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Studies of Correlation and Path Coefficients for Tomato Yield and Quality Attributes (*Solanum lycopersicum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Fifteen genotypes of tomatoes (*Solanum lycopersicum* L.) with 18 yield contributing traits, were studied for correlations and path coefficients. The experiment has been done at Vegetable Research Farm of Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, during Rabi season of 2020-21. The experiment was laid under Randomized Block Design with three replications. Using genotypic correlation, it has been found that the fruit yield per plant significantly positively correlates with lycopene, titrable acidity, pericarp thickness, fruits per plant, ascorbic acid and days to 50% flowering. This indicates that the selection

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of these qualities will impact the number of fruits produced by each plant. Yield per plant was showed the significant positive direct effects with ascorbic acid, pericarp thickness, firmness, fruit yield per plant, TSS, locules per fruit, number of fruits per plant, fruit diameter, lycopene content, seed test weight and days to 50% flowering at the genotypic path coefficient level that indicated the selection for these traits might be effective and there is a possibility of improving yield per plant through selection based on these characters. The investigation contains the necessary information to support the objectives, as shown by the residual influence at the genotypic (0.198) and phenotypic (0.206) routes.

Keywords: Solanum lycopersicum L.; correlation; path coefficient; yield and residual influence.

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is among the most industrially useful vegetables in the world. It is one of the most significant vegetables in the world and is a South American origin. It is used as a model plant species to study the stages of fruit formation, ripening and the metabolic activities of various metabolites in other plants bearing berry fruit. It self-pollinated annual crops that are diploid with twelve pairs of chromosomes (2n = 24). Becoming more popular with consumers for their beneficial properties, farmers for their high market value, researchers for their genetic and genomic characteristics. Production in India was 20.33 MT, while cultivated an area of 0.84 million hectares [1]. It is an excellent source of minerals including Ca, K and Fe as well as vitamins like vit. A and vit. C which are extremely beneficial for the body and protect from serious diseases [2]. About 90% of the tomato is consisting of water, followed by soluble and insoluble solids (5-7%), citric and other organic acids [3]. Due to the fruit's excellent nutritional value, tomatoes are known as "Poor man's orange" [4]. Lycopene, an antioxidant that may help to prevent some cancers, is found in high concentrations in ripe tomatoes [5]. Tomatoes function as a mild renal stimulant and helps in the removal of toxins and other impurities from the body. Additionally, tomato 's excellent for treating digestive problems, gastrointestinal problems, morning sickness, and excessive gas production in the intestines. The tomato can help both respiratory issues and joint pain issues as well [6]. Recent epidemiological research has discovered that eating tomatoes and tomato-related items lowers the chance of acquiring prostate and stomach cancers [7]. Salads, cooked foods or processed foods like ketchup, juice, puree, sauce and entire canned fruits are the major ways that tomatoes are ingested [8].

The yield has a complicated traits as a result of the interaction of several components and the environmental condition. The correlation coefficient assesses how closely different traits are related to each other and identifies the constituent traits from which genetic improvement for yield and yield traits that contribute to increasing yield [9]. Path Coefficient analysis examines the direct impact of one variable on another and allows the division of the correlation coefficient into components of direct and indirect effects [10]. The current research effort has been undertaken to explore the correlation and path coefficient analysis to estimate correlations among desirable features and their direct and indirect contributions toward yield. Thus, with the mentioned aspects in view, the current research was done to examine the correlation and path coefficient analysis in 15 genotypes on 18 tomato traits.

2. MATERIALS AND METHODS

The field experiment was conducted at the Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh during rabi season 2020-21, to evaluate fifteen various genotypes of tomato in Randomized Complete Block Design (RCBD). Row to row and plant to plant distances were also kept to the prescribed spacing of 60 x 60 cm. Standard cultural, fertilization and plant protection procedures were used to assure a healthy crop in the experimental field. Genotypic and phenotypic correlation coefficients were calculated according to the formula suggested by Johnson et al. [11] and Hanson et al. [12]. Correlation coefficient were further partitioned into components of direct and indirect effects by path coefficient analysis originally developed by Wright (1921) and later described by Dewey and Lu [10].

The experimental material comprised of tomato 15 genotypes and released varieties as checks (VRT-13, VRT-19, VRT-30, VRT-34, ToLCV-16, ToLCV-28, Kashi Amrit, BT-12, Azad T-5, Pant T-3, Arya, Navodaya, Arka Rakshak and Himsona) which were obtained from Department of Horticulture, BHU (Varanasi), Local market (Varanasi) and Local market, (Rajasthan) Farm which were evaluated systematically during the research period.

3. RESULTS AND DISCUSSION

3.1 Correlation Coefficient

The data was represented in Table 1. The fruit yield per plant has been observed to get a substantial positive correlation with lycopene, titrable acidity, pericarp thickness, fruits per plant, ascorbic acid and days to 50% flowering using genotypic correlation. This suggests that the selection for these traits will contribute to fruit yield per plant. Some other parameters are also positively and negatively related to other traits which were mentioned in the experimental finding. The number of fruits produced per plant, which was one of the most important features, influences all other attributes. Fruit yield per plant exhibited a substantial positive association with the lycopene, titrable acidity, pericarp thickness fruits per plant, days to 50% flowering and ascorbic acid by using phenotypic correlation. These results were similar according to Hannan et al. [13], Tasisa et al. [14] and Sridharan et al. [15]. The fruit yield per plant which was significantly positively correlated to days to 50% flowering; whereas fruits per plant was negatively correlated with fruit diameter as was studied by Isam et at. [16] and Ullah et al. [17].

3.2 Path Coefficient Analysis

The data adverting path analysis was represented in Table 2. When combined with path coefficient analysis, correlation studies offer a clearer view of the effect and relationship between different characters under study. The traits such as lycopene content, titrable acidity, fruits per plant, fruit weight, days to first flowering, fruit firmness and pericarp thickness were observed to have maximum significant positive effect on fruit yield per plant at genotypic level. However, phenotypic path coefficient analysis revealed that average lycopene content, titrable acidity, fruit weight, fruits per plant and days to first flowering had the maximum indirect positive effect on fruit yield per plant. The residual impact at the genotypic (0.198) and phenotypic (0.206) paths indicates that the study covers all necessary information to support the goal. Similar results were observed by Tiwari and Upadhyay [18]. Fruit weight was directly associated with fruit yield; this similar result was observed by Hydar et al. [19]. The parameters like pericarp thickness showed positive direct and indirect effects with fruit yield per plant and fruit diameter also directly affected fruit yield per plant as was also reported by Isam et al. [16] and Ullah et al. [17]. The fruit yield per plant also showed direct and indirect positive effects with number of fruits per plant; such similar result was also observed by Singh et al. [20] and Meena and Bahadur [21].

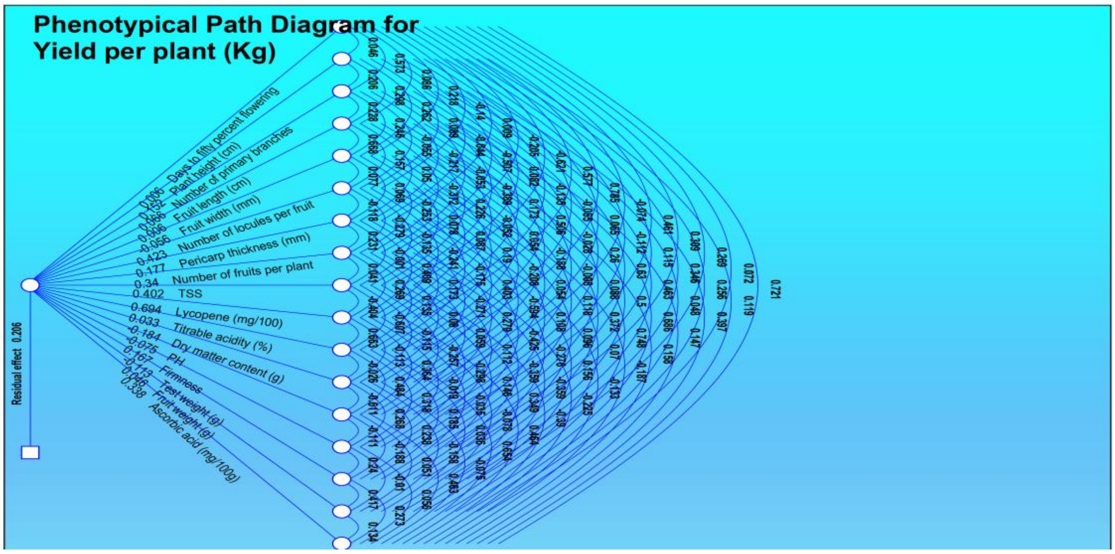

Fig. 2. Phenotypical path diagram for fruit yield per plant and 17 fruit yield attributing characters of tomato

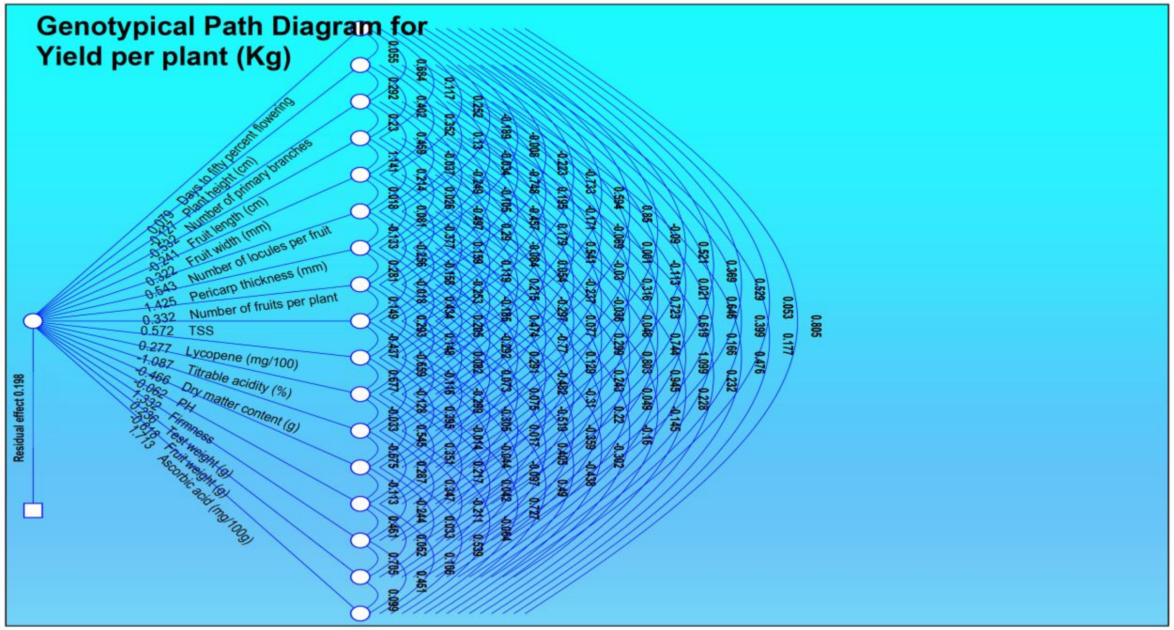

Fig. 2. Genotypical path diagram for fruit yield per plant and 17 fruit yield attributing characters of tomato

Table 1. Phenotypic and genotypic correlation of fruit yield per plant and its components in tomato

		DF	PH	NB	FL	FD	NL	PT	NF	TSS	LC	TA	DW	PH	FF	STW	FW	AC	YF
DF	P	1.0000	0.0457	0.573**	0.0861	0.2178	-0.1395	0.0087	-0.2045	-0.621**	0.577**	0.785**	-0.0738	0.461*	0.309*	0.2690	0.0720	0.721**	0.336*
	G	1.0000	0.0547	0.684**	0.1171	0.2516	-0.1886	-0.0085	-0.2233	-0.733**	0.594**	0.850**	-0.0896	0.521**	0.369*	0.529**	0.0525	0.805**	0.368*
PH	P		1.0000	0.2057	0.298*	0.2616	0.0890	-0.0436	-0.507**	0.0817	-0.1348	-0.0549	0.0653	-0.1125	0.1146	0.346*	0.2559	0.1194	-0.0239
	G		1.0000	0.2922	0.402*	0.352*	0.1299	-0.0339	-0.748**	0.1951	-0.1711	-0.0687	0.0005	-0.1134	0.0207	0.646**	0.399*	0.1770	-0.1051
NB	P			1.0000	0.2276	0.2459	-0.0551	-0.2165	-0.0530	-0.389*	0.1732	0.506**	-0.0278	0.2601	0.630**	0.463*	0.0477	0.397*	0.1640
	G			1.0000	0.2301	0.460*	-0.0371	-0.2486	-0.1055	-0.457*	0.1795	0.541**	-0.0295	0.316*	0.723**	0.619**	0.1658	0.476**	0.1845
FL	P				1.0000	0.668**	0.1570	0.0502	-0.372*	0.2255	-0.0516	0.0545	-0.1883	-0.0082	0.0882	0.500**	0.686**	0.1466	0.1092
	G				1.0000	1.1406	0.2142	0.0257	-0.497**	0.2902	-0.0844	0.0536	-0.2368	-0.0365	0.0477	0.744**	1.0991	0.2323	0.1044
FD	P					1.0000	0.0771	0.0688	-0.2531	0.0780	0.0875	0.1897	-0.2080	0.0541	0.1175	0.372*	0.748**	0.1580	0.1620
	G					1.0000	0.0184	0.0809	-0.377*	0.1590	0.1194	0.2151	-0.297*	0.0773	0.299*	0.803**	0.945**	0.2285	0.1965
NL	P						1.0000	-0.1181	-0.2790	-0.1355	-0.2411	-0.1752	0.403*	-0.594**	0.1079	0.0960	0.0698	-0.1868	0.0027
	G						1.0000	-0.1328	-0.2560	-0.1577	-0.2532	-0.1854	0.474*	-0.770**	0.1286	0.2427	0.0489	-0.1449	0.0297
PT	P							1.0000	0.2315	-0.0006	0.409*	0.1730	-0.2708	0.2789	-0.425*	-0.2760	0.1556	-0.1325	0.422*
	G							1.0000	0.2813	-0.0176	0.435*	0.2053	-0.2922	0.2910	-0.483**	-0.310*	0.2199	-0.1600	0.481**
NF	P								1.0000	0.0407	0.2687	0.1349	0.0602	0.0589	0.1115	-0.359*	-0.359*	-0.2252	0.352*
	G								1.0000	0.1494	0.2929	0.1475	0.0821	0.0734	0.0747	-0.519**	-0.359*	-0.302*	0.370*
TSS	P									1.0000	-0.404*	-0.607**	-0.1151	-0.2567	-0.298*	0.1459	0.349*	-0.390*	-0.1031
	G									1.0000	-0.437*	-0.659**	-0.1158	-0.299*	-0.305*	0.0173	0.405*	-0.438*	-0.0823
LC	P										1.0000	0.663**	-0.1134	0.364*	-0.0188	-0.0353	-0.0778	0.464*	0.752**
	G										1.0000	0.677**	-0.1285	0.395*	-0.0135	-0.0441	-0.0974	0.490**	0.809**
TA	P											1.0000	-0.0260	0.484**	0.318*	0.1850	0.0363	0.654**	0.494**
	G											1.0000	-0.0332	0.545**	0.352*	0.2167	0.0417	0.727**	0.529**
DW	P												1.0000	-0.611**	0.2682	0.2381	-0.1584	-0.0753	-0.1183
	G												1.0000	-0.675**	0.2874	0.347*	-0.2113	-0.0640	-0.1654
PH	P													1.0000	-0.1112	-0.1882	0.0511	0.463*	0.1825
	G													1.0000	-0.1128	-0.2441	0.0329	0.539**	0.2360
FF	P														1.0000	0.2399	-0.0101	0.0565	0.0585
	G														1.0000	0.461*	0.0515	0.1057	0.0372
TW	P															1.0000	0.417*	0.2734	-0.0149
	G															1.0000	0.705**	0.451*	0.0299
FW	P																1.0000	0.1337	0.0945
	G																1.0000	0.0989	0.1672
AC	P																	1.0000	0.350*
	G																	1.0000	0.390*
YF	P																		1.0000
	G																		1.0000

Significance levels	***0.05***	***0.001***
If correlation r = >	***0.29***	***0.47***

DF - Days to 50 % flowering (days), PH - Plant height (cm), NB - Number of primary branches, FL - Fruit length (cm), FD - Fruit diameter (cm), NL - Number of locules per fruit, PT - Pericarp thickness (mm), NF - Number of fruits per plant, TSS - Total soluble solids (^{o}B), LC - Lycopene content (mg/100g), TA - Titrable acidity (%), DW – Dry fruit, FF - Fruit firmness, STW - Seed test weight, FW - Fruit weight, AC - Ascorbic acid content, YF - Fruit yield per plant.

Table 2. Phenotypic and genotypic Path coefficient analysis for fruit yield per plant

	DF	PH	NB	FL	FD	NL	PT	NF	TSS	LC	TA	DW	PH	FF	STW	FW	AC	YF
DF (P)	**0.006**	0.0003	0.0035	0.0005	0.0013	-0.0008	0.0001	-0.0012	-0.0037	0.0035	0.0047	-0.0004	0.0028	0.0019	0.0016	0.0004	0.0043	0.336*
G	**0.0793**	0.0043	0.0542	0.0093	0.0200	-0.0150	-0.0007	-0.0177	-0.0581	0.0471	0.0674	-0.0071	0.0413	0.0293	0.0419	0.0042	0.0639	0.368*
PH (P)	0.0069	**0.1515**	0.0312	0.0452	0.0396	0.0135	-0.0066	-0.0768	0.0124	-0.0204	-0.0083	0.0099	-0.017	0.0174	0.0524	0.0388	0.0181	-0.0239
G	-0.0069	**-0.1266**	-0.0370	-0.0509	-0.0445	-0.0164	0.0043	0.0947	-0.0247	0.0217	0.0087	-0.0001	0.0144	-0.0026	-0.0817	-0.0505	-0.0224	-0.1051
NB (P)	0.0377	0.0135	**0.0658**	0.015	0.0162	-0.0036	-0.0142	-0.0035	-0.0256	0.0114	0.0333	-0.0018	0.0171	0.0414	0.0305	0.0031	0.0261	0.1640
G	-0.3633	-0.1553	**-0.5316**	-0.1223	-0.2442	0.0197	0.1322	0.0561	0.2428	-0.0954	-0.2877	0.0157	-0.1680	-0.3845	-0.3289	-0.0882	-0.2528	0.1845
FL (P)	0.0005	0.0018	0.0013	**0.0059**	0.0039	0.0009	0.0003	-0.0022	0.0013	-0.0003	0.0003	-0.0011	0	0.0005	0.0029	0.004	0.0009	0.1092
G	-0.0283	-0.0971	-0.0556	**-0.2414**	-0.2754	-0.0517	-0.0062	0.1200	-0.0701	0.0204	-0.0129	0.0572	0.0088	-0.0115	-0.1797	-0.2653	-0.0561	0.1044
FD (P)	-0.0122	-0.0146	-0.0137	-0.0373	**-0.0558**	-0.0043	-0.0038	0.0141	-0.0044	-0.0049	-0.0106	0.0116	-0.003	-0.0066	-0.0207	-0.0418	-0.0088	0.1620
G	0.0811	0.1133	0.1481	0.3676	**0.3223**	0.0059	0.0261	-0.1215	0.0513	0.0385	0.0693	-0.0956	0.0249	0.0963	0.2590	0.3046	0.0736	0.1965
NL(P)	-0.059	0.0376	-0.0233	0.0664	0.0326	**0.4228**	-0.0499	-0.118	-0.0573	-0.1019	-0.0741	0.1703	-0.2513	0.0456	0.0406	0.0295	-0.079	0.0027
G	-0.1024	0.0705	-0.0202	0.1163	0.0100	**0.5429**	-0.0721	-0.1390	-0.0856	-0.1374	-0.1006	0.2574	-0.4183	0.0698	0.1318	0.0265	-0.0787	0.0297
PT (P)	0.0015	-0.0077	-0.0383	0.0089	0.0122	-0.0209	**0.177**	0.041	-0.0001	0.0724	0.0306	-0.0479	0.0494	-0.0752	-0.0489	0.0275	-0.0235	0.422*
G	-0.0121	-0.0484	-0.3542	0.0366	0.1152	-0.1892	**1.4247**	0.4007	-0.0251	0.6190	0.2925	-0.4163	0.4146	-0.6874	-0.4421	0.3133	-0.2279	0.481**
NF (P)	-0.0695	-0.1723	-0.018	-0.1266	-0.086	-0.0948	0.0787	**0.3399**	0.0138	0.0913	0.0459	0.0205	0.02	0.0379	-0.1221	-0.1221	-0.0765	0.352*
G	-0.0741	-0.2484	-0.0350	-0.1650	-0.1252	-0.0850	0.0934	**0.3320**	0.0496	0.0972	0.0490	0.0273	0.0244	0.0248	-0.1722	-0.1192	-0.1004	0.370*
TSS(P)	-0.2498	0.0329	-0.1563	0.0907	0.0313	-0.0545	-0.0002	0.0164	**0.4021**	-0.1624	-0.2441	-0.0463	-0.1032	-0.1196	0.0587	0.1402	-0.1568	-0.1031
G	-0.4187	0.1115	-0.2611	0.1658	0.0909	-0.0901	-0.0101	0.0854	**0.5715**	-0.2496	-0.3768	-0.0662	-0.1708	-0.1740	0.0099	0.2317	-0.2502	-0.0823
LC (P)	0.4007	-0.0936	0.1203	-0.0359	0.0607	-0.1674	0.2839	0.1866	-0.2804	**0.6945**	0.4602	-0.0787	0.2529	-0.013	-0.0245	-0.054	0.322	0.752**
G	0.1646	-0.0475	0.0498	-0.0234	0.0331	-0.0702	0.1205	0.0812	-0.1211	**0.2774**	0.1877	-0.0356	0.1096	-0.0038	-0.0122	-0.0270	0.1358	0.809**
TA(P)	0.0257	-0.0018	0.0166	0.0018	0.0062	-0.0057	0.0057	0.0044	-0.0199	0.0217	**0.0327**	-0.0008	0.0158	0.0104	0.0061	0.0012	0.0214	0.494**
G	-0.9236	0.0747	-0.5884	-0.0583	-0.2339	0.2015	-0.2232	-0.1604	0.7166	-0.7356	**-1.0870**	0.0361	-0.5924	-0.3821	-0.2355	-0.0453	-0.7899	0.529**
DW(P)	0.0136	-0.012	0.0051	0.0347	0.0383	-0.0743	0.0499	-0.0111	0.0212	0.0209	0.0048	**-0.1844**	0.1127	-0.0494	-0.0439	0.0292	0.0139	-0.1183
G	0.0417	-0.0003	0.0138	0.1103	0.1382	-0.2208	0.1361	-0.0383	0.0540	0.0598	0.0155	**-0.4658**	0.3145	-0.1339	-0.1618	0.0984	0.0298	-0.1654
PH (P)	-0.0345	0.0084	-0.0195	0.0006	-0.0041	0.0445	-0.0209	-0.0044	0.0192	-0.0273	-0.0363	0.0458	**-0.075**	0.0083	0.0141	-0.0038	-0.0347	0.1825
G	-0.0325	0.0071	-0.0197	0.0023	-0.0048	0.0480	-0.0181	-0.0046	0.0186	-0.0246	-0.0340	0.0421	**-0.0623**	0.0070	0.0152	-0.0021	-0.0336	0.2360
FF(P)	0.0518	0.0192	0.1054	0.0148	0.0197	0.0181	-0.0711	0.0187	-0.0498	-0.0031	0.0532	0.0449	-0.0186	**0.1675**	0.0402	-0.0017	0.0095	0.0585
G	0.4916	0.0276	0.9631	0.0635	0.3980	0.1713	-0.6424	0.0995	-0.4055	-0.0180	0.4680	0.3826	-0.1502	**1.3316**	0.6139	0.0686	0.1408	0.0372
TW(P)	-0.0305	-0.0391	-0.0524	-0.0566	-0.0421	-0.0109	0.0312	0.0407	-0.0165	0.004	-0.0209	-0.027	0.0213	-0.0272	**-0.1132**	-0.0472	-0.031	-0.0149
G	0.1249	0.1525	0.1461	0.1757	0.1897	0.0573	-0.0733	-0.1225	0.0041	-0.0104	0.0512	0.0820	-0.0577	0.1089	**0.2361**	0.1664	0.1064	0.0299
FW (P)	0.0033	0.0118	0.0022	0.0316	0.0344	0.0032	0.0072	-0.0165	0.016	-0.0036	0.0017	-0.0073	0.0024	-0.0005	0.0192	**0.046**	0.0062	0.0945
G	-0.0325	-0.2465	-0.1026	-0.6797	-0.5843	-0.0302	-0.1360	0.2220	-0.2507	0.0602	-0.0258	0.1307	-0.0204	-0.0319	-0.4358	**-0.6184**	-0.0612	0.1672
AC(P)	0.2435	0.0403	0.1341	0.0495	0.0534	-0.0631	-0.0448	-0.076	-0.1317	0.1566	0.2207	-0.0254	0.1564	0.0191	0.0923	0.0451	**0.3377**	0.350*
G	1.3795	0.3033	0.8147	0.3979	0.3914	-0.2483	-0.2740	-0.5181	-0.7499	0.8386	1.2448	-0.1097	0.9236	0.1811	0.7720	0.1694	**1.7131**	0.390*
YW (P)	0.336*	-0.0239	0.1640	0.1092	0.1620	0.0027	0.422*	0.352*	-0.1031	0.752**	0.494**	-0.1183	0.1825	0.0585	-0.0149	0.0945	0.350*	**1.0000**
G	0.368*	-0.1051	0.1845	0.1044	0.1965	0.0297	0.481**	0.370*	-0.0823	0.809**	0.529**	-0.1654	0.2360	0.0372	0.0299	0.1672	0.390*	**1.0000**
R^2	0.002	-0.0036	0.0108	0.0006	-0.009	0.0011	0.0748	0.1196	-0.0415	0.5224	0.0161	0.0218	-0.0137	0.0098	0.0017	0.0043	0.1181	
	0.0292	0.0133	-0.0981	-0.0252	0.0633	0.0161	0.6855	0.1227	-0.0470	0.2243	-0.5752	0.0771	-0.0147	0.0496	0.0071	-0.1034	0.6687	

Residual effects (phenotypic) = 0.206, Residual effects (genotypic) = 0.198; P= Phenotypic , G = genotypic DF - Days to 50 % flowering (days), PH - Plant height (cm), NB - Number of primary branches, FL - Fruit length (cm), FD - Fruit diameter (cm), NL - Number of locules per fruit, PT - Pericarp thickness (mm), NF - Number of fruits per plant, TSS - Total soluble solids (^oB), LC - Lycopene content (mg/100g), TA - Titrable acidity (%), DW - Dry fruit, FF - Fruit firmness, STW - Seed test weight, FW - Fruit weight, AC - Ascorbic acid content, YF - Fruit yield per plant, R^2 – Partial R^2

4. CONCLUSION

The correlation analysis clearly showed that fruit yield per plant had a significantly positive correlation with these traits. Hence, selection for all these characteristics can contribute in yield enhancement since an improvement in one will get a favourable effect on the other. The most significant beneficial effects on fruit yield per plant were determined by path coefficient analysis. The parameters like lycopene content, titrable acidity, fruits per plant, fruit weight, days to first flowering, firmness and pericarp thickness showed direct effect on fruit yield. So, by improving these traits yield can be significantly increased.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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