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PHENOTYPIC AND GENOTYPIC COEFFICIENT OF VARIATION AND PATH COEFFICIENT ANALYSIS IN TOMATO (*Lycopersicon esculentum* mill.)

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ABSTRACT

The experiment was initiated with objectives to estimate the nature and extent of variability in the available varieties of tomato for fruit characteristics and fruit yield to establish the inter relationship among yield contributing traits to assess direct and indirect contribution towards yield and quality components. The Phenotypic and genotypic coefficient of variation and path coefficient analysis were studied using 28 tomato genotypes. The highest genotypic and phenotypic coefficient of variation was recorded for pericarp thickness (53.21 mm), number of locules per fruit (35.69), fruit weight (31.56 g) and plant height 29.95 (cm). The highest yield was recorded in genotype Uday PGT-II (6.97 kg/plant), followed by Pusa Ruby (6.45 kg/plant) and Local-2 (6.08 kg/ plant). In this analysis yield per plant was taken as dependent variable and rest of the characters were considered as in dependable variables. Path coefficient analysis revealed that fruit weight (0.897), number of locules per fruit (0.474), number of primary branches per plant (0.319), total soluble solids (0.318), fruit length (0.162), days to 50% flowering (0.125), plant height (0.050) and pericarp thickness (0.033) had positive direct effect on yield per plant. This shows the significant effect of these characters towards the increased yield of tomato.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is universally treated as 'Protective food' number one processing vegetable in the world. This crop has wider adaptability under various agro-climatic conditions. Tomato is very popular solanaceous fruit vegetable crop. The fruits of tomatoes are used for soup, salad, pickles, ketchup, pure, sauces and many other ways. Tomato is rich source of minerals, vitamins and organic acid and fruit provides 3-4% total sugar, 4-7% total solids, 15-30 mg/100g ascorbic acid, 7.5-10 mg/100 ml tritrable acidity and 20-50 mg/ 100g fruit weight of lycopene. During ripening, there is a 500 fold increase in the level of lycopene in tomato fruit (Bai and Lindhot, 2007). For improvement of any crop, it is foremost step to study the existing variability amongst available germplasm. Therefore, development and adoption of locality based varieties to respond well under suitable condition and to withstand stress condition could be an absolute approach. The knowledge of genotypic and phenotypic coefficient of variation is being useful in designing selection criteria from variable population. This helps the breeder for improving both the traits simultaneously. Path coefficient analysis is an important tool for partitioning the correlation coefficients into the direct and indirect effects of independent variables on a dependent variable. Several path coefficient analysis has been conducted in tomato, using different type of cultivars Verma and Sarnaik (2000); Bodunde (2002); Islam *et al.* (2010) and Rahman *et al.* (2015).With the inclusion of more variables in correlation study, their direct association becomes more complex. Two characters may show correlation, just because they are correlated with a common third one. In such circumstances, path coefficient analysis provides an effective means of a critical examination of specific forces action to produce a given correlation and measure the relative importance of each factor. Therefore the present experiment was carried out to study the phenotypic and genotypic coefficient of variation and path coefficient analysis in selected genotypes.

MATERIALS AND METHODS

This investigation was laid out at All India Coordinated Vegetable Improvement Project, Horticultural Research Farm, Indira Gandhi krishi Vishwavidyalaya, Raipur, (C.G.) in Rabi season. Twenty eight genotypes (SC-3, Local-2, Uday PGT-II, Sarvodaya, S-22, RK-318, S-22 UP, S-21, Navodaya, Punjab Kesary, PKM-1, C-21, Pusa Early Dwarf, Pant-T-7, RCMT-2, RCMT-1, JTP-02-09, Pant-T-3, Pant-T-8, Improved Shalimar, KS-229, KS-227, ALT-02-39, VR-20, JTP-02-07, Pusa Ruby, DVRT-2 and CO-3) of tomato were collected from various sources; randomized block design was used to grow tomato plant with three replication. 30 days old seedlings were transplanted to the main field with spacing 60cm between rows and 40cm between plant to plant. All the standard crop management practices were adopted during the experiment. Observations were recorded on 11 quantitative and 4 qualitative characters from randomly selected five plants from each genotype in each replication. Quantitative character were recorded such as plant height (cm), number of primary branch, days to 50% flowering, fruit weight (g), fruit length (cm), fruit width (cm), number of locules per fruit, pericarp thickness (mm). Quality characters of fruits such as TSS (Total soluble solid), pH, acidity (%) and reducing sugar (%) and fruit yield per plant (kg) were also recorded. Genotypic and phenotypic coefficient of variation was calculated using formula given by Burton (1952). The genotypic correlation coefficients were further partitioned into direct and indirect effects with the help of path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959). Path coefficient was calculated separately for all important characters considering fruit yield as dependable variable. Association among the characters is useful in formulation of breeding programme focused for achieving the desired combinations of various components of yield.

RESULTS AND DISCUSSION

The information on the nature of extent of genetic variability present in the population for desirable characters in selection

Table 1: Genetic parameters of variation

Character	Mean	Range		Coefficient of variation		Heritability	Genetic advance as
		Minimum	Maximum	Phenotypic	Genotypic	(h2 %)	% of mean
Days to 50% Flowering	70.7	61.00	89.00	9.92	9.82	98.1	20.81
Plant height (cm)	71.16	43.67	118.60	29.95	29.86	99.4	61.34
Number of primary	12.01	9.00	17.33	19.50	12.80	43.1	17.32
branches per plantFruit weight (g)	66.27	33.07	115.44	31.56	30.53	93.6	60.84
Fruit Length (cm)	5.24	4.28	6.02	12.73	4.82	14.4	3.82
Fruit width (cm)	4.53	3.36	5.92	16.67	14.38	74.4	25.61
Number of locules per fruit	3.79	2.33	6.00	35.69	15.74	19.4	14.25
Number of calyx per fruit	5.82	5.00	7.00	10.74	5.28	24.1	5.33
Pericarp thickness (mm)	0.13	0.03	0.32	53.21	52.77	98.4	107.69
Number of seeds per fruit	166.15	102	263	29.15	29.15	99.9	60.02
Total soluble solid (%)	4.27	3.13	5.20	12.90	12.76	97.9	25.99
Reducing sugar (%)	4.99	3.50	6.91	18.89	18.82	99.3	38.68
Acidity (%)	0.54	0.30	0.87	29.20	27.91	91.4	53.7
pH	4.21	3.82	4.70	5.18	4.47	74.5	7.82
Fruit yield per plant (kg)	4.35	1.31	6.97	28.09	27.11	93.2	54.02

Table 2: Phenotypic (P) and genotypic (G) correlation coefficient among different characters in tomato.

Characters		Days to 50% flow ering	Plant height (cm)	No. of primary branches	Fruit weight (g) per plant	Fruit length (cm)	Fruit width (cm)	No. of locules /Fruit	No.of calyx / fruit	Pericarp thickness (mm)	No. of seeds / fruit	Total soluble solids (%)	Reducing sugar (%) (%)	Acidity	pH	Fruit yield/ plant (kg)
DFF	P	1	0.206	0.034	0.17	-0.112	-0.031	-0.111	0.385	0.177	-0.28	0.054	0.159	-0.013	-0.102	0.148
	G		0.209	0.394*	-0.117	-0.026	-0.28	-0.128	0.259	-0.092	-0.161	0.064	0	-0.011	-0.256	0.217
PH (cm)	P			0.106	-0.112	-0.026	-0.153	-0.162	0.184	0	-0.127	0.104	-0.129	0.109	0.083	0.046
	G			0.590**	0.177	0.465*	0.685**	-0.078	0.071	0.344	-0.017	0.034	0.282	-0.166	0.065	0.455*
NPB	P				-0.119	-0.252	0.473*	0.013	-0.13	0.043	0.187	-0.131	0.046	-0.207	0.094	0.228
	G				-0.146	-0.790**	-0.017	-0.023	-0.061	0.375*	-0.072	0.015	0.357	-0.318	-0.096	0.273
FW (g)	P					-0.065	-0.318	-0.252	-0.051	0.025	0.122	0.05	0.028	-0.037	0.054	-0.016
	G					1.284	-0.33	-0.255	0.775**	0.082	-0.106	0.144	-0.054	-0.221	-0.132	0.277
FL (cm)	P						0.840**	-0.737	0.547**	0.181	0.002	0.181	0.132	0.003	0.12	0.189
	G						0.970**	-0.307	0.847**	-0.093	-0.283	-0.246	-0.215	-0.074	-0.052	-0.047
FWi (cm)	P							-0.213	0.079	-0.019	-0.162	0.059	0.131	0.227	0.017	0.285
	G							-0.093	0.066	0.36	-0.189	0.066	0.161	0.157	-0.099	-0.228
NOL/Fruit	P								-0.023	0.164	-0.018	0.193	0.002	-0.011	0.166	-0.323
	G								-0.357	0.452*	0.454**	0.024	-0.167	-0.015	-0.138	-0.08
NOC/ fruit	P									0.006	-0.085	-0.322	0.285	0.199	-0.3	0.156
	G									0.176	0.273	0.017	0.112	-0.174	0.139	0.228
P T (mm)	P										-0.0224	0.131	0.409*	-0.661**	0.061	0.016
	G										0.002	0.279	0.042	-0.410*	0.220	0.493*
NOS/fruit	P											0.186	-0.127	-0.056	0.034	*0.634*
	G											-0.249	0.136	-0.366	-0.013	*0.3
TSS (%)	P												-0.126	0.002	-0.393*	0.052
	G												0.133	-0.078	-0.145	0.605**
RS (%)	P													0.245	-0.600**	0.196
	G													0.164	0.02	-0.049
Acidity (%)	P														-0.112	0.311
	G														0.228	-0.234
pH	P															-0.353
	G															-0.066
FY/ P (kg)	P															
	G															

●Significant at 5 %, ** : Significant at 1 %; ●Full Forms of DFF, PH, NPB, FW, FL, FWi, NOL, NOC, PT, NOS, TSS, RS, FY etc. written in the top of this table.

Table 3: Direct and indirect effect of component character on fruit yield per plant in tomato.

Characters	Days to 50% flowering	Plant height (cm)	No. of primary branches per plant	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	No. of locules /Fruit	No.of calyx / fruit	Pericarp thickness (mm)	No. of seeds / fruit	Total soluble solids (%)	Reducing sugar (%)	Acidity (%)	pH	Fruit yield/ plant (kg)
Days to 50% flowering	0.125	0.01	0.034	0.159	-0.041	0.008	-0.119	-0.079	0.006	0.067	0.019	-0.06	0.004	0.022	0.156
Plant height (cm)	0.026	0.05	0.188	-0.107	-0.013	0.151	-0.121	-0.055	-0.003	0.038	0.021	-0.001	0.005	0.049	0.228
No. of primary branches plant	0.013	0.029	0.319	-0.131	-0.011	0.157	-0.35	-0.086	-0.001	0.045	0.061	0.062	-0.07	-0.023	0.016
Fruit weight (g)	0.022	-0.006	-0.046	0.897	0.208	-0.398	-0.146	-0.008	0.012	0.004	0.008	-0.106	0.062	-0.01	0.493
Fruit length (cm)	-0.031	-0.004	-0.021	1.152	0.162	-0.46	-0.101	-0.007	0.005	-0.115	-0.103	-0.042	0.234	-0.036	0.634
Fruit width (cm)	-0.002	-0.016	-0.105	0.754	0.158	-0.474	-0.044	0.002	0.015	0.02	0.006	-0.152	0.145	-0.006	0.3
No.of locules/Fruit	-0.031	-0.013	-0.235	-0.276	-0.035	0.044	0.474	0.036	0	-0.065	0.042	-0.016	0.02	0.002	-0.052
No.of calyx/ fruit	0.097	0.027	0.27	0.071	0.011	0.011	-0.169	-0.101	0.006	0.053	0.089	0.047	0.129	0.064	0.605
Pericarp thickness (mm)	0.023	-0.005	-0.006	0.323	0.027	-0.215	0.003	-0.018	0.033	-0.001	0.059	-0.051	-0.001	0.024	0.196
No. of seeds/fruit	-0.035	-0.008	-0.06	-0.016	0.079	0.04	0.129	0.023	0	-0.238	-0.079	0.081	0.027	0.01	-0.049
Total soluble solids (%)	0.007	0.003	0.061	0.021	-0.052	-0.008	0.062	-0.028	0.006	0.059	0.318	-0.05	-0.087	-0.003	0.311
Reducing sugar (%)	0.02	0	-0.053	0.256	0.018	-0.194	0.02	0.013	0.004	0.052	0.042	-0.373	-0.058	0.018	-0.234
Acidity (%)	-0.001	-0.001	0.064	-0.157	-0.107	0.195	-0.027	0.037	0	0.019	0.078	-0.061	-0.353	-0.037	-0.353
pH	-0.017	-0.015	0.044	0.054	0.036	-0.016	-0.006	0.04	-0.005	0.014	0.006	0.042	-0.081	-0.163	-0.066

•Residual value: 0.3073

for improvement of a crop. The knowledge of genotypic and phenotypic coefficient of variation is being useful in designing selection criteria from variable population. Genotypic and phenotypic coefficients of variation of different characters are presented in Table 1.0. In general, it was noted that the value of phenotypic coefficient of variation is higher than the genotypic coefficient of variation. The highest value of phenotypic coefficient of variation was locules per fruit (35.69), fruit weight (31.56), plant height (29.15), acidity (29.20 per cent), number of seeds per fruit (29.15), fruit yield per plant (28.09), number of primary branches per plant (19.50), reducing sugar (18.89 per cent), fruit width (16.67), total soluble solids (12.90), fruit length (12.73), number of calyx per fruit (10.74) and days to 50 per cent flowering (9.92) whereas, lowest phenotypic coefficient of variation was recorded for pH of fruit (5.18). Similar results were cited by Meena *et al*. (2015); Rahman *et al*. (2015); Ahmed *et al*. (2016) and Doddamani *et al*. (2017).

In case of genotypic coefficient of variation highest value was recorded by pericarp thickness (52.77) followed by fruit weight (30.53), plant height (29.86), number of seeds per fruit (29.15), acidity (27.91), fruit yield per plant (27.11), reducing sugar (18.82), number of locules per fruit (15.74), fruit width (14.38), number of primary branches per plant (12.80), total soluble solids (12.76), days to 50 per cent flowering (9.82), number of calyx per fruit (5.28) and fruit length (4.82) whereas, lowest genotypic coefficient of variation was recorded for pH of fruit (4.47). Similar results were observed Singh and Raj (2004); Shravan *et al*. (2004); Rajasekhar *et al*. (2013); Prakash *et al*. (2019) and Sharmin *et al*. (2019) in different genotypes of tomato. The magnitude of phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for most of the characters. This might be due to the interaction of the genotypes with the environment to some degree or environmental factors influencing the expression of these characters.

Close correspondence between phenotypic and genotypic coefficient of variation were observed for following characters *viz*., days to 50 per cent flowering (9.92 and 9.82), plant height (29.95 and 29.86), number of primary branches per plant (19.50 and12.80), fruit weight (31.56 and 30.53), fruit width (16.67 and 14.38), pericarp thickness (53.21 and 52.77), number of seeds per fruit (29.15 and 29.15), total soluble solids (12.90 and12.76), reducing sugar (18.89 and 18.82), acidity (29.20 and 27.91), pH (5.18 and 4.47) and fruit yield per plant (28.09 & 27.11). These findings are in consonance with Rattan *et al*. (1983) for fruit weight, seed percentage, fruit length, fruit width, fruit yield per plant and acidity. Similar findings were also observed by Prasad and Rai (1999) and Mahesha *et al*. (2006) for plant height and total soluble solids (TSS) and Ahmed *et al*. (2006) for plant height, total fruit yield per plant and fruit weight.

The path coefficient analysis divides total correlation coefficient of different characters into direct and indirect effects on fruit yield per plant in such a manner that the sum of direct and indirect effects is equal to total genotypic correlation. The data revealed that fruit weight showed the highest positive direct effect (0.897) on fruit yield per plant followed by number of locules per fruit (0.474), number of primary branches per plant (0.319), total soluble solids (0.318), fruit length (0.162) and days to 50 per cent flowering (0.125). Fruit width (-0.474), reducing sugars (-0.373), acidity (-0.353), number of seeds per fruit (-0.238), pH (-0.163) and number of calyx per fruit (-0.101) showed negative direct effects on fruit yield per plant. Supporting evidence of direct positive influence of no. of fruit/plant on yield/ plant had been reported earlier (Rani *et al*., 2008; Islam *et al*., 2010 and Rahman *et al*., 2015).Whereas, the sum of direct and indirect effect of number of calyx per fruit (0.605) showed positive effect on fruit yield per plant. Days to 50 % flowering showed positive indirect effect on fruit yield per through fruit weight (0.159), number of seeds per fruit (0.067), number of primary branches per plant (0.034), pH (0.022) and total soluble solids (0.019). Plant height exhibited positive indirect effect on fruit yield per plant via., number of primary branches per plant (0.188), fruit width (0.151), pH (0.049), number of seeds per fruit (0.038), days to 50% flowering (0.026) and total soluble solids (0.021). Plant height showed positive and indirect effect on fruit yield per plant through number of primary branches per plant (0.151), and pH (0.049). Number of primary branches per plant exhibited positive indirect effect on fruit yield per plant through fruit width (0.157), reducing sugar (0.062), total soluble solids (0.061) and number of seeds per fruit (0.045). Fruit weight showed positive indirect effect on fruit yield per plant via, fruit length (0.208), whereas fruit length showed positive indirect effect on fruit yield per plant via, fruit weight (1.152) and acidity (0.234). However, fruit width showed positive indirect effect on fruit yield per plant through fruit weight (0.754), fruit length (0.158) and acidity (0.145). These results are in conformity with the findings of Rani *et al*. (2008); Ara *et al*. (2009); Sharmin *et al*. (2019) and Basfore *et al*. (2020).

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