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

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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.

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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 qualitative and quantitative 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 (^{o}Brix), acidity (%), ascorbic acid (mg/100g), lycopene (mg/100g), phenol (µg /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 yield 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 (-0.092), plant height (-0.060), fruit shape index (-0.044), acidity

Table 1. Genotypic coefficient of correlation among different characters in 43 tomato genotypes

	PH	NB	DFF	D50F	NIP	NFC	NFRP	NFRC	FSP	PD	ED	FSI	NLF	IFW	PDI	TSS	ACD	ASA	LYC	PNL	YPP
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	0.470**	0.810**	0.501**	-0.534**	-0.275	-0.416**	-0.400**	-0.634**	0.643**
ED											1.000	-0.625**	0.561**	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
LYC																			1.000	0.499**	0.068
PNL																				1.000	-0.583**
YPP																					1.000

*Significant at 5 % level and **Significant at 1 % level

PH: Plant height (cm)
NB: Number of branches per plant
DFF: Days to first flowering
D50F: Days to 50 per cent flowering
NIP: Number of inflorescence per plant

NFC: Number of flowers per cluster
NFRP: Number of fruits per plant
NFRC: Number of fruits per cluster
FSP: Fruit set per cent
PD: Polar diameter of fruit (cm)

ED: Equatorial diameter of fruit (cm)
FSI: Fruit shape index
NLF: Number of locule per fruit
IFW: Individual fruit weight (g)
PDI: PBNV Disease Incidence %

TSS: Total soluble solids (°brix)
ACD: Acidity (%)
ASA: Ascorbic acid (mg per 100g)
LYC: Lycopene (mg per 100g)
PNL: Total phenol (µg/g)

YPP: Yield per plant

(-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 yield 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 coefficient showing direct (diagonal) and indirect effect (off diagonal) of different characters on fruit yield in tomato

	PH	NB	DFF	D50F	NIP	NFC	NFRP	NFRC	FSP	PD	ED	FSI	NLF	IFW	PDI	TSS	ACD	ASA	LYC	PNL	YPP
PH	-0.060	-0.012	0.014	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	0.009	0.046	-0.016	-0.023	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	0.278	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	0.212	-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	0.046	-0.001	-0.009	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	-0.079	0.046	0.049	-0.056	-0.233	-0.112	-0.161	0.023	0.119	0.137	-0.115	0.124	0.106	0.102	-0.090	-0.016	-0.041	-0.050	-0.065	-0.370
FPP	-0.088	-0.143	0.039	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	0.162	0.161	-0.092	-0.100	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	0.040	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
PD	0.035	0.045	-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	-0.033	0.023	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	-0.009	0.013	0.017	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	0.010	-0.000	-0.004	-0.003	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
IFW	-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
PDI	-0.021	-0.028	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	0.063	0.001	-0.017	0.069	0.072	0.137	0.107	0.101	-0.101	-0.114	0.090	-0.070	-0.137	-0.095	0.189	0.025	0.095	0.084	0.146	-0.608
ACD	-0.004	-0.007	0.005	0.007	-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	0.069	0.095	-0.050	-0.083	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
LYC	0.044	0.074	-0.052	-0.062	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
PNL	-0.046	-0.043	-0.010	0.004	-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 Effect = 0.3016

PH: Plant height (cm)
NB: Number of branches per plant
DFF: Days to first flowering
D50F: Days to 50 per cent flowering
NIP: Number of inflorescence per plant
NFC: Number of flowers per cluster
NFRP: Number of fruits per plant
NFRC: Number of fruits per cluster
FSP: Fruit set per cent
PD: Polar diameter of fruit (cm)
ED: Equatorial diameter of fruit (cm)
FSI: Fruit shape index
NLF: Number of locule per fruit
IFW: Individual fruit weight (g)
PDI: PBNV Disease Incidence %
TSS: Total soluble solids (°brix)
ACD: Acidity (%)
ASA: Ascorbic acid (mg per 100g)
LYC: Lycopene (mg per 100g)
PNL: Total phenol (µg/g)
YPP: Yield per plant

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.

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