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

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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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ABSTRACT

A study was conducted on 14 genotypes (10 Lines and 3 Testers and a check-'Pant T1') of tomato (*Solanum lycopersicum* L.) at the Vegetable Research Farm of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, during the Rabi season of 2019-20, 2020-21 and 2021-22. The research focused on examining correlations and path coefficients among 15 yield-contributing traits. The experimental design employed was a Randomized Block Design with three replications. The yield per ha was significantly positively correlated with fruit yield per plant (0.943 and 0.876), fruits per plant (0.705 and 710), fruit width

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(0.266 and 0.296), number of primary branches (0.264 and 0.280), average fruit weight (0.246 and 0.246), pericarp thickness (0.245 and 0.283) and TSS (0.204 and 0.210) at phenotypic and genotypic respectively. Whereas the number of fruits per plant (0.710) showed a significantly positive indirect effect with fruit yield (q/ha) and other traits as average fruit yield per plant (0.876), fruit width (0.296), pericarp thickness (0.283), primary branches per plant (0.280), average fruit weight (0.248), TSS (0.210) and plant height (0.188) are also showed positive indirect impact on fruit yield (q/ha) at genotypic level which specified that yield can be improved by enhancing these attributes.

Keywords: Tomato; genotypic correlation; phenotypic correlation; genotypic path analysis; yield and attributes.

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a member of the Solanaceae family and is a significant warm season self-pollinating vegetable that is cultivated across both fresh as well as processed industries [1]. Increasing popularity with consumers for its nutritional benefits, farmers for their high demand, and investigators for its genetic as well as genomic traits. India produced 20.33 MT, with 0.84 million ha under cultivation [2,3]. Tomato consists of phytonutrients such as Vit. A, Vit. C, GSH, carotenoids, and polyphenols, as well as minerals such as calcium, phosphorus, and iron. They are eaten fresh and in a variety of recipes. Tomato and its by products are the most abundant dietary source of lycopene and antioxidants in the diet of human beings, while lycopene levels increase 500 times at the time of maturity [4].

Systematic research and assessment of genotypes are critical for agricultural, agronomic and genetic development now and in the coming years. Furthermore, to determine the correlation coefficient and path analysis, A complicated attribute i.e yield consists of a series of both linear and non-linear relationships between yield components that have differing degrees of influence which is known as the correlation coefficient. While formulating an effective breeding plan, genetic criteria such as the degree of association between different traits and the direct and indirect impacts of characters that contribute to the overall fruit yield are constantly significant called path analysis [5,6].

Enhancement of self-pollinated plants such as tomatoes is typically accomplished by hybridization or the selection of cultivars containing desired natural trait variations [7]. In light of the foregoing context, the study has been designed accordingly. The present research investigation was designed with all of this information considered to evaluate the correlation coefficient and path analysis through direct and indirect association of characters with yield per hactare in tomato.

2. MATERIALS AND METHODS

During the 2019–2020 Rabi season, ongoing studies were conducted at the Vegetable Research Farm of the Department of Horticulture, Institute of Agricultural Sciences, B.H.U., Varanasi-221 005, Uttar Pradesh. Here is information on the materials and techniques utilized in the experiment. The genotype material was collected from ICAR- Indian Institute of Vegetable Research, Jakhani, Varanasi, that was used in this investigation.

Three replications, each with a plot size of 3 x 3 meters, were used in the Randomized Block Design (RBD) experimental layout. All genotype plants were spaced 60 x 60 centimeters apart. To grow the commercial crop of tomato for the trial in the present research, a total of sixteen genotypes were used. The experimental field was repeatedly ploughed with a disc plough, and varieties were shown after followed by planking. The necessary thickness was acquired before transplantation. Plots under designated areas were created. A base fertilizer dosage is administered.

2.1 Analytical Statistics

Using the formulas of Johanson *et al* [8]. the correlation coefficients of variation between genotype and phenotype were calculated. The path analysis was computed using the Dewey and Lu [9] approach.

3. RESULTS AND DISCUSSION

3.1 Correlation Coefficients

Fig. 1 and Table 3 present the correlation coefficients between every possible pair of ten quantitative characters. Correlation analysis can

Table 1. Phenotypic correlation

	DTF	PH	NPBP	FL	FW	AFW	FYPP	NFPP	PT	NLPF	TSS	AAC	PH	CC	FYPH
DTF	1.0000	0.0417	0.0494	-0.301**	0.204*	-0.0205	-0.1706	-0.1207	-0.209*	0.311**	-0.0728	0.0111	-0.253*	-0.0329	-0.1679
PH		1.0000	-0.0553	0.1552	-0.0427	0.307**	0.1493	-0.1128	0.0195	-0.1349	-0.1015	-0.1090	0.0134	0.0564	0.1512
NPBP			1.0000	0.1004	0.213*	0.286**	0.263*	0.0511	0.315**	0.0951	-0.0155	0.324**	-0.0326	0.1681	0.264*
FL				1.0000	0.222*	0.425**	0.1579	-0.1681	0.353**	-0.1266	-0.1347	-0.296**	-0.0095	0.232*	0.1582
FW					1.0000	0.206*	0.267*	0.0552	0.335**	0.411**	0.1365	-0.1262	-0.1202	0.1018	0.266*
AFW						1.0000	0.246*	-0.468**	0.312**	0.1166	-0.1640	-0.232*	-0.0230	0.0841	0.246*
FYPP							1.0000	0.706**	0.246*	-0.0705	0.204*	0.0804	-0.211*	0.1035	0.943**
NFPP								1.0000	-0.0394	-0.1317	0.341**	0.222*	-0.176*	0.0391	0.705**
PT									1.0000	0.0286	0.0802	0.0425	0.0176	0.205*	0.245*
NLPF										1.0000	0.1571	-0.0506	0.1007	0.0115	-0.0705
TSS											1.0000	-0.0066	0.1509	0.0754	0.204*
AAC												1.0000	-0.0365	0.1019	0.0849
PH													1.0000	-0.0397	-0.210*
CC														1.0000	0.1030
FYPH															1.0000

DTF- Days to 50%flowering, PH- Plant height (cm), NPBP- Number of primary branches per plant, FL- Fruit length (mm), FW- Fruit width (mm), AFW- Average fruit weight (g), FYPP- Fruit yield per plant (kg), NFPP- Number of fruit per plant, PT- Pericarp thickness (mm), NLPF- Number of locules/fruit, TSS- Total soluble solids (^{0}Brix), AAC- Ascorbic acid content (mg/100 ml), CC-Chlorophyll content (nmol/cm2), FYPH- Fruit yield per ha (Kg)

Table 2. Genotypic correlation

	DTF	PH	NPBP	FL	FW	AFW	FYPP	NFPP	PT	NLPF	TSS	AAC	PH	CC	FYPH
DTF	1.0000	-0.0578	0.1012	-0.412**	0.394**	-0.0430	-0.229*	-0.1474	-0.393**	0.446**	-0.1689	0.0071	-0.439**	0.0230	-0.233*
PH		1.0000	-0.0612	0.201*	-0.0870	0.370**	0.190*	-0.1317	0.0819	-0.1417	-0.1199	-0.1509	0.0840	0.1218	0.188*
NPBP			1.0000	0.1190	0.234*	0.307**	0.281*	0.0528	0.357**	0.1269	-0.0130	0.341**	-0.0046	0.223*	0.280*
FL				1.0000	0.246*	0.428**	0.1586	-0.1704	0.399**	-0.1354	-0.1400	-0.304**	0.0004	0.349**	0.1598
FW					1.0000	0.225*	0.295**	0.0606	0.442**	0.469**	0.175*	-0.1344	-0.187*	0.263*	0.296**
AFW						1.0000	0.248*	-0.466**	0.362**	0.1259	-0.172*	-0.240*	-0.0238	0.1271	0.248*
FYPP							1.0000	0.708**	0.283*	-0.0728	0.209*	0.0846	-0.319**	0.1470	0.876**
NFPP								1.0000	-0.0501	-0.1378	0.356**	0.237*	-0.273*	0.0496	0.710**
PT									1.0000	0.0352	0.0806	0.0517	0.0945	0.350**	0.283*
NLPF										1.0000	0.173*	-0.0581	0.1261	-0.0191	-0.0739
TSS											1.0000	-0.0104	0.269*	0.0814	0.210*
AAC												1.0000	-0.1101	0.1183	0.0819
PH													1.0000	-0.1049	-0.319**
CC														1.0000	0.1478
FYPH															1.0000

DTF- Days to 50%flowering, PH- Plant height (cm), NPBP- Number of primary branches per plant, FL- Fruit length (mm), FW- Fruit width (mm), AFW- Average fruit weight (g), FYPP- Fruit yield per plant (kg), NFPP- Number of fruit per plant, PT- Pericarp thickness (mm), NLPF- Number of locules/fruit, TSS- Total soluble solids (0Brix), AAC- Ascorbic acid content (mg/100 ml), CC-Chlorophyll content (nmol/cm2), FYPH- Fruit yield per ha (Kg)

Table 3. Genotypic path matrix of fruit yield per ha (kg)

	DTF	PH	NPBP	FL	FW	AFW	FYPP	NFPP	PT	NLPF	TSS	AAC	PH	CC	FYPH
DTF	0.1077	-0.0062	0.0109	-0.0444	0.0424	-0.0046	-0.0247	-0.0159	-0.0423	0.0480	-0.0182	0.0008	-0.0472	0.0025	-0.233*
PH	0.0017	-0.0297	0.0018	-0.0060	0.0026	-0.0110	-0.0056	0.0039	-0.0024	0.0042	0.0036	0.0045	-0.0025	-0.0036	0.188*
NPBP	-0.0031	0.0019	-0.0311	-0.0037	-0.0073	-0.0095	-0.0087	-0.0016	-0.0111	-0.0039	0.0004	-0.0106	0.0001	-0.0069	0.280*
FL	-0.0210	0.0102	0.0061	0.0510	0.0125	0.0218	0.0081	-0.0087	0.0203	-0.0069	-0.0071	-0.0155	0.0000	0.0178	0.1598
FW	-0.0278	0.0062	-0.0166	-0.0174	-0.0707	-0.0159	-0.0208	-0.0043	-0.0313	-0.0332	-0.0124	0.0095	0.0132	-0.0186	0.296**
AFW	0.0011	-0.0095	-0.0078	-0.0109	-0.0058	-0.0255	-0.0063	0.0119	-0.0093	-0.0032	0.0044	0.0061	0.0006	-0.0032	0.248*
FYPP	-0.2472	0.2049	0.3026	0.1710	0.3176	0.2669	1.0778	0.7631	0.3047	-0.0785	0.2255	0.0912	-0.3437	0.1584	0.876**
NFPP	0.0045	0.0041	-0.0016	0.0053	-0.0019	0.0144	-0.0219	-0.0309	0.0015	0.0043	-0.0110	-0.0073	0.0084	-0.0015	0.710**
PT	-0.0206	0.0043	0.0187	0.0209	0.0232	0.0190	0.0148	-0.0026	0.0524	0.0018	0.0042	0.0027	0.0049	0.0183	0.283*
NLPF	-0.0063	0.0020	-0.0018	0.0019	-0.0066	-0.0018	0.0010	0.0019	-0.0005	-0.0140	-0.0024	0.0008	-0.0018	0.0003	-0.0739
TSS	-0.0019	-0.0014	-0.0001	-0.0016	0.0020	-0.0020	0.0024	0.0041	0.0009	0.0020	0.0115	-0.0001	0.0031	0.0009	0.210*
AAC	0.0000	-0.0009	0.0021	-0.0019	-0.0008	-0.0015	0.0005	0.0015	0.0003	-0.0004	-0.0001	0.0062	-0.0007	0.0007	0.0819
PH	-0.0197	0.0038	-0.0002	0.0000	-0.0084	-0.0011	-0.0143	-0.0123	0.0042	0.0057	0.0121	-0.0050	0.0450	-0.0047	-0.319**
CC	-0.0003	-0.0015	-0.0028	-0.0044	-0.0033	-0.0016	-0.0018	-0.0006	-0.0044	0.0002	-0.0010	-0.0015	0.0013	-0.0125	0.1478
FYPH	-0.233*	0.188*	0.280*	0.1598	0.296**	0.248*	0.876**	0.710**	0.283*	-0.0739	0.210*	0.0819	-0.319**	0.1478	1.0000
Partial R^2	-0.0251	-0.0056	-0.0087	0.0081	-0.0209	-0.0063	1.0781	-0.0219	0.0148	0.0010	0.0024	0.0005	-0.0143	-0.0019	

DTF- Days to 50%flowering, PH- Plant height (cm), NPBP- Number of primary branches per plant, FL- Fruit length (mm), FW- Fruit width (mm), AFW- Average fruit weight (g), FYPP- Fruit yield per plant (kg), NFPP- Number of fruit per plant, PT- Pericarp thickness (mm), NLPF- Number of locules/fruit, TSS- Total soluble solids (0Brix), AAC- Ascorbic acid content (mg/100 ml), CC-Chlorophyll content (nmol/cm2), FYPH- Fruit yield per ha (Kg)

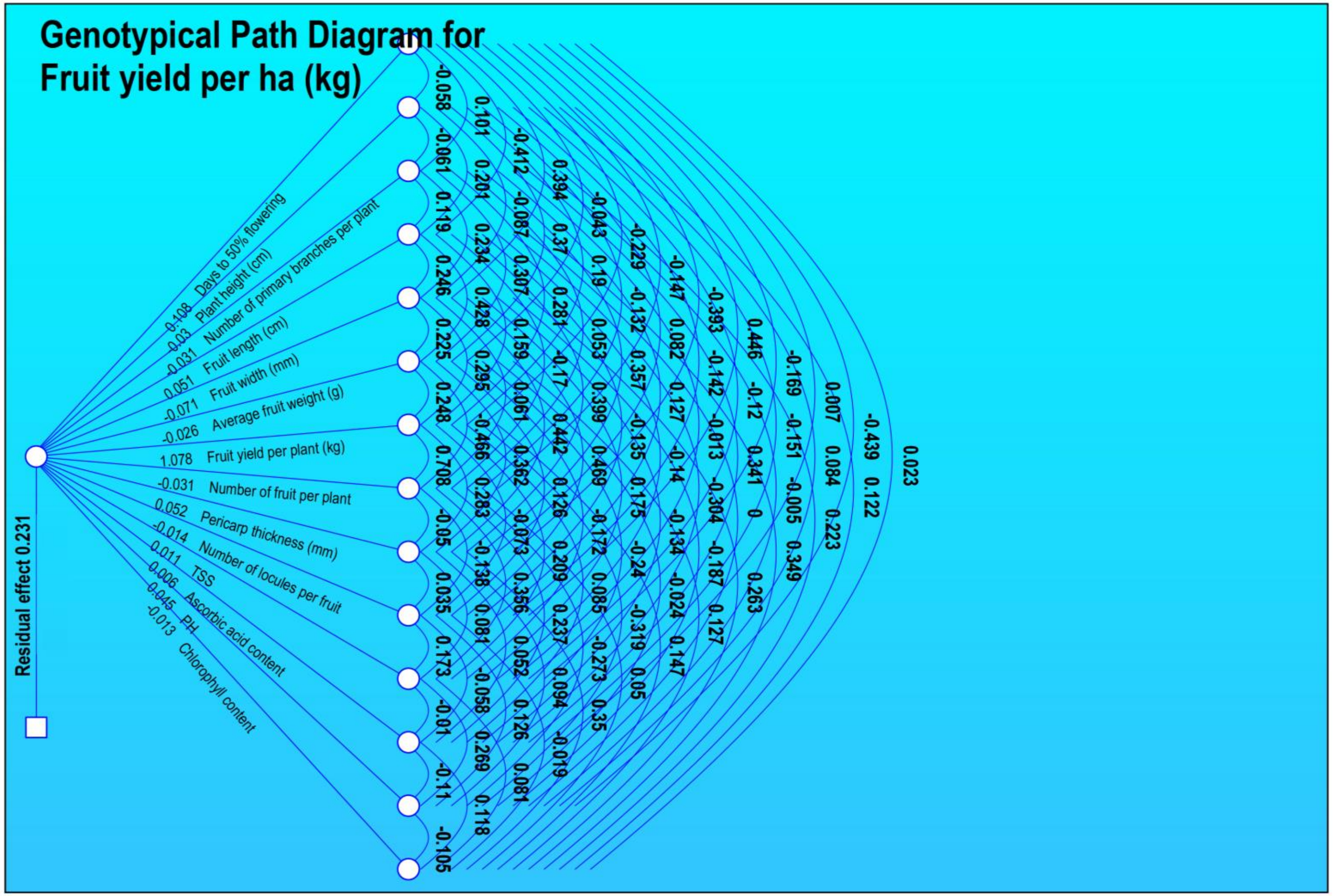

Fig. 1. Genotypical path diagram for fruit yield per ha (Kg)

be used to identify the component traits that will serve as the basis for selection to increase yield. Both genotypic and phenotypic correlations are significance; however, the genotypic correlations (rg) are greater in magnitude than the phenotypic correlations (rp), suggesting that genes had an impact on the expression of every characteristic as well as the traits under study were innately connected. According to Panda et al. [10], there is a strong positive association between traits and fruit yield per ha. This correlation may be attributed to increased phenotypic correlation and decreased environmental variance, as well as genetic linkage.

All characters were positively or negatively correlated with fruit yield per ha, which was one of the important characteristics. The yield per ha was observed highly positive correlation with fruit yield per plant (0.943 and 0.876), number of fruits per plant (0.705, 710), fruit width (0.266,0.296), number of primary branches (0.264 and 0.280) have been significantly positively correlated at phenotypic and genotypic respectively. Similar results were found by Souze et al. [11] and Khan et al. [12], similar findings were found by Behera et al. [13], that the fruit yield was positively associated with several fruits per plant and Sahoo et al. [14]. While average fruit weight (0.246 and 0.246), pericarp thickness (0.245, 0.283), and TSS (0.204, 0.210) were also significantly positively associated with yield per ha at phenotypic and genotypic levels respectively, and height of plant (0.188) showed the positive genotypic correlation with fruit yield per ha and these similar results were observed by Alam et al. [15], Basfore et al. [16], Arya et al. [17], whereas fruit yield ha $^{-1}$ phenotypically and genotypically negative correlated with pH (-0.210, -0.319) respectively and days to 50 % flowering (-0.233) at genotypic level. Thus, a higher yield of that plant would inevitably come from selecting plants with a greater number of branches per plant and more number of fruits per plant. Meena and Bahadur's [18]. research showed a significant and positive correlation between fruit yield and both fruit weight and the total number of fruits per plant. Meitei et al. [19] and Behera et al. (2017) also reported similar findings in tomatoes.

3.2 Path Analysis

When dividing the correlation coefficients into the direct and indirect effects of independent variables on a dependent variable, path coefficient analysis is an important tool. The indirect association between more variables in a correlation study becomes more complicated. Two characters might show a connection, since they are corresponded with a normal third one. In such conditions, coefficient examination gives a successful method for a basic assessment of explicit powers activity to create a given relationship and measure the general significance of each component. The fruit yield per ha was used as the dependent variable in this analysis, and the other characters were considered unreliable variables.

The analysis about genotypic path matrix for fruit yield (q/ha) revealed that number of fruits per plant (0.710) showed the highest significantly positive indirect effect followed by average fruit yield per plant (0.876), fruit width (0.296), pericarp thickness (0.283), primary branches per plant (0.280), average fruit weight (0.248), TSS (0.210) and plant height (0.188) and however, the highest direct negative impact on fruit yield per ha has been shown by days to 50% flowering (-0.233) and P^H (-0.319). Similar results were found by Meitei et al. [19], Nagariya et al. [20], Sudesh and Anita [21] and Alam et al. [15].

The fact that the residual factor (0.231) did not affect the fruit yield per hectare suggests that there is no other significant yield component left over. The present research findings show that the fruit yield per plant showed a direct and significant positive effect on fruit yield per plant, days to 50% flowering, pericarp thickness, fruit length, pH, TSS and ascorbic acid, so we can conclude that to increase the fruit yield per ha, the traits fruit yield per plant, days to 50% flowering and pericarp thickness play a very important role and similar result was found by Islam et al. [22]. additionally saw that Pericarp thickness showed positive direct impact on yield per ha, and similar results also observed by Nagariya et al. [20], Alam et al. [23] and Maurya et al. [24,25].

4. CONCLUSION

In these findings, we can conclude that yield per plant, fruits per plant, fruit width, primary branches, average fruit weight, pericarp thickness, and TSS contributed to increasing yield and quality in tomatoes simultaneously because these characteristics directly influenced yield and quality. This concentrate likewise uncovered that enormous size tomato natural products are not simply great yielders in addition they are similarly healthfully rich in quality parameters.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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