

# Studies on Correlation and Path Analysis for Yield and Quality Traits in Tomato (Solanum lycopersicum L.)

S.Sridharan\*, S. Mariappan, A.Beaulah and S.Harish

Department of Vegetable Crops, Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Correlation and path analysis were carried out in nineteen tomato genotypes for yield and quality characters. The association studies showed that fruit yield per plant was positively and significantly correlated with polar diameter of fruit, equatorial diameter of fruit, number of locules per fruit, individual fruit weight and *Peanut bud necrosis virus* (PBNV) disease incidence per cent. However, fruit yield per plant was negatively and significantly correlated with number of branches per plant, fruit set per cent, acidity, ascorbic acid and lycopene. Preferable negative correlation coefficient values were also recorded by days to first flowering and days to 50 per cent flowering with and without significance, respectively. Hence, direct selection for these traits can be done for improving fruit yield in tomato.

Key words: Correlation and Path analysis, Tomato, Genotypes, Yield and quality

Tomato (*Solanum lycopersicum* L.) is one of the most widely grown vegetables in the world. It is cultivated in varied climatic conditions including sub tropic and tropic. It is universally treated as protective food. Tomato is known for its outstanding nutritive value and 100 g of edible part contains, Vitamin A (320 I.U.), Vitamin C (31 mg), potassium (114 mg), phosphorous (36 mg), calcium (20 mg), iron (1.8 mg), protein (1.9 mg) and various other minerals (Aykroyd, 1963); also, it is an excellent processing vegetable. It is native of Peru-Ecuador-Bolivian region (Rick, 1969). Tomato was introduced to India during British period in the year 1828 by the Royal Agri-Horticultural Society, Calcutta. In India.

A crop breeding programme aimed at increasing the plant productivity requires consideration not only of yield; but also, of its components that have direct or indirect bearing on yield. Correlation and path coefficient analysis give an insight into the genetic variability present in plant populations. Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters, on which selection can be based for improvement in yield. Path analysis splits the correlation coefficients into direct and indirect effects of a set of dependent variables on the independent variable; thereby, aids in selection of elite genotypes. An improvement in yield and quality in a self pollinated crop like tomato is normally achieved by selecting the genotypes with desirable character combinations existing in nature or by hybridization. Information on the nature and extent of variability present in genetic stocks, heritability, genetic advance and interrelationship among various characters is a prerequisite for framing a viable selection program.

\*Corresponding author's e-mail: sridharanvdm@gmail.com

#### **Materials and Methods**

Forty three genotypes of tomato consisting of thirty three exotic collections and varieties were evaluated in a Randomized Block Design with two replication at college orchard, Department of vegetable crops, Horticultural College and Research Institute, TNAU, Coimbatore. Observations were recorded for twenty one gualitative and guantitative characters viz., plant height (cm), number of branches per plant, days to first flowering, days to 50 per cent flowering, number of inflorescences per plant, number of flowers per cluster, number of fruits per plant, number of fruits per cluster, fruit set per cent, polar diameter of fruit (cm), equatorial diameter of fruit (cm), fruit shape index, number of locules per fruit, individual fruit weight (g), yield per plant (g), total soluble solids (°Brix), acidity (%), ascorbic acid (mg/100g), lycopene (mg/100g), phenol ( $\mu g / g$ ) and PBNV disease incidence per cent .

### **Results and Discussion**

Simple correlation studies were carried out for all the characters studied (Table 1). Polar diameter of fruit (0.643), equatorial diameter of fruit (0.646), number of locules per fruit (0.465), individual fruit weight (0.881) and PBNV disease incidence per cent (0.552) had positively and significantly correlated with vield per plant at genotypic level. Hence, the results suggest that these are primary yield determining traits in tomato. The results are in concurrence with the findings of Ara et al. (2009), Mohanty (2002), Kumar and Dudi (2011) and Saini et al. (2013). However, non-significant but, positive correlation was noticed for number of branches per plant (0.227), fruit set per cent (0.030), acidity (0.218), ascorbic acid (0.092) and lycopene (0.068) with yield per plant. Preferable negative correlation coefficient values were also recorded by days to first flowering (-.210) and days

to 50 per cent flowering (-0.260) with and without significance, respectively.

Number of inflorescence per plant (0.507), number of fruits per plant (0.752), number of fruits per cluster (0.466), fruit set per cent (0.461), total soluble solids (0.775), acidity (0.320), ascorbic acid (0.491) and lycopene (0.499) had positive and significantly correlated with phenol. Lycopene was positive and significant correlation with plant height (0.342), number of branches per plant (0.580), number of inflorescences per plant (0.498), number of fruits per plant (0.760), number of fruits per cluster (0.495), fruit set per cent (0.645), total soluble solids (0.449), acidity (0.699) and ascorbic acid (0.915). Likewise, plant height (0.472), number of branches per plant (0.644), number of inflorescences per plant (0.536), number of fruits per plant (0.848), number of fruits per cluster (0.404), fruit set per cent (0.613), total soluble solids (0.503) and acidity (0.919) showed positive and significant correlation with ascorbic acid. The results of inter correlation among these traits are in concurrence with the reports of Kumar and Dudi (2011) and Manna and Paul (2012).

Acidity in tomato was positive and significantly correlation with plant height (0.306), number of branches per plant (0.561), number of inflorescences per plant (0.478), number of fruits per plant (0.604), fruit set per cent (0.490). Total soluble solids of tomato was positive and significantly correlated with plant height (0.391), number of branches per plant (0.335), number of inflorescences per plant (0.365), number of flowers per cluster (0.384), number of fruits per plant (0.728), number of fruits per cluster (0.569), fruit set per cent (0.535), fruit shape index (0.480). Similar results were noted by Indurani et al. (2010), Manna and Paul (2012) and Buckseth et al., (2012). PBNV disease incidence per cent was positive and significantly correlated with polar diameter of fruit (0.501), equatorial diameter of fruit(0.508), number of locules per fruit (0.344), individual fruit weight (0.564). But, the number of inflorescences per plant (-0.399), number of flowers per cluster (-0.437), number of fruits per plant (-0.732) and number of fruits per cluster (-0.473) were negative and significantly correlated with fruit number per cluster.

Individual fruit weight in tomato was positive and significantly correlated with polar diameter of fruit (0.810), equatorial diameter of fruit (0.822), number of locules per fruit (0.556); whereas, number of locules per fruit was positive and significantly correlated with polar diameter of fruit (0.470), equatorial diameter of fruit (0.561). Similarly, the fruit shape index was positive and significantly correlated with number of flowers per cluster (0.491). Golani *et al.* (2007) and Manna and Paul (2012) also reported that the locules number correlated with polar diameter of fruit in tomato genotypes.

The equatorial diameter of fruit was also positive and significantly correlated with polar diameter of fruit (0.972). while polar diameter of fruit in tomato was the positive and significantly correlated with number of inflorescences per plant (0.329), number of flowers per cluster (0.509), number of fruits per plant (0.638) and number of fruits per cluster (0.577). The present investigation is in consonance with earlier findings of Chernet *et al.* (2013).

The fruit set per cent was positive and significantly correlated with plant height (0.412), number of branches per plant (0.363), number of inflorescences per plant (0.442), number of fruits per plant (0.511) and number of fruits per cluster (0.561). Whereas the number of fruits per cluster was positive and significantly correlated with plant height (0.467), number of branches per plant (0.463), number of inflorescences per plant (0.498), number of flowers per cluster (0.691), number of fruits per cluster (0.641). It is an agreement with findings of Ara et al. (2009). Number of fruits per plant was positively and significantly correlated to plant height (0.348), number of branches per plant (0.563), number of inflorescences per plant (0.679) and number of flowers per cluster (0.481). The result agree with Mohanty (2002), Regassa et al. (2012) and Mehta and Asati (2008), who also reported that the fruit number per plant correlated with these traits in tomato genotypes.

Number of flowers per cluster was positively and significantly correlated with number of branches per plant (0.341).Number of inflorescences per plant was positively and significantly correlated with plant height (0.337), number of branches per plant per plant (0.647). Whereas, days to 50% flowering had negative significant correlation with number of branches per plant (-0.504). Days to first flowering was negative and significantly correlated with number of branches per plant (-0.361). The results agree with Mohanty (2002), Regassa *et al.* (2012) and Mehta and Asati (2008)

Some of the traits *viz.*, polar diameter, equatorial diameter of fruit and individual fruit weight represent their significant contribution to yield. Days to first flowering and days to 50 per cent flowering had negative correlation with yield per plant, which was favourable. Hence, consideration of these traits could be made in tomato crop improvement programmes.

The path coefficient studies (Table 2) revealed that individual fruit weight (0.981), number of fruits per cluster (0.348), days to first flowering (0.278), equatorial diameter of fruit (0.216), total soluble solids (0.189), ascorbic acid (0.147), PBNV disease incidence per cent (0.134), lycopene (0.128), number of inflorescences per plant (0.071) and number of branches per plant (0.046) had direct positive effect on yield per plant. The highest negative direct effect on yield per plant was exerted by days to 50 per cent flowering (-0.420), polar diameter of fruit (-0.381), number of fruits per plant (-0.254), number of flowers per cluster (-0.233), phenol (-0.167), fruit set per cent (-0.159), number of locules per fruit (-0.044), acidity

Table 1. (	Genotypic	coeffic	ient of c	correlati	ion am	ong difi	ferent cl	naracte	rs in 43	tomato	genoty	bes								
-	H NB	DFF	D50F	NIP	NFC	NFRP	NFRC	FSP	PD	ED	FSI	NLF	IFW	IDI	TSS	ACD	ASA	гус	PNL	ΥРΡ
PH 1.	000 0.206	-0.243	-0.091	0.337*	0.124	0.348*	0.467**	0.412**	-0.093	0.079 -	-0.540**	-0.110	-0.151	0.161	0.391**	0.306*	0.472**	0.342*	0.276	-0.023
NB	1.000	-0.361*	-0.504**	0.647**	0.341*	0.563**	0.463**	0.363*	-0.119	0.154	0.201	0.009	-0.000	-0.209	0.335*	0.561**	0.644**	0.580**	0.262	0.227
DFF		1.000	0.921**	-0.018	-0.197	-0.156	-0.264	-0.250	0.027	0.107	-0.309*	0.052	-0.060	0.080	0.007	-0.400**	-0.339*	-0.403**	0.062	-0.210
D50F			1.000	-0.131	-0.210	-0.293	-0.288	-0.323*	0.054	0.134 -	-0.398**	0.035	-0.041	0.188	-0.091	-0.517**	-0.562**	-0.483**	-0.024	-0.260
FCP				1.000	0.240	0.679**	0.498**	0.442**	0.329*	0.238	-0.119	-0.062	-0.197	0.399**	0.365*	0.478**	0.536**	0.498**	0.507**	-0.036
FPC					1.000	0.481**	0.691**	-0.100	0.509** -	.0.588**	0.491** -(	0.531**	0.453** -	0.437**	0.384*	0.068	0.176	0.213	0.277	-0.370*
FPP						1.000	0.641**	0.511**	0.638** -	.0.589**	0.225 -	-0.329* -	0.514**	-0.732**	0.728**	0.604**	0.848**	0.760**	0.752**	-0.332*
FPC							1.000	0.561**	0.577** -	.0.579**	0.241 -(	0.455** -	0.584**	-0.473**	0.569**	0.181	0.404**	0.495**	0.466**	-0.349*
FSP								1.000	-0.324*	-0.272	-0.188	-0.067	-0.230	-0.240	0.535**	0.490**	0.613**	0.645**	0.461**	0.030
PD									1.000	0.972**	-0.141 (	.470** (	0.810**	0.501**	-0.534**	-0.275	-0.416**	-0.400**	-0.634**	0.643**
ED										1.000 -	-0.625** C	).561** (	0.822**	0.508**	-0.605**	-0.191	-0.437**	-0.345*	-0.583**	0.646**
FSI											1.000 -	-0.314*	-0.303*	-0.297	0.480**	-0.161	0.181	0.079	0.121	-0.267
NLF												1.000 (	0.556**	0.344*	-0.374*	0.001	-0.124	-0.034	-0.242	0.465**
IFW													1.000	0.564**	-0.725**	0.048	-0.144	-0.164	-0.641**	0.881**
PDI														1.000	-0.504**	-0.346*	-0.497**	-0.463**	-0.667**	0.552**
TSS															1.000	0.135	0.503**	0.449**	0.775**	-0.608**
ACD																1.000	0.919**	0.699**	0.320*	0.218
ASA																	1.000	0.915**	0.491**	0.092
гус																		1.000	0.499**	0.068
PNL																			1.000	-0.583**
ΥРΡ																				1.000
*Significant	at 5 % level	and **Signi	ficant at 1 5	% level																
PH: Plant	t height (cr	(		NFC: I	Number	of flower:	s per clust	ter ED	: Equator	ʻial diam∈	eter of frui	it (cm)	TSS:	Total solu	Ible solid	s (°brix)	Ϋ́	PP: Yield p	ber plant	
NB: Num	ber of bra	nches pei	<sup>-</sup> plant	NFRP	: Numbe	er of fruits	s per plan	t FSI	: Fruit sh	lape inde	×		ACD:	Acidity (	(%)					
DFF: Day	/s to first flc	wering		NFRC	: Numbe	er of fruits	s per clust	er NL	=: Numb∈	er of locu	le per frui	it	ASA:	Ascorbic	acid (mg	per 100ç	(6			
D50F: Dé	ays to 50 p∈	sr cent flo	wering	FSP: F	<sup>⊐</sup> ruit set	per cent		Ν	V: Individ	ual fruit v	veight (g)		LYC:	Lycopen	ة (mg pei	r 100g)				
NIP: Numt	ter of inflores	scence per	. plant	PD: Po	ılar diame	ster of fruit	(cm)	PDI	: PBNV Di	isease Inc.	idence %		PNL: '	Total phenc	(b/brl) lu					

in 43 tomato denotypes different characters 200 200 Table 1 Genotynic coefficient of correlation (-0.013). These results are in agreement with the findings of Golani *et al.* (2007). Kumar and Dudi (2011), Kumar *et al.* (2013) and Mahapatra *et al.* (2013) who reported direct and indirect effect of these traits on yield per plant in tomato.

The highest indirect and positive effect of plant height on vield per plant was through fruit shape index (0.032), days to first flowering (0.014), individual fruit weight (0.009), PBNV disease incidence per cent (0.009), number of locules per fruit (0.006), days to 50% flowering (0.005) and polar diameter of fruit (0.005). Whereas, number of branches per plant influenced the yield per plant indirectly and positively through number of inflorescences per plant (0.030), ascorbic acid (0.030), lycopene (0.027), acidity (0.026), number of fruits per plant (0.026), number of fruits per cluster (0.021), fruit set per cent (0.016), number of flowers per cluster (0.015), total soluble solids (0.015), phenol (0.012), plant height (0.009), fruit shape index (0.009). Similar results of indirect positive effect of plant and primary branch number through other traits were also reported by Kumar and Dudi (2011).

Days to first flowering influenced yield per plant indirectly and positively through days to 50% flowering (0.256), equatorial diameter of fruit (0.029), PBNV disease incidence per cent (0.022), phenol (0.017) number of locules per fruit (0.014), polar diameter of fruit (0.007) and total soluble solids (0.002). Days to 50 per cent flowering influenced yield per plant indirectly and positively through lycopene (0.230), ascorbic acid (0.236), acidity (0.217), number of branches per plant (0.212), fruit shape index (0.167), fruit set per cent (0.136), number of fruits per plant (0.123), number of fruits per cluster (0.121), number of flowers per cluster (0.088), total soluble solids (0.038), plant height (0.038), individual fruit weight (0.017), phenol (0.010) and number of inflorescences per plant (0.005). These results are in accordance with the findings of Tasisa et al. (2012) and Chernet et al. (2013).

Number of inflorescences per plant influenced yield per plant indirectly through number of fruits per plant (0.048), number of branches per plant (0.046), ascorbic acid (0.038), phenol (0.036), number of fruits per cluster (0.035), lycopene (0.035), acidity (0.034), fruit set per cent (0.031), total soluble solids (0.026), plant height (0.024) and number of flowers per cluster (0.017). The number of flowers per cluster influenced yield per plant indirectly and positively through equatorial diameter of fruit (0.137), number of locules per fruit (0.124), polar diameter of fruit (0.119), individual fruit weight (0.106), PBNV disease incidence per cent (0.102), days to 50% flowering (0.049), days to first flowering (0.046) and fruit set per cent (0.023)

The number of fruits per plant influenced yield per plant indirectly and positively through polar diameter of fruit (0.162), equatorial diameter of fruit (0.149), individual fruit weight (0.130), PBNV disease incidence per cent (0.106), number of locules per fruit (0.083), days to 50 per cent flowering (0.074) and days to first flowering (0.039). Number of fruits per cluster influenced yield per plant indirectly and positively through number of flowers per cluster (0.240), number of fruits per plant (0.223), total soluble solids (0.198), fruit set per cent (0.195), number of inflorescences per plant (0.173), lycopene (0.172), phenol (0.162), plant height (0.162), number of branches per plant (0.161), ascorbic acid (0.140), fruit shape index (0.084) and acidity (0.063).

Fruit set per cent influenced yield per plant indirectly and positively through number of flowers per cluster (0.160), days to 50% flowering (0.051), polar diameter of fruit (0.051), equatorial diameter of fruit (0.043), days to first flowering (0.040), PBNV disease incidence per cent (0.038), individual fruit weight (0.036), fruit shape index (0.030) and number of locules per fruit (0.010). Similar results were also reported by Manna and Paul (2012) and Mahapatra *et al.* (2013) in their studies.

Polar diameter of fruit influenced yield per plant indirectly and positively through number of fruits per plant (0.243), phenol (0.242), total soluble solids (0.230), number of fruits per cluster (0.220), number of flowers per cluster (0.194), ascorbic acid (0.159), lycopene (0.152), number of inflorescences per plant (0.125), fruit set per cent (0.123), acidity (0.105), fruit shape index (0.054), number of branches per plant (0.045) and plant height (0.035). Equatorial diameter of fruit influenced yield per plant indirectly and positively through polar diameter of fruit (0.210), individual fruit weight (0.177), number of locules per fruit (0.121), PBNV disease incidence per cent (0.110), days to 50% flowering (0.029), days to first flowering (0.023) and plant height (0.017).

Fruit shape index influenced yield per plant indirectly and positively through equatorial diameter of fruit (0.027), plant height (0.024), days to 50% flowering (0.017), number of locules per fruit (0.014), days to first flowering (0.013), individual fruit weight (0.013), PBNV disease incidence per cent (0.013), fruit set per cent (0.008), acidity (0.007), polar diameter of fruit (0.006) and number of inflorescences per plant (0.005). While, number of locules per fruit influenced yield per plant indirectly and positively through number of flowers per cluster (0.048), total soluble solids (0.034), number of fruits per plant (0.030), fruit shape index (0.028), phenol (0.022), ascorbic acid (0.011), plant height (0.010), fruit set per cent (0.006), number of inflorescences per plant (0.005), number of fruits per cluster (0.004) and lycopene (0.003). Chernet et al. (2013) and Saini et al. (2013) also reported indirect and positive effect of fruit shape index and locules number per fruit through different traits on yield per plant.

Individual fruit weight influenced yield per plant indirectly and positively through equatorial diameter of fruit (0.807), polar diameter of fruit (0.0795), PBNV disease incidence per cent (0.553), number of locules

Table 2.	Path coe	efficient	showi	ng dir€	ect (dia	igonal)	and ind	irect ef	fect (of	f diago	nal) of (	differen	chara(	cters or	n fruit y	ield in t	omato				
	Н	NB	DFF	D50F	NIP	NFC	NFRP	NFRC	FSP	PD	ED	FSI	NLF	IFW	PDI	TSS	ACD	ASA	ГУС	PNL	ЧРР
- Hd	0.060 -0.	012 0.0	)14 0.	005	0.020	-0.007	-0.021	-0.028	-0.025	0.005	-0.004	0.032	0.006	0.009	0.009	-0.023	-0.018	-0.028	-0.020	-0.016	-0.023
) NB	0.00 0.0	)46 -0.	016 -0	).023 C	0:030	0.015	0.026	0.021	0.016	-0.005	-0.007	0.009	0.000	0.000	-0.009	0.015	0.026	0.030	0.027	0.012	0.227
DFF .	0.067 -0.	100 0.2	?78 0.	256	0.005	-0.054	-0.043	-0.073	-0.069	0.007	0.029	-0.086	0.014	-0.016	0.022	0.002	-0.111	-0.094	-0.112	0.017	-0.210
D50F (	0.038 0.2	:12 -0.	387 -0	.420 0	.005	0.088	0.123	0.121	0.136	-0.023	-0.056	0.167	-0.014	0.017	-0.079	0.038	0.217	0.236	0.230	0.010	-0.260
FCP (	0.024 0.0	)46 -0.	001 -0	000	0.071	0.017	0.048	0.035	0.031	-0.023	-0.017	-0.008	-0.004	-0.014	-0.028	0.026	0.034	0.038	0.035	0.036	-0.036
- FPC	0.029 -0.0	079 0.0	)46 0.	049	0.056	-0.233	-0.112	-0.161	0.023	0.119	0.137	-0.115	0.124	0.106	0.102	060.0-	-0.016	-0.041	-0.050	-0.065	-0.370
- FPP	0.088 -0.	143 0.0	139 0.	074	0.172	-0.122	-0.254	-0.163	-0.129	0.162	0.149	-0.057	0.083	0.130	0.106	-0.185	-0.153	-0.215	-0.193	-0.191	-0.332
FPC (	.162 0.1	161 -0.	092 -0	).100 C	0.173	0.240	0.223	0.348	0.195	-0.201	-0.201	0.084	-0.158	-0.230	-0.164	0.198	0.063	0.140	0.172	0.162	-0.349
FSP .	0.065 -0.	058 0.0	140 0.	051 -	0.070	0.160	-0.081	-0.089	-0.159	0.051	0.043	0:030	0.010	0.036	0.038	-0.085	-0.078	-0.098	-0.103	-0.073	0.030
) (	0.035 0.0	)45 -0.	010 -0	020 0	).125	0.194	0.243	0.220	0.123	-0.381	-0.371	0.054	-0.179	-0.309	-0.191	0.230	0.105	0.159	0.152	0.242	0.643
ED (	0.017 -0.0	033 0.C	123 0.	029 -	0.051	-0.127	-0.127	-0.125	-0.058	0.210	0.216	-0.135	0.121	0.177	0.110	-0.131	-0.041	-0.094	-0.074	-0.126	0.646
FSI (	0.024 -0.0	009 0.0	113 0.	017 C	0.005	-0.021	-0.010	-0.010	0.008	0.006	0.027	-0.044	0.014	0.013	0.013	-0.021	0.007	-0.008	-0.003	-0.005	-0.256
NLF (	.010 -0.	.0- 000	004 -0	).003 C	0.005	0.048	0.030	0.004	0.006	-0.043	-0.051	0.028	-0.092	-0.051	-0.031	0.034	-0.000	0.011	0.003	0.022	0.465
- M	0.148 -0.	000 -0.	059 -0	.040	0.193	-0.445	-0.505	-0.573	-0.225	0.795	0.807	-0.298	0.545	0.981	0.553	-0.712	0.047	-0.142	-0.161	-0.629	0.881
- IQ4	0.021 -0.	028 0.0	010 0.	025 -	0.053	-0.058	-0.098	-0.063	-0.032	0.067	0.068	-0.039	0.046	0.075	0.134	-0.067	-0.046	-0.066	-0.062	-0.089	0.552
TSS (	0.074 0.0	)63 0.C	0- 10(	.017 0	.069	0.072	0.137	0.107	0.101	-0.101	-0.114	060.0	-0.070	-0.137	-0.095	0.189	0.025	0.095	0.084	0.146	-0.608
ACD -	0.004 -0.0	007 0.C	05 0.	)- 1007	0.006	-0.001	-0.008	-0.002	-0.006	0.003	0.002	0.002	0.000	-0.000	0.004	-0.001	-0.013	-0.012	-0.009	-0.004	0.218
ASA (	0.0 0.0	.0	050 -0	0.083 0	0.079	0.025	0.125	0.059	0.090	-0.061	-0.064	0.026	-0.018	-0.021	-0.073	0.074	0.135	0.147	0.134	0.072	0.092
TYC (	0.044 0.C	.00.	052 -0	).062 C	0.064	0.027	0.098	0.063	0.083	-0.051	-0.044	0.016	-0.004	-0.021	-0.059	0.057	0.090	0.118	0.128	0.064	0.068
- JNH	0.046 -0.	043 -0.	010 0.	- 100	0.085	-0.046	-0.126	-0.078	-0.077	0.106	0.097	-0.020	0.040	0.107	0.111	-0.129	-0.053	-0.082	-0.083	-0.167	-0.583
Residual E	ffect = 0.301	16																			
PH: Pla	nt height (c	(m:			NFC:	Number	of flower	s per clu	ster	ED: Equ	uatorial d	iameter o	of fruit (cı	T (r	SS: Total	soluble	solids (°b	rix)	ΥPF	P: Yield p	er plant
NB: Nur	nber of bi	ranches <sub> </sub>	oer plant		NFRF	: Numbe	er of fruits	per plar	It	FSI: Fru	uit shape	index		A	CD: Acid	ity (%)					
DFF: D	ays to first t	flowering			NFRC	C: Numbe	er of fruits	s per clus	ster	NLF: NI	umber of	locule pe	er fruit	A	SA: Asco	orbic acid	(mg per	100g)			
D50F: [	ays to 50	per cent	flowerinç	Ē	FSP:	Fruit set	per cent			IFW: In	dividual f	ruit weigh	ıt (g)	<u> </u>	rC: Lyco	pene (m	g per 10	(bc			
NIP: Nu	mber of inf	florescen	ce per p	olant	PD: F	olar diar	neter of fi	ruit (cm)		PDI: PE	SNV Dise	ase Incid	ence %	۵.	NL: Total	phenol	(b/brl)				

per fruit (0.545) and acidity (0.047). PBNV disease incidence per cent influenced yield per plant indirectly and positively through individual fruit weight (0.075), equatorial diameter of fruit (0.068), polar diameter of fruit (0.067), number of locules per fruit (0.046), days to 50 per cent flowering (0.025) and days to first flowering (0.010). These results are in accordance with findings of Kumar and Dudi (2011) and Manna and Paul (2012).

Total soluble solids influenced yield per plant indirectly and positively through phenol (0.146), number of fruits per plant (0.137), number of fruits per cluster (0.107), fruit set per cent (0.101), ascorbic acid (0.095), fruit shape index (0.090), lycopene (0.084), plant height (0.074), number of flowers per cluster (0.072), number of inflorescences per plant (0.069), number of branches per plant (0.063), acidity (0.025) and days to first flowering (0.001).

Acidity influenced yield per plant indirectly and positively through days to 50% flowering (0.007), days to first flowering (0.005), PBNV disease incidence per cent (0.004), polar diameter of fruit (0.003), equatorial diameter of fruit (0.002) and fruit shape index (0.002) while ascorbic acid influenced yield per plant indirectly and positively through acidity (0.135), lycopene (0.134), number of fruits per plant (0.125), number of branches per plant (0.095), fruit set per cent (0.090), number of inflorescences per plant (0.079), total soluble solids (0.074), phenol (0.72), plant height (0.069), number of fruits per cluster (0.059), number of flowers per cluster (0.025) and fruit shape index (0.026). These observations agree with those of Kumar and Dudi (2011) and Manna and Paul (2012).

Lycopene influenced yield per plant indirectly and positively through ascorbic acid (0.118), number of fruits per plant (0.098), acidity (0.090), fruit set per cent (0.083), number of branches per plant (0.074), number of inflorescences per plant (0.064), phenol (0.064), number of fruits per cluster (0.063), total soluble solids (0.057), plant height (0.044), number of flowers per cluster (0.027) and fruit shape index (0.016). Phenol influenced yield per plant indirectly and positively through PBNV disease incidence per cent (0.111), individual fruit weight (0.107), polar diameter of fruit (0.106), equatorial diameter of fruit (0.097), number of locules per fruit (0.040), days to 50% flowering (0.004). This was in conformity with findings of Indurani et al. (2010) and Kumar and Dudi (2011).

## Conclusion

The association and cause effect studies showed that fruit yield per plant was positively and significantly correlated with polar diameter, equatorial diameter of fruit and individual fruit weight. High direct effects were also observed for these traits. These observations lead to the inference that by improving these traits, yield can be significantly increased in tomato.

#### References

- Ara, A., R. Narayan, N. Ahmed and S.H. Khan. 2009. Genetic variability and selection parameters for yield and quality attributes in tomato. *Indian J. Hort.*, 66 (1): 73-78.
- Aykroyd, W.R. 1963. Indian Council of Medical Research, Special series, **42**.
- Buckseth, T., M.K. Sharma, and K.S. Thakur.2012. Genetic diversity and path analysis in tomato (*Solanum lycopersicum* L.). *Veg.Sci.* **39(2):** 221-223.
- Chernet, S., D. Belew, and F. Abay. 2013.Genetic variability and association of characters in tomato (*Solanum lycopersicum* L.). *Int. J. Agric. Res.*, **1**: 1-10.
- Golani, I.J., D.R. Mehta, V.L. Purohit, H.M. Pandya and M.V. Kanzariya. 2007. Genetic variability, correlation and path coefficient studies in tomato. *Indian J. Agric. Res.*, **41(2)**: 146-149.
- Indurani, C., I. Muthuvel, and D. Veeraragavathatham. 2010. Correlation and path coefficient for yield components and quality traits in tomato (*Lycopersicon esculentum* Mill.). Agr. Sci. Digest., **30(1)**: 11-14.
- Kumar, M. and B.S. Dudi.2011. Study of correlation for yield and quality characters in tomato (*Lycopersicon esculentum* Mill.). Electron. *J.Plant Breed.*, 2(3): 453-460.
- Kumar, D., R. Kumar, S. Kumar, M.L. Bhardwaj, M.C. Thakur, R. Kumar, K.S. Thakur, B.S. Dogra, A. Vikram, A. Thakur and P. Kumar. 2013. Genetic variability, correlation and path coefficient analysis in tomato. *Int. J. Veg. Sci.*, **19**:313-323.
- Manna, M. and A. Paul. 2012. Studies of genetic variability and character association of fruit quality parameters in tomato. Hort. *Flora. Res. Spectrum*, **1(2)**: 110-116.
- Mahapatra, S.A., A.K. Singh,M.V. Vani, R. Mishra, H. Kumar and B.V. Rajkumar. 2013. Inter-relationship for various components and path coefficient analysis in tomato (*Lycopersicon esculentum* Mill.). *Int. J. Curr. Microbiol. App. Sci.*, 2(9): 147-152.
- Mehta, N. and B. Asati. 2008. Genetic relationship of growth and development traits with fruit yield in tomato (*Lycopersicon esculentum* Mill.). *Karnataka J. Agric. Sci.* **21(1)**: 92-96.
- Mohanty, B.K. 2002. Studies on variability, heritability, interrelationship and path analysis in tomato. *Ann. Agric. Res.*, **2** (1): 65-69.
- Mohanty, B.K. 2003. Genetic variability, correlation and path coefficient studies in tomato. Indian J. Agric. Res., 37 (1): 68-71.
- Rick, C.M. 1969. Origin of cultivated tomato and status of the problem. Abstr. XI Int. Bot. Congr., pp: 180.
- Regassa, M.D., A. Mohammed and K. Bantte. 2012. Evaluation of tomato (*Lycopersicon esculentum* Mill.) genotypes for yield and yield components. *African J. Plant Sci. Biotech.*, **6(1)**: 45-49.
- Saini, R., A.S. Sidhu, D. Singh, and A. Kumar. 2013. Studies on genetic diversity in growth and, yield and quality traits in tomato (*Lycopersicon esculentum* Mill.). J. Hort. Sci. 8(1): 21-24.
- Tasisa, J., D. Belew and K. Bantte. 2012. Genetic association analysis among some traits of tomato (*Lycopersicon esculentum* Mill.) genotypes in West Showa, Ethiopia. *Int. J. Plant Breed. Genet.*, 6(3): 129-139.

Received after revision: June 21, 2016; Accepted: June 30, 2016