STUDIES OF CORRELATION AND PATH COEFFICIENTS FOR TOMATO YIELD AND QUALITY ATTRIBUTES (*Solanum lycopersicum* L.)

Comment [CLE1]: Do they all have to be in capital letters?

Abstract

Fifteen genotypes of tomatoes (*Solanum lycopersicum*L.) with 18 yield contributing traits and 15 varieties, were studied for correlations and path coefficients. The experiment has been done at theVegetable Research Farm of Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, during theRabi 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 of these qualities will impact the number of fruits produced by each plant. Yield per plant showed significantpositive 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. 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.

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 of 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,andresearchers for their genetic and genomic characteristics. Production in India was 20.33 MT, whilecultivated an area of 0.84 million hectares (Anonymous, 2021-

22).It is an excellent source of minerals including Ca, K, and Fe as well as vitamins like vit. A and vit. C, which is extremely beneficial for the body and protects from serious diseases (Saleem *et al*., 2013).About 90% of the tomato is consisting of water, followed by soluble and insoluble solids (5-7%), citric, and other organic acids (Pedro and Ferreira, 2007). Due to the fruit's excellent nutritional value, tomatoes are known as "Poor man's orange" (Singh *et al*., 2004). Lycopene, an antioxidant that may help to prevent some cancers, is found in high concentrations in ripe tomatoes (Agarwal and Rao, 2000). Tomatoes function as a mild renal stimulant and help 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 withboth respiratory issues and joint pain issues as well (Friedman, 2013). Recent epidemiological research has discovered that eating tomatoes and tomato-related items lowers the chance of acquiring prostate and stomach cancers (Khapte and Jansirani, 2014). Salads, cooked foods, or processed foods like ketchup, juice, puree, sauce,and entire canned fruits are the major ways that tomatoes are ingested (Thamburaj and Singh, 2013).

The yield has a complicated trait 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(Nagariya*et al*., 2015).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(Dewey and Lu, 1959).The current research effort has been undertaken to explore 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.

Material 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 therabi season 2020-21, to evaluate fifteen various genotypes(Table1) of tomatoes 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. (1955) and Hanson et al. (1956). Correlation coefficients 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 (1959).

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, ArkaRakshak, and Himsona) which were obtained from Department of Horticulture, BHU (Varanasi), Local market (Varanasi) andLocal market, (Rajasthan) Farm which were evaluated systematically during the research period.

Result and Discussion

Correlation coefficient

The data was represented in Table 2. 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.* (2007), Tasisa*et al.* (2012), and Sridharan *et al.* (2016). The fruit yield per plant was significantly positively correlated to days to 50% flowering; whereas fruits per plant were negatively correlated with fruit diameter as was studied by Isam*et at.* (2010) and Ullah *et al.* (2008).

Path coefficient analysis

The data adverting path analysis was represented in Table 3. 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 amaximum significant positive effect on fruit yield per

plant at thegenotypic 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 (2011). Fruit weight was directly associated with fruit yield; this similar result was observed by Hydar*et al*. (2007). The parameters like pericarp thickness showed positive direct and indirect effects on fruit yield per plant and fruit diameter also directly affected fruit yield per plant as was also reported by Isam*et al*. (2010) and Ullah *et al*. (2008). The fruit yield per plant also showed direct and indirect positive effects with thenumber of fruits per plant; a similar result was also observed by Singh *et al*. (2018) and Meena and Bahadur (2015).

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 to yield enhancement since an improvement in one will get a favorable 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 adirect effect on fruit yield. So, by improving these traits yield can be significantly increased.

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		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

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

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.

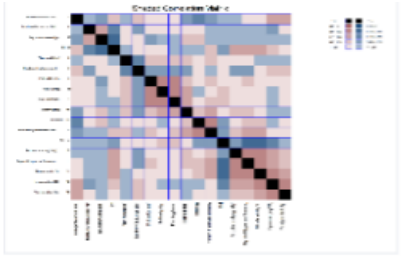
	DF	PH	NB	FL	FD	NL	PT	NF	TSS	LC	TA	DW	PH	FF	STW	FW	AC	YF
DF (P)	**0.006**	0.0003	0.0035	0.0005	0.0013	-0.0008	0.0001	-0.0012	-0.0037	0.0035	0.0047	-0.0004	0.0028	0.0019	0.0016	0.0004	0.0043	0.336*
G	**0.0793**	0.0043	0.0542	0.0093	0.0200	-0.0150	-0.0007	-0.0177	-0.0581	0.0471	0.0674	-0.0071	0.0413	0.0293	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	

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

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 (^{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, R^2 – Partial R^2.

Fig 1 : Phenotypic correlation diagram for fruit yield per plant



Phenotypic correlation diagram for fruit yield per plant

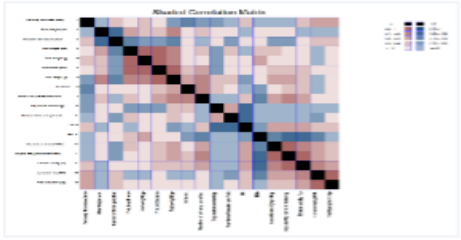


Fig 2 :Genotypic correlation diagram for fruit yield per plant

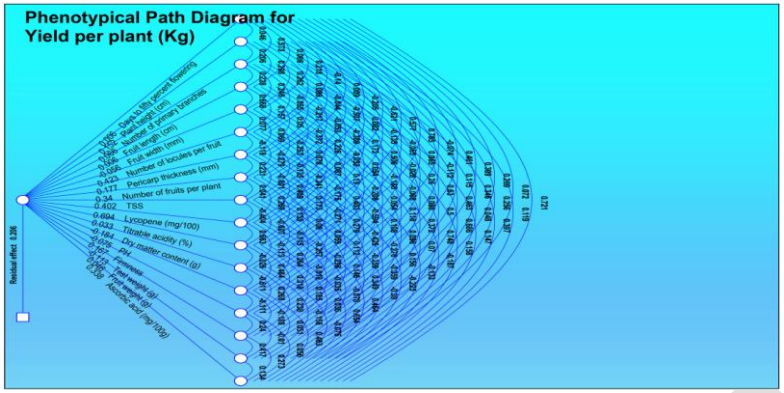


Fig 3 : Phenotypical path diagram for fruit yield per plant and 17 fruit yield attributing characters of tomato

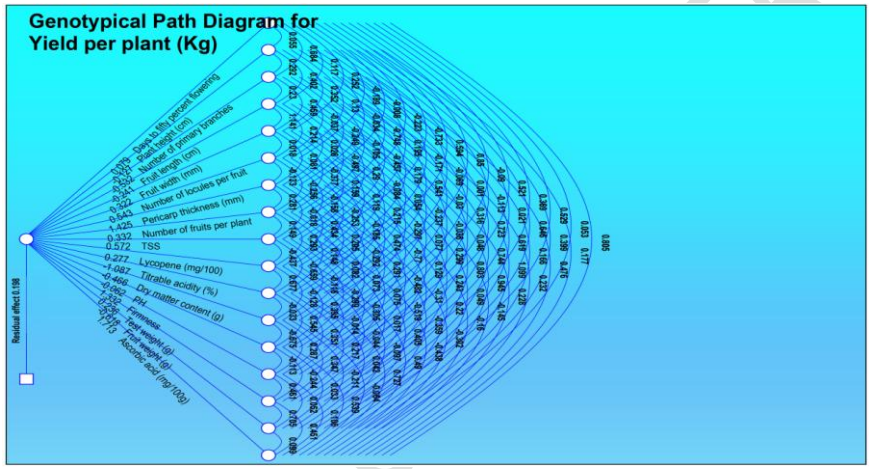


Fig 4 : Genotypical path diagram for fruit yield per plant and 17 fruit yield attributing characters of tomato