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Correlation and path analysis studies of some genotypes in tomato (*Solanum lycopersicum* L.)

Panchbhai JR and Kulkarni GB

Abstract
The correlation and path analysis of thirteen quantitative characteristics of fourteen parental lines and two commercial checks of tomato (*Solanum lycopersicum* L.) had been considered for the study conducted during November 2016 to April 2017 to assess the nature and magnitude of genetic variability. A wide range of variation was noticed among the characters studied. Among the quantitatve character, Plant height, number of branches per plant, number of fruits per plant, average fruit weight and yield per hectare (t), all had a highly significant as well as positive link with yield per plant (kg). In genotypic correlation, among the quantitatve character, yield per plant (kg) possessed highly significant and positive correlation with plant height (0.772), number of branches per plant (0.773), number of fruits per plant (0.999), average fruit weight (0.827), yield per hectare (t) (1.038). However, it showed inversly significant correlation with days to 50% flowering (-0.517), fruit color (-0.393) and days to first harvest (-0.320). In genotypic path analysis, all the characters except plant height, days to 50% flowering, fruit color, brix and titrable acidity recorded positive direct effect on yield.

Keywords: Tomato, (*Solanum lycopersicum* L.), quantitative characteristics, correlation, path analysis, titrable acidity

Introduction
Tomato (2n=24), belongs family solanaceae, (*Solanum lycopersicum* L., formerly *Lycopersicon esculentum* Mill.), is derived from two words: lyco-persicon, which means "wolf-peach," and esculentum, which means "edible". It is one of the most significant protective food because of its exceptional nutritional value. It is cultivated in rainy, summer and winter season. Tomato is crop of special economic importance in the horticultural industry worldwide (He *et al.*, 2003) [20]. It is the best alternative and drudgery-free approach for managing resources more efficiently in this current context of constant need for veggies from dwindling land holdings in the developing countries.
Crop productivity is influenced by cultivar genetic traits, growing environment, and management practises. Knowledge of the type and degree of the relationship between yield and yield contributing component is critical for effective selection in future generations. The analysis of correlation between distinct quantitative attributes provides an idea of association that could be successfully utilised to design selection strategies for boosting agricultural yield components. For a successful selection process, the relative size of correlation of various features with yield must be evaluated. Systematic study and evaluation of germplasm is of great importance for current and future agronomic and genetic improvement of the crop (Reddy *et al.*, 2013) [21].
The path coefficient technique helps in assessing the direct and indirect contribution of various traits out of the total correlation towards yield. The study aimed to analyse the quantum importance of individual characters to accelerate the selection programme for better gains in tomato.

Materials and Methods
The experimental material for this study consisted of 14 parental lines of Tomato (*Solanum lycopersicum* L.) and two commercial checks. The 14 tomato genotypes were selected based on diversity for various traits. Out of these 14 genotpes 5 genotypes *viz*, Arka Alok,Arka Abha, Arka Vikas, Arka Meghali and Arka Saurabh were received from IIHR, Bangalore, 2 genotypes *viz*. Vaibahv and Nandi were received from UAS, Bangalore, 3 genotypes GT-2,AT-3 and JT-3 were received from NAU, Gujarat, Utkal Kumari and BT-20 from OUAT Bhubaneshwar, PKM-1 from TNAU Coimbatore and S22 from IARI New Delhi.

From these 14 genotypes, 48 crosses were evolved in a line x tester design with 8 genotypes as female parents (lines) and 6 genotypes as male parents (tester). The observations for yield and yield contributing characters *viz*; plant height, number of branches per plant, days to 50% floweing, days to first harvest, total number of fruits per plant, average fruit weight, total fruit yield per plant (kg), fruit yield per hectare, number of locules per fruit, pericarp thickness, fruit color, brix, titrable acidity were recorded from five randomly selected competent plants within each plot per replication for evaluation of genotypes, the mean observation considered for analysis of variance of randomized block design.

The analysis of variance was completed according to the procedure suggested by Panse and Sukhatme (1967) [11] for each of the characters separately. Phenotypic and genotypic correlation coefficients were assessed as per the procedure suggested by Singh and Choudhary (1985) [17]. The direct and indirect effects of the yield contributing factors were estimated through path analysis by Wright, (1921) [19]; Dewey and Lu, (1959) [3].

Table 1: Genotypic correlation coefficients studies in tomato

	Plant Height(cm)	Number of Branches	Days to 50% Flowering	Number of Fruits/plant	Average Fruit Wt. (gm)	Yield/ha (tons)	Number of Locules/	Pericarp Thickness (mm)	Fruit Colour(Hue)	Brix (%)	Titrable Acidity (%)	Days to Ist Harvest
Plant height (cm)	1.000											
No. of Branches	0.767**	1.000										
Days to 50% Flowering	-0.442*	-0.612**	1.000									
Number of Fruits/plant	0.717**	0.772**	-0.557*	1.000								
Average Fruit Wt. (gm)	0.658**	0.553*	-0.307*	0.544*	1.000							
Yield/ha (tons)	0.779**	0.783**	-0.511*	0.987**	0.819**	1.000						
Number of Locules/	-0.318*	-0.378*	-0.178*	-0.015	-0.109*	-0.092	1.000					
Pericarp Thickness (mm)	0.173*	0.002	0.272*	-0.049	0.360*	0.106	-0.659**	1.000				
Fruit Colour(Hue)	-0.509*	-0.361*	0.192*	-0.403*	-0.276*	-0.392*	0.267*	0.004	1.000			
Brix (%)	0.075	-0.253*	0.254*	-0.130*	-0.096	-0.127*	-0.012	0.158*	-0.232*	1.000		
Titrable Acidity (%)	-0.151*	-0.066	-0.135*	-0.059	-0.120*	-0.079	0.492*	-0.221*	0.088	-0.016	1.000	
Days to Ist Harvest	-0.243*	-0.515*	0.633**	-0.376*	-0.173*	-0.324*	-0.124	0.066	-0.061	0.397*	0.027	1.000
Yield/plant (Kg)	0.772**	0.773**	-0.517*	0.999**	0.827**	1.038**	-0.092	0.120	-0.393*	-0.128*	-0.074	-0.320*

* and ** ; significance at 1 % and 5 % probability level by F test

Table 2: Genotypic path analysis in tomato

	Plant Height (cm)	Number of Branches	Days to 50% Flowering	Number of Fruits/plant	Average Fruit Wt.	Yield/ha (tons)	Number of Locules/	Pericarp Thickness (mm)	Fruit Colour (Hue)	Brix (%)	Titrable Acidity (%)	Days to Ist Harvest	Yield/ plant (Kg)
Plant Height(cm)	-0.079	-0.061	0.035	-0.057	-0.052	-0.062	0.025	-0.014	0.040	-0.006	0.012	0.019	0.772**
Number of Branches	0.232	0.302	-0.185	0.233	0.167	0.237	-0.114	0.001	-0.109	-0.076	-0.020	-0.156	0.773**
Days to 50% Flowering	0.009	0.013	-0.021	0.012	0.006	0.011	0.004	-0.006	-0.004	-0.005	0.003	-0.013	-0.517*
Number of Fruits/plant	0.228	0.246	-0.177	0.318	0.173	0.314	-0.005	-0.016	-0.128	-0.041	-0.019	-0.120	0.999**
Average Fruit Wt. (gm)	0.030	0.026	-0.014	0.025	0.046	0.038	-0.005	0.017	-0.013	-0.004	-0.006	-0.008	0.827**
Yield/ha (tons)	0.408	0.410	-0.268	0.517	0.429	0.524	-0.048	0.056	-0.205	-0.066	-0.041	-0.170	1.038**
Number of Locules/	-0.094	-0.111	-0.052	-0.004	-0.032	-0.027	0.294	-0.194	0.078	-0.004	0.145	-0.036	-0.092
Pericarp Thickness (mm)	0.044	0.000	0.068	-0.012	0.091	0.027	-0.166	0.252	0.001	0.040	-0.056	0.017	0.120
Fruit Colour (Hue)	0.023	0.016	-0.009	0.018	0.013	0.018	-0.012	0.000	-0.045	0.011	-0.004	0.003	-0.393**
Brix (%)	-0.003	0.011	-0.011	0.005	0.004	0.005	0.001	-0.007	0.010	-0.042	0.001	-0.017	-0.128*
Titrable Acidity(%)	0.014	0.006	0.013	0.006	0.011	0.007	-0.046	0.021	-0.008	0.002	-0.094	-0.003	-0.074
Days to Ist Harvest	-0.040	-0.084	0.104	-0.062	-0.028	-0.053	-0.020	0.011	-0.010	0.065	0.004	0.164	-0.320*

R^2 1.063

Table 3: Phenotypic correlation analysis in tomato

	Plant Height(cm)	Number of Branches	Days to 50% Flowering	Number of Fruits/plant	Average Fruit Wt.(gm)	Yield/ha(tons)	Number of Locules/	Pericarp Thickness (mm)	Fruit Colour (Hue)	Brix (%)	Titrable Acidity (%)	Days to Ist Harvest
Plant Height(cm)	1.000											
Number of Branches	0.541**	1.000										
Days to 50% Flowering	-0.364**	0.378**	1.000									
Number of Fruits/p	0.577**	0.566**	-0.402**	1.000								
Average Fruit Wt.(gm)	0.574**	0.366**	-0.273**	0.410**	1.000							
Yield/ha(tons)	0.689**	0.592**	-0.430**	0.809**	0.699**	1.000						
Number of Locules	-0.176*	-0.063	-0.033	0.024	-0.034	0.002	1.000					
Pericarp Thickness (mm)	0.129	-0.045	0.191***	-0.064	0.250*	0.089	-0.205*	1.000				
Fruit Colour (Hue)	-0.394**	-0.206**	0.120	-0.250*	-0.226*	-0.283**	0.130*	0.053	1.000			
Brix (%)	0.068	-0.174*	0.216**	-0.093	-0.121	-0.107	-0.037	0.132	-0.157	1.000		
Titrable Acidity (%)	-0.135	-0.088	-0.115	-0.054	-0.059	-0.057	0.271*	-0.164	0.046	-0.023	1.000	
Days to Ist Harvest	-0.143*	-0.195*	0.318**	-0.193*	-0.141*	-0.173*	-0.010	0.046	0.065	0.256*	0.010	1.000
Yield / Plant (Kg)	0.700**	0.605**	-0.419**	0.789**	0.684**	0.935**	0.003	0.068	-0.281**	-0.105	-0.066	-0.178*

Table 4: Phenotypic path analysis in tomato

	Plant Height (cm)	Number of Branches	Days to 50% Flowering	Number of Fruits/plant	Average Fruit Wt. (gm)	Yield/ha (Tons)	Number of Locules	Pericarp Thickness (mm)	Fruit Colour (Hue)	Brix (%)	Titrable Acidity (%)	Days to Ist Harvest	Yield / Plant (Kg)
Plant Height(cm)	0.084	0.045	-0.031	0.048	0.048	0.058	-0.015	0.011	-0.033	0.006	-0.011	-0.012	0.700**
Number of Branches	0.029	0.054	-0.020	0.031	0.020	0.032	-0.003	-0.002	-0.011	-0.009	-0.005	-0.011	0.605**
Days to 50% Flowering	-0.001	-0.001	0.003	-0.001	-0.001	-0.001	0.000	0.001	0.000	0.001	0.000	0.001	-0.419**
Number of Fruits/plant	0.064	0.063	-0.045	0.111	0.045	0.090	0.003	-0.007	-0.028	-0.010	-0.006	-0.021	0.789**
Average Fruit Wt. (gm)	0.052	0.033	-0.025	0.037	0.090	0.063	-0.003	0.023	-0.020	-0.011	-0.005	-0.013	0.684**
Yield/ha (Tons)	0.480	0.412	-0.299	0.563	0.487	0.696	0.001	0.062	-0.197	-0.075	-0.040	-0.121	0.935**
Number of Locules	-0.003	-0.001	-0.001	0.000	-0.001	0.000	0.018	-0.004	0.002	-0.001	0.005	0.000	0.003
Pericarp Thickness (mm)	-0.002	0.001	-0.003	0.001	-0.004	-0.001	0.003	-0.016	-0.001	-0.002	0.003	-0.001	0.068
Fruit Colour (Hue)	-0.003	-0.001	0.001	-0.002	-0.001	-0.002	0.001	0.000	0.006	-0.001	0.000	0.000	-0.281**
Brix (%)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	0.000	-0.001	-0.105
Titrable Acidity (%)	0.001	0.001	0.001	0.000	0.000	0.000	-0.002	0.001	0.000	0.000	-0.006	0.000	-0.066
Days to Ist Harvest	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.178*

R^2 0.888

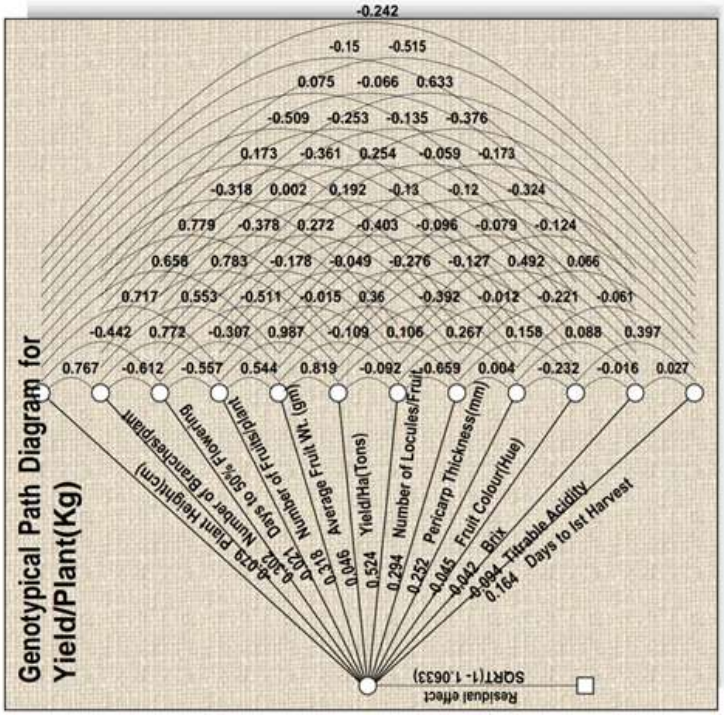

Fig 1: Genotypic path diagram of Yield /plant (Kg)

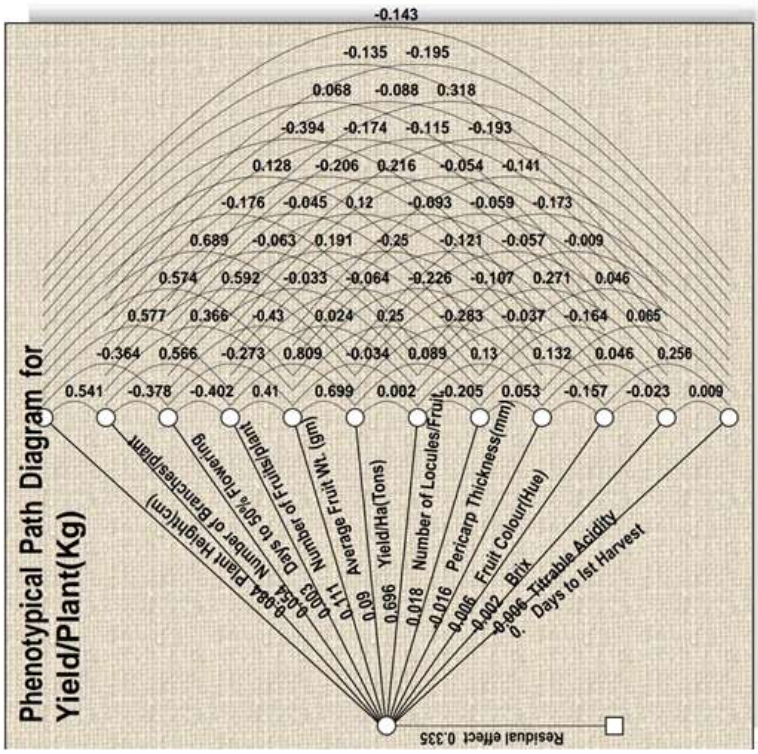

Fig 2: Phenotypic path diagram for yield per plant (Kg)

Results and Discussion

In the study, correlations between eight traits were worked out in all possible combinations at both phenotypic and genotypic levels (Table 1 & 3). In general, the magnitude of genotypic correlation coefficients were greater than the corresponding values of the phenotypic correlation coefficients. This is an indication of strong genetic association between these traits. Similar result was observed by Sahoo *et al.* (2022) [2] in a study where forty-six genotypes of tomato were assessed for yield contributing characters to observe their associations and direct and indirect effect on yield. This study also recorded that both genotypic and phenotypic correlations were similar in direction.

In genotypic correlation, yield per plant (kg) possessed highly significant and positive correlation with plant height (0.772), number of branches per plant (0.773), number of fruits per plant (0.999), average fruit weight (0.827), yield per hectare (t) (1.038). However, it showed negative significant correlation with days to 50% flowering (-0.517), fruit color (-0.393) and days to first harvest (-0.320).

Number of fruits per plant and average fruit weight exhibited positive significant correlation with plant height (0.717, 0.658), number of branches per plant (0.772, 0.553) respectively.

In phenotypic correlation, yield per plant (kg) possessed highly significant and positive correlation with plant height (0.700), number of branches per plant (0.605), number of fruits per plant (0.789), average fruit weight (0.684), yield per hectare (t) (0.935). While, it showed significant negative correlation with days to 50% flowering (-0.419), fruit color (-0.281) and days to first harvest (-0.178).

These results are in agreement with the findings of Madhurima and Paul (2012) [8], Patel *et al.* (2013) [12] and Nevani and Sridevi (2022) [15]. Thus, it can be stated that selection for plant height, number of branches per plant, number of fruits per plant, average fruit weight would be helpful for yield improvement of tomato. Emphasis for selection of these traits in desired direction for crop improvement in tomato had also been suggested by earlier workers Narolia *et al.*, (2012) [10], Kumar *et al.*, (2013) [7], Sahoo *et al*. (2022) [2].

Correlation coefficients reveal only the relation between yield as well as yield components and not the actual direct and indirect effects of the components on yield. Path analysis helps in partitioning the genotypic correlation coefficient into direct and indirect effects of the component characters on yield on the basis of which crop improvement programmes can be planned effectively. The differential emphasis is to be given based on the degree of direct and indirect influence of the component characters on the economic character of interest as revealed by path coefficient analysis. If the correlation between yield and any of its components is due to the direct effect, it reflects a true relation between them and selection can be practiced for such character in order to improve yield. However, if the correlation is mainly due to indirect effect of the character *via* another component trait, the breeder has to select the latter trait through which the indirect effect is exerted.

In genotypic path analysis, all the characters except plant height, days to 50% flowering, fruit color, brix and titrable acidity recorded positive direct effect on yield. Highest positive direct effects was recorded by yield per hectare (t) followed by number of fruits per plant (0.318), number of branches per plant (0.302), number of locules per fruit (0.294), pericarp thickness (0.252) and days to first harvest (0.164). This trend indicates the importance of these characters in yield improvement programme.

Indirect effects of plant height *via* all the characters except number of locules per fruit, brix and days to first harvest were positive and similar to its genotypic correlation. However, indirect effects for number of fruit per plant *via* all the characters except plant height, number of locules per fruit, pericarp thickness and days to first harvest were positive and similar to its genotypic correlation (Fig. 1).

In phenotypic path analysis, all the characters except pericarp thickness, brix and titrable acidity recorded positive direct effect on yield. Highest positive direct effects was recorded by yield per hectare (t) (0.696) followed by number of fruits per plants (0.111), average fruit weight (0.090) and plant height (0.084). This trend indicates the importance of these characters in yield improvement programme.

Indirect effects of plant height *via* all the characters except days to 50% flower, number of locules per fruit, pericarp thickness, fruit color were positive and similar to phenotypic correlation. However, indirect effects for number of fruits per plant *via* all the characters except plant height, number of locules per fruit, pericarp thickness and days to first harvest were positive and similar to its phenotypic correlation (Table 2 & 4; Fig 2).

These findings are in consonance with the reports of Rani *et al.* (2008) [14]; Ara *et al.* (2009) [1] Monamodi *et al.* (2013) [9] and Sahoo *et al.* (2022) [2] with respect to fruit weight where fruit weight exerted high direct positive effecton yield. Ghosh *et al.* (2010) [4], Monamodi *et al.* (2013) [9], Sant Kumar Namdeo *et al.* (2018) [16] and Sangmesh *et al.* (2022) [15] reported that fruits per plant showed high positive direct effect on fruit yield per plant as observed in this study.

Conclusion

The study revealed that yield per plant (kg) possessed highly significant and positive correlation with plant height, number of branches per plant, number of fruits per plant, average fruit weight, yield per hectare (t). While, it showed significant negative correlation with days to 50% flower, fruit color and days to first harvest.

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