL-1174, LO-2840, LO-4379, LO-2831, CLN-519-93D4-1-0-3 were better in performance for different characters. Similarly genotype LO-006235 showed good performance for yield per plant. So, these genotypes may be used in the breeding program to increase the yield in tomato.

Correlation coefficients were analyzed for all the yield contributing traits. Most of the genotypic correlation coefficients were slightly higher than phenotypic once which showed that environmental effects were very low (Kumar *et al*., 2006). Clusters per plant, fruits per cluster, fruit weight, fruit width, fruit length and leaf area showed positive and significant correlation with yield per plant indicated that these traits are very important traits for selection to improve the yield in tomato. Plant height had positively and significantly correlated with branches per plant. The results showed that if the plant height increases branches per plant would also increases. The results are in accordance with Kumar *et al*. (2006), Dhankhar and Dhankar (2006), Singh (2007), Ara *et al*. (2009), Maurya *et al*. (2011), Madhurina and Paul (2012), Narolia *et al*. (2012), Mahapatra *et al*. (2013). Significant and positive association of fruit weight with yield per plant showed that as fruit weight increases yield per plant would also increases. These results were in conformity with Mohanthy (2002) and Ahmad *et al*. (2007).

Path coefficient analysis measures the relative importance of different yield and yield contributing traits. It helps to find out the direct and indirect effects which measures the critical examination of specific forces acting to produce a given correlation. Results of present investigation revealed that fruit length, plant height, leaf area, branches per plant and clusters per plant had positive direct effect on yield per plant. So, these traits are very important for the improvement of yield in tomato. Similar results have been reported by Mahesha *et al*. (2006), Anjum *et al*. (2009), Islam *et al*. (2010), Madhurina and Paul (2012) and Narolia *et al*. (2012). Flowers per cluster, fruit width, branches per plant and plant height exhibited positive indirect effect on yield through maximum traits so these traits may be important to increase the yield in tomato plant. Similar findings have been reported by Islam *et al*. (2010), Tiwari and Upadhyay (2011).

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Table 1: Tomato genotypes used in the present study

Sr. No.	Genotypes	Sr. No.	Genotypes	Sr. No.	Genotypes	Sr. No.	Genotypes
1	LA-0716	**11**	BL-1078	**21**	PB.017889	**31**	LO-4713
2	LA-1278	**12**	BL-1079	**22**	LO-2576	**32**	LO-4379
3	LA-1279	**13**	CLN-2413R	**23**	LO-2752	**33**	LO-006231
4	LA-2662	**14**	CLN-2418A	**24**	LO-2831	**34**	LO-006232
5	LA-2711	**15**	CLN-519-93D4-1-0-3	**25**	LO-2840	**35**	LO-006233
6	LA-3120	**16**	2001-A	**26**	LO-2846	**36**	LO-006235
7	LA-3320	**17**	CLN-1621	**27**	LO-2875	**37**	17863
8	3847	**18**	BL-1174	**28**	LO-3715	**38**	17865
9	BL-1076	**19**	BL-1175	**29**	LO-4166	**39**	17867
10	BL-1077	**20**	BL-1176	**30**	LO-4363	**40**	17868

Table 2: Mean squares of tomato genotypes for various plant traits

SOV	DF	PH	LA	BPP	CPP	FLPC	FRPC	FS%	FWT	FWI	FL	YPP
Genotypes	39	2091.50**	87.99**	1.05**	35.04**	1.77**	2.45**	147.15**	744.22**	2.11**	1.45**	2.32**
Replications	2	4.16	0.04	0.006	0.165	0.004	0.06	0.24	0.05	0.002	0.002	0.40
Error	78	3.28	0.06	0.02	0.112	0.01	0.03	0.35	0.59	0.01	0.02	0.05

**= Significant at 0.01 probability level
SOV= Source of variation, **DF**= Degree of freedom
PH= Plant height, **LA**= Leaf area, **BPP**= Branches per plant, **CPP**= Clusters per plant, **FLPC**= Flowers per cluster **FRPC**= Fruits per cluster **FS%=** Fruit setting percentage, **FWT**= Fruit weight, **FWI**= Fruit width, **FL**= Fruit length, **YPP**= Yield per plant

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Table 3: Genotypic (bold) and phenotypic correlation of various quantitative traits

Traits	r	Clusters per plant	Flowers per cluster	Fruits per cluster	Fruit setting %	Fruit weight	Fruit width	Fruit length	Plant height	Leaf area	Yield per plant
Branches per plant	**G**	**0.376***	**-0.249**	**0.058**	**0.213***	**-0.052**	**-0.133**	**-0.248**	**0.261***	**0.309***	**0.150**
	P	0.372**	-0.245**	0.059	0.212*	-0.051	-0.132	-0.243**	0.259**	0.307**	0.147
Clusters per plant	**G**		**-0.187**	**-0.225**	**0.272***	**0.004**	**-0.152**	**-0.242**	**-0.055**	**0.202***	**0.222***
	P		-0.186*	-0.222*	0.275**	0.004	-0.151	-0.241**	-0.056	0.201*	0.221*
Flowers per cluster	**G**			**0.687***	**0.059**	**-0.047**	**-0.132**	**-0.107**	**-0.051**	**-0.201**	**0.049**
	P			0.681**	0.060	-0.047	-0.132	-0.106	-0.051	-0.200*	0.047
Fruits per cluster	**G**				**0.076***	**0.142***	**-0.027**	**-0.059**	**0.036**	**-0.069**	**0.284***
	P				0.074	0.148	-0.027	-0.058	0.035	-0.069	0.285**
Fruit setting %	**G**					**-0.077**	**-0.166**	**-0.232**	**0.165***	**-0.0506**	**-0.009**
	P					-0.077	-0.166	-0.230*	0.165	-0.051	-0.010
Fruit weight	**G**						**0.779***	**0.514***	**0.064***	**0.203***	**0.827***
	P						0.776**	0.511**	0.065	0.203*	0.818**
Fruit width	**G**							**0.608***	**-0.032**	**0.062**	**0.717***
	P							0.602**	-0.032	0.062	0.707**
Fruit length	**G**								**-0.299**	**0.272***	**0.454***
	P								-0.297**	0.270**	0.445**
Plant height	**G**									**0.193***	**-0.045**
	P									0.193*	-0.044
Leaf area	**G**										**0.282***
	P										0.279**

Table 4: Direct (bold) and Indirect effects of various traits on yield per plant of tomato genotypes

	Branches per plant	Clusters per plant	Flowers per cluster	Fruits per cluster	Fruit setting %	Fruit weight	Fruit width	Fruit length	Plant height	Leaf area
Branches per plant	**0.1084**	0.040	0.021	-0.005	-0.020	0.009	0.119	-0.152	0.087	0.000
Clusters per plant	0.0394	**0.1068**	0.016	0.020	-0.025	-0.0007	0.136	-0.148	-0.018	-0.067
Flowers per cluster	-0.0260	-0.0200	**-0.0853**	-0.062	-0.006	0.009	0.118	-0.066	-0.017	-0.053
Fruits per cluster	0.0061	-0.0240	-0.0587	**-0.0902**	-0.007	-0.027	0.024	-0.037	0.012	-0.053
Fruit setting %	0.0223	0.0294	-0.0051	-0.0068	**-0.0922**	0.014	0.149	-0.142	0.055	-0.041
Fruit weight	-0.0054	0.0004	0.0040	-0.0134	0.0071	**-0.1834**	-0.698	0.315	0.021	0.081
Fruit width	-0.0139	-0.0162	0.0113	0.0024	0.0153	-0.1430	**-0.8947**	0.372	-0.011	0.132
Fruit length	-0.0260	-0.0259	0.0092	0.0054	0.0214	-0.0942	-0.5437	**0.6124**	-0.090	0.009
Plant height	0.0273	-0.0059	0.0043	-0.0032	-0.0153	-0.0118	0.0287	-0.1830	**0.3332**	0.061
Leaf area	0.0036	-0.0250	0.0160	0.0169	0.0132	-0.0526	-0.4158	0.0200	0.0710	**0.2839**