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Original Research

Associations among Yield and Yield Component Characters of F2 Segregating Populations of Tomato (*Solanum lycopersicum* L)

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Abstract

*Tomato, is the most commercially significant vegetable cultivated in Ethiopia. However, its yield in Ethiopia remains below the global average. The creation of superior varieties is necessary to increase productivity, and this calls for comprehending the kind and extent of geneticdiversity as well as the degree of correlation between desired qualities. Therefore, the study was undertaken to elucidate the interrelationships among the evaluated traits of tomato genotypes. There have been few reports of tomato segregation variability, particularly in the study location. The study was conducted at Hareto and Shambu, Correlation and path coefficient analysis were therefore performed on a 5*2m plot with 28 F2 tomato genotypes for 11 yield contributing traits. ANOVA demonstrated that the traits exhibited statistically significant differences from one another. Correlation coefficients were calculated to determine the correlations between the traits under investigation. Individual fruit weight, total fruit weight per plant, and fruit diameter exhibited significant and positive genotypic and phenotypic associations with fruit yield. Notably, individual fruit weight (0.52) and total fruit yield per plant (1.02) demonstrated the most substantial direct effects on total yield. Conversely, pH (-0.39) and total soluble solids (TSS; -0.70) have adverse direct effects on fruit yield. The relatively small residual effect observed in the phenotypic path analysis (0.090) and the genotypic path coefficient (0.017) indicates that the analyzed traits collectively accounted for a substantial proportion of the variation in yield-related characteristics.*

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INTRODUCTION

One of the most commercially significant vegetables in the world is the tomato. The tomato, an annual crop that self-pollinates and is diploid with twelve pairs of chromosomes (2n = 24), is a member of the *Solanaceae* family (Jenkins, 1948). Since it is the primary source of various plant nutrients and contributes significantly to the nutritional content of the human diet, it is the most often eaten vegetable in many countries (Willcox *et al.,* 2003). About 182,301,395 metric tons of tomatoes were produced worldwide in 2017 on 4,848384 hectares of cultivable land (FAO, 2022).

Ascorbic acid, vitamin B, vitamin A, and the potent antioxidant lycopene are all abundant in tomatoes. As antioxidants, these vitamins and beta-carotene work to counteract dangerous free radicals in the blood. The integrity of cells is threatened by free radicals, which may result in cellular damage. According to Yadav *et al*. (2013), tomatoes are mostly eaten in a variety of ways, such as raw salad, prepared meals, or processed into a broad range of goods such as sauces, ketchup, juice, puree, and entire canned fruits.

Tomato yield in Ethiopia remains below the global average, necessitating the development of improved varieties to enhance productivity. The efficiency of selection is largely influenced by the nature and extent of genetic variability, as well as the degree of association among desirable traits (Rasheed *et al*., 2017). Given the complexity of economic yield as a quantitative trait, direct improvement poses significant challenges. Analyzing trait interrelationships is essential for identifying economically important attributes that contribute to yield. Breeding programs are more effective when the linkages between fruit yield and its contributing factors are identified because it makes it possible to create suitable selection indices (Alam *et al*., 2016).

A significant genetic association between two desirable features facilitates selection for concurrently enhancing traits, claim Al-Ballat and Al-Araby (2021). On the other hand, it is impossible to develop both desired attributes significantly when they have a negative connection. Because yield is a quantitative trait, it is inherently complex, with low heritability and reliance on multiple components that exhibit high heritability. As a result, simple correlation analyses are inadequate for capturing the intricate biological relationships between these traits and yield (Alam et al., 2016).

The degree of link between a pair of traits is demonstrated by the correlation coefficients, which used to be a helpful tool for choosing desirable traits for a breeding program. Tomato yield, like that of other crops, is the end result of the direct and indirect interactions between many features (Rasheed *et al.,* 2017; Reddy *et al.,* 2013). In order to choose desired traits, it is crucial to conduct a relative analysis of the essential ones. However, path coefficient analysis is a practical tool in situations where the correlation coefficient by itself is unable to provide a comprehensive picture of the causal foundation of a connection (Reddy *et al.,* 2013).

A few investigations have been carried out in the past on the development of inbred tomato lines for using genetic variability. However, selecting F_2 plants with desirable traits is an effective approach, as the F_2 generation, derived from the selfing of F_1 hybrids, provides significant genetic diversity. Subsequent selfing of these selected genotypes further contributes to the development of inbred lines. The relative influence of various traits and their degree of association can be statistically estimated through correlation analysis (Premalakshmi *et al*., 2014). To effectively employ indirect selection for high yield in crop plants, it is essential to focus on traits that are easily measurable, exhibit high heritability, and demonstrate a meaningful correlation with fruit yield (Falconer and Mackay, 1996). However, there is a lack of data concerning the economic, nutritional, and breeding/research significance of association analysis for the study area. Consequently, this study aims to evaluate the direct and indirect effects of these variables on fruit yield, along with the phenotypic and genotypic correlations between fruit yield and its components.

Materials and methods

The experiment at the research center on the Shambu site included greenhouse crossings. The field study was conducted during the off-season of 2021–2022 at two separate locations. The field study was conducted during the off-season of 2021–2022 at two locations, Hareto and Shambu. Hareto is situated 320 kilometers to the west of Addis Ababa. The area is characterized by a single, extended rainy season that spans from May to September, with an average annual rainfall of 1,950 mm. While Shambu is situated at an elevation of 2400 meters above sea level with a single, extended rainy season from May to September with an average annual rainfall of 1950 mm, Hareto is 2176 meters above sea level and has the geographic coordinates 9°22.008' N latitude and 37°06.473' E longitude (JGWPEDO, 2020, unpublished). According to Fanta et al. (2018), the region's air temperatures fluctuate between 10°C and 23°C. The soils in the area are predominantly clay loams.

Experimental materials

The experiment utilized twenty-eight F_2 segregating tomato generations. Crossing was performed using eight tomato parent varieties or types provided by the Melkasa Agricultural Research Center. A half-diallel mating routine was applied to cross the parental lines to produce 28 F_1 hybrid seeds, which were subsequently self-pollinated. The selection of cultivars was based on their superior agronomic performance. For the field investigation, a 5 × 2 m plot design was employed, with a 0.5 m spacing between and within plots.

Data collected

Eleven quantitative characters were used to record the data, namely.

Days to 50% flowering: The total number of days that passed from the transplant date and the day when 50% of the plants in each plot were set to bloom was recorded.

Plant height (cm): A tape measure was used to measure the height of ten randomly chosen plants from each plot. From the plant's base, which is above ground, to the tip of the terminal leaf, which has fully extended, measurements were made. Centimeters are used to express the recorded values.

Number of primary branches per plant: Ten randomly chosen plants from each plot were counted to find the number of primary branches at maturity.

Fruits per plant: The total number of fruits produced by each plant across multiple harvests was counted and recorded.

Average fruit weight (g): The average fruit weight per plant was determined by dividing the total fruit weight per plant by the total number of fruits harvested.

Fruit clusters per plant: The number of fruit clusters per plant was determined by counting the total number of fruit clusters at maturity.

Total marketable fruit yield per plant (kg): Ten randomly chosen plants in each plot were weighed to determine the total marketable fruit output per plant.

Fruits that were damaged, deformed, or affected by stress were excluded from the weighing process.

Fruit yield (ton ha^{-1}): Fruit yield was calculated by converting the marketable fruit weight (kg) per plot from each successive harvest into tons per hectare.

Fruit Density: was measured as the ratio of the mass to the volume of the fruit.

Total soluble solids (TSS): measured using a digital refractometer with a resolution of 0.2 °Brix and a range of 0 to 32 °Brix. One or two drops of fruit juice were applied to the refractometer's prism for measurement.

pH Meter (pH) Value: A JENWAY; 3505 pH meter was used to measure the samples' pH levels directly

Data analysis

Data analysis was performed using SAS software version 9.3 (SAS, 2012). An analysis of variance (ANOVA) was conducted on the experimental data, and the pooled data from the two study sites were subjected to correlation and path coefficient analyses. Genotypic correlation coefficients were calculated for both the components of yield and for the relationship between yield and its components Using mean square values and the mean sum of products, genotypic variance and covariance were obtained from the analysis of variance, and covariance tables in line with the method described by Al-Jibouri et al. (1958). Path analysis was carried out using the Dewey and Lu (1959) technique. The previously calculated genotypic and phenotypic correlation coefficients were used in the analysis.

Results and Discussion

Correlation among characters

In the present study, pericarp thickness, plant height, and fruit density exhibited positive associations with days to 50% flowering. Conversely, negative correlations were observed between the number of fruit clusters per plant, the number of fruits per plant, individual fruit weight, fruit diameter, and length, total soluble solids (TSS), and fruit yield per hectare (Table 1). Furthermore, the number of marketable fruits per plant showed a significant and positive correlation with both the number of fruit clusters per plant and the total marketable fruit yield per plant. However, fruit density, pericarp thickness, and days to 50% flowering were negatively correlated with marketable fruit yield (Table 1).

The total marketable fruit yield per plant, fruit yield per hectare, fruit yield per plant, and plant height were all strongly and favorably correlated with the number of fruit clusters per plant. In contrast, individual fruit weight, pericarp thickness, fruit density, fruit diameter, and days to 50% flowering were all negatively correlated (Table 1). The findings suggest that in order to increase tomato output per plant, selection should prioritize these attributes.

Marketable fruit yield was negatively correlated with days to 50% flowering, pH, total soluble solids (TSS), and plant height, but positively and significantly correlated with individual fruit weight, number of fruit clusters per plant, number of fruits per plant, fruit weight per plant, fruit diameter, fruit density, and pericarp thickness (Table 1). These results are consistent with those of Sherpa et al. (2014) and Sangamesh et al. (2022).

Plant height, fruit weight per plant, fruit diameter, fruit length, pericarp thickness, fruit density, and marketable fruit product all showed moderate to significant positive associations with single fruit weight. This implies that breeding efforts should concentrate on these features in order to increase tomato production per plant. Sudesh and Anita (2016) and Alam et al. (2019) reported similar results. Plant height, fruit weight per plant, fruit diameter, fruit length, fruit density, and marketable fruit production all showed favorable correlations with pericarp thickness. However, it did exhibit a negative correlation with total soluble solids (TSS), plant height, and the number of fruit clusters per plant. Marketable fruit yield (t/ha), marketable fruit weight per plant, individual fruit weight, and the number of fruit clusters per plant were all negatively correlated with total soluble solids (TSS). Conversely, TSS was positively correlated with pericarp thickness, days to 50% flowering, pH, and plant height. These outcomes concur with the research presented by Alam et al. (2019).

Fruit diameter, pericarp thickness, and fruit output per plant all showed favorable correlations with fruit length. In contrast, total soluble solids (TSS) showed a substantial negative connection, which is consistent with Rajolli et al.'s 2017 findings. Fruit outcome showed a strong positive association, however fruit number per plant showed a substantial negative correlation. There was a substantial correlation between fruit diameter and every component. Furthermore, it revealed that TSS and the number of fruits per plant were negatively correlated, but that fruit diameter and pericarp thickness, fruit yield per plant, yield, and the number of seeds per fruit were positively correlated. These findings are consistent with those reported by Alam et al. (2019).

Prins (2013) and Chabbi et al. (2018) also found a significant correlation between tomato crop output and fruit diameter and length. At both study sites, genotypic correlations were generally higher than the corresponding phenotypic correlations, indicating a strong intrinsic relationship between the traits. Conversely, the consistently higher phenotypic correlation values compared to genotypic correlation values underscored the influence of environmental factors.

The number of fruits per plant, individual fruit weight, and fruit diameter should be given priority in selection based on the current results. This is because they showed a positive inter-correlation and a high positive association with fruit output per hectare. The genetic components of the genotypes may be responsible for the positive but non-significant correlation that was found between the number of fruits per plant and the number of fruit clusters per plant. Thus, when choosing for this feature, a balanced strategy should be used. These results are consistent with those of Nwosu *et al*. (2014).

Table 1. Above diagonal (genotypic) and, below diagonal (phenotypic) correlation coefficient for yield and yield components of tomato genotypes during 2018-2019

Variables	DF	NClpp	NMFpp	PlH	IFWg	TMFWp	Fdi	FL	PCThi	Fd	TSS	pH	MFY
DF	X	-0.28	-0.31	-0.32*	-0.19	0.22	-0.08	-0.18	0.06	0.11	0.05	0.22	-0.14
NClpp	-0.23	X	0.9**	0.14	-0.19	0.61*	-0.13	0.19	-0.1	-0.03	-0.11	0.11	0.22
NMFpp	-0.27	0.9*	X	0.06	-0.28	0.6*	-0.19	0.03	0.20	-0.13	-0.06	0.12	0.19
PlH	-0.17	0.14	0.06	X	0.18	0.29	0.23	0.07	0.16	0.11	0.16	0.07	0.24
IFWg	0.16	-0.19	0.2	0.17	X	0.57*	0.70	0.12	0.09	0.42	-0.12	-0.07	0.54*
TMFWpp	-0.08	0.6*	0.61*	0.21	0.54*	X	0.35	0.11	0.20	0.22	0.20	0.04	0.45*
Fdi	-0.02	-0.10	0.19	0.21	0.6*	0.34	X	0.28	0.31	-0.03	-0.12	0.12	0.5*
FL	-0.15	0.17	0.02	0.004	0.08	0.08	0.30	X	0.04	-0.02	-0.24	0.09	0.24
PCThi	0.03	-0.06	-0.1	0.203	0.16	0.05	0.19	0.03	X	0.39	0.13	0.24	0.21
Fd	0.08	-0.04	-0.13	0.12	0.4*	0.19	0.28	-0.02	0.39	X	0.04	0.51	0.18
TSS	-0.02	0.09	0.05	-0.15	-0.15	0.18	0-.02	0.24	-0.14	0.13	X	0.04	-0.24
pH	0.19	0.24	0.104	-0.08	-0.04	-0.06	0.06	0.13	-0.09	0.16	0.5*	X	-0.4*
MFY	-0.11	0.27	0.18	0.11	0.46*	0.51*	0.49*	0.19	0.18	-0.24	-0.02	0.11	X

*,** indicates significant at 0.05 &0.01 level of probability, DF50%-days to 50% flowering, Nclpp-number of cluster per plant, NoMFpp -number of marketable fruit per plant, PlH-plant height at last harvest, IFW-individual fruit weight, TMFWpp-total fruit weight per plant, FL-fruit length, Fdi-fruit diameter, FD-fruit density, PcThk- pericarp thickness, TSS-total soluble solid, pH-potential of hydrogen and MFtonhac^{-1} –marketable fruit yield (t /ha

Analysis of Phenotypic path coefficient for yield and contributing characters

Fruit production was significantly positively influenced by marketable fruit per plant (1.02) and individual fruit weight (0.52), as evidenced by the phenotypic path coefficient analysis (Table 2). Direct selection for traits that exert a substantial direct effect on plant yield may prove effective, and selecting for these characteristics could lead to increased plant productivity. Gopinath and Vethamoni (2017) and Venkadeswaran *et al*. (2021) found similar findings of direct beneficial benefits for certain qualities. However, via one another, these two characteristics had a significant counterbalanced influence. These traits had a significant beneficial direct impact on fruit output in the current study. It suggested that direct selection and the real link between these features may be used to increase tomato fruit output Stated otherwise, the direct benefit of marketable fruit weight per plant (r = 0.51) and individual fruit weight (r = 0.46) on fruit result suggest that improving these traits will increase tomato fruit production.

While the number of fruit clusters per plant (-0.196), days to flowering (-0.27), plant height (-0.12), fruit density (-0.156), number of fruits per plant (-0.06), total soluble solids (TSS; -0.70), and pH (-0.39) showed negative direct effects, fruit diameter (0.15), fruit length (0.21), and pericarp thickness (0.32) showed positive but weak effects on fruit yield. These findings suggest that direct selection for these traits may not lead to an increase in yield. The results of Rahaman et al. (2015) align with the observation that fruit yield per plant has the strongest positive direct influence on yield. Similar patterns were also noted by Alam et al. (2016) in grapevine fruit production.

The direct impact of marketable fruit per plant on total yield was counterbalanced by the indirect effects of fruit density (-0.092), days to flowering (-0.072), TSS (-0.35), and pH (-0.055). The magnitude of these effects was less than the correlation coefficient (0.51). This finding suggested that direct selection of these features is ineffective for increasing yield. Even though the marketable fruit weight per plant's indirect impact on fruit output through the aforementioned characteristics was too tiny, it was seen that their combined effect was fair enough to counterbalance; therefore all were taken into consideration. The biggest positive direct influence on yield contributing variables was discovered in the fruit yield per plant by Rahman *et al.* (2015), and Islam *et al.* (2022).

Indirect effects of individual fruit weight through marketable fruit yield per plant (-0.012), fruit diameter (-0.011), fruit length (0.0511), and pericarp thickness (-0.028), counterbalanced the direct effects of pH (-0.008) and total soluble solids (TSS; -0.003) on Total fruit production. Despite these counteracting effects, the total association (0.46) remained significant, highlighting the importance of these traits. These findings emphasize the importance of considering these factors simultaneously when selecting for higher tomato yield. This is consistent with the results reported by Alam et al. (2016). Residual effects of 0.09012 in the current study indicates that the majority of yield-related factors were accounted for in the analysis of the relationships and variations in tomato fruit yield. Similar results have been reported by Alam et al. (2019).

Table 2 Partitioning the phenotypic correlation into direct (bold) and indirect effects of 12 characters on yield per plant in F2 segregating population of 28 tomato hybrids

Variable	DF	NClpp	NMFpp	PlH	IFWg	TMFWp	Fdi	FL	PCThi	Fd	TSS	pH	rp
DF	**-0.27**	0.062	-0.072	0.045	-0.043	0.021	0.005	0.04	-0.008	-0.02	0.005	-0.05	-0.11
NClpp	0.022	**-0.196**	-0.018	-0.067	0.018	-0.057	0.19	-0.016	0.312	0.123	-0.018	-0.023	0.27
NMFpp	0.016	-0.0318	**-0.06**	-0.003	-0.012	-0.01	-0.011	0.051	-0.028	0.008	-0.003	-0.08	0.18
PlH	0.231	-0.011	-0.007	**-0.12**	-0.02	-0.012	-0.015	0.051	-0.013	-0.014	0.018	0.009	0.11
IFWg	-0.083	0.098	-0.104	-0.088	**0.52**	0.012	0.171	-0.041	-0.092	-0.02	0.078	0.02	0.46
TMFWpp	-0.079	0.097	0.098	-0.075	-0.027	**1.02**	0.0155	-0.085	0.213	-0.03	-0.39	-0.87	0.51
Fdi	-0.003	-0.015	-0.029	0.032	0.09	0.051	**0.15**	0.045	0.029	0.042	-0.003	0.009	0.49
FL	-0.032	0.036	0.004	0.001	0.017	0.017	-0.205	**0.21**	0.063	-0.004	0.05	0.027	0.19
PCThi	0.01	-0.019	-0.032	0.074	0.051	0.016	0.061	-0.326	**0.32**	0.125	-0.05	-0.02	0.18
Fd	-0.045	0.022	0.073	-0.067	0.231	0.251	0.019	0.011	-0.218	**-0.156**	-0.07	-0.09	-0.04
TSS	0.014	-0.063	-0.035	0.121	0.466	-0.126	0.213	-0.168	0.458	-0.091	**-0.07**	-0.13	-0.005
pH	0.074	0.094	-0.055	-0.031	-0.016	-0.023	0.023	0.051	-0.035	0.072	0.198	**-0.04**	0.11

Residuals= 0.09012

Analysis of genotypic path coefficients for yield and contributing traits

Genomic path coefficient analysis was employed to assess the genotypic direct and indirect effects on yield and its 12 component traits (Table 3). Fruit yield was most positively affected by marketable fruit production per plant (0.19). Through individual fruit weight (0.21), pericarp thickness (0.074), number of fruit clusters per plant (0.094), and number of fruits per plant (0.091), this trait also exhibited a positive indirect effect.

Fruit diameter (-0.035), fruit length (-0.35), total soluble solids (TSS; -0.092), and plant height (-0.092) all exhibited negative indirect effects (Table 3). The strongest positive direct influence on tomato yield was noted by Kahpte and Jansirinia (2014), Rahaman et al. (2015), and Kumar et al. (2013), who also found similar patterns in grapevine fruit production. The combined direct and indirect impacts created a positive and highly significant correlation (0.45) between fruit production per plant and yield (t/ha).

A positive correlation (0.54) was observed between the number of fruit clusters per plant and marketable fruit output (t/ha). Fruit diameter (-0.2), individual fruit weight (-0.293), total soluble solids (TSS; -0.056), and pH (-0.071) exhibited negative indirect impacts on marketable production of fruit, but fruit yield per plant (0.04) and the number of fruits per plant (0.198) had useful indirect effects. Plant height and the number of days to 50% flowering were without detectable effect on the number of marketable fruit. The number of fruit clusters per plant and yield (t/ha) (0.22) had a significant correlation as a result of the combined direct and indirect impacts (Table 3). These results are in line with those of Islam *et al.* (2010), who found that the more fruit clusters a plant had, it increased its yield.

Fruit yield had a positive effect on individual fruit weight (0.279). Fruit yield per plant (0.159) revealed a favorable indirect effect, whereas fruit diameter (0.234) and pericarp thickness (0.027) showed negative indirect effects. Days to 50% flowering (-0.053) and total soluble solids (TSS; -0.034) also showed negative indirect effects. Individual fruit weight and yield (t/ha) showed a strong and highly significant relation (0.54) as a result of the combined direct and indirect influences (Table 3). Meena *et al*. (2014), Nagariya et al. (2015), and Sudesh and Anita (2016) also found similar results. Furthermore, it was found that the weight of all the fruit significantly affected the amount yielded per plant.

Fruit diameter had a direct negative impact on yield (-0.026). Fruit clusters (0.025), the number of marketable (0.016), and days to 50% flowering (0.702) exhibited positive indirect effects, whereas fruit yield per plant, individual fruit weight (-0.06), plant height (-0.02), and the number of fruits per plant (-0.03) showed negative indirect effects (Table 3). These findings are consistent with those reported by Saleem *et al.* (2013), fruit length also had a direct negative impact on fruit yield (-0.104) (Table 3).

The number of fruits per cluster, pericarp thickness, individual fruit weight and the number of fruits per plant were identified as having the most significant positive indirect effects on fruit yield per plant. In contrast, plant height had a small indirect impact, while fruit diameter, total soluble solids and days to 50% flowering exhibited negative indirect effects.

Marketable fruit yield was directly and negatively affected by total soluble solids (-0.062) and pH (-0.367) (Table 3). Rahman *et al*. (2012) and Saleem *et al.* (2013) reported similar findings. Fruit yield per plant showed positive indirect effects, underlining the value of characteristics like the number of fruits per cluster, pericarp thickness, individual fruit weight, and fruit number per plant.

When choosing to increase tomato output, these factors must be carefully taken into account at the same time. Plant height demonstrated a relatively minor indirect influence, while fruit diameter, plant height, and days to 50% blooming all exhibited negative indirect effects. Almost all of the variability in tomato fruit output was explained by the features under investigation, as seen by the remarkably low residual effects (0.01707). Alam *et al*. (2019) reported similar findings in their study of genotypic and phenotypic path coefficients.

Only a measure of association between two variables is provided by correlation analysis. Alam *et al*. (2016) note out that route analysis, on the other hand, allows dividing of genotypic correlation coefficients of different variables on grain production into direct and indirect effect.

This approach offers valuable insights into how a trait influences grain yield both directly and indirectly through other traits. Such information is essential when selecting traits that significantly contribute to yield improvement.

Table 3 Partitioning the genotypic correlation into direct (bold) and indirect effects of 12 characters on yield per plant in F_2 segregating population of 28 tomato hybrids

Var	DF	NClpp	NMFpp	PlH	IFWg	TMFWp	Fdi	FL	PCThi	Fd	TSS	pH	rg
DF	**-0.207**	0.018	0.064	0.066	0.039	-0.046	0.017	0.037	-0.012	-0.023	-0.01	-0.046	-0.14
NClpp	-0.032	**0.541**	0.198	0.016	-0.293	0.04	-0.2	0.193	-0.041	-0.047	-0.056	-0.071	0.22
NMFpp	0.077	-0.038	**0.353**	-0.092	0.131	0.0113	0.021	-0.046	-0.083	0.02	0.05	-0.185	0.19
PlH	0.573	-0.019	-0.008	**-0.134**	-0.024	-0.039	-0.031	-0.009	-0.021	-0.015	-0.021	-0.009	0.24
IFWg	-0.053	-0.053	-0.078	0.05	**0.279**	0.159	0.234	0.034	0.027	0.017	-0.034	-0.02	0.54
TMFWpp	-0.07	0.094	0.091	-0.092	0.096	**0.818**	-0.35	-0.035	0.078	-0.07	-0.092	-0.013	0.45
Fdi	0.702	0.025	0.016	-0.02	-0.06	-0.03	**-0.085**	-0.024	-0.026	0.003	0.01	-0.01	0.50
FL	0.018	-0.019	-0.003	-0.007	-0.012	-0.011	-0.028	**-0.100**	-0.004	0.382	0.035	-0.009	0.24
PCThi	0.05	-0.083	0.066	0.003	0.075	0.166	0.057	0.033	**-0.300**	0.324	-0.108	-0.072	0.21
Fd	-0.029	0.008	0.048	-0.029	-0.11	-0.058	0.854	0.005	-0.102	**-0.262**	-0.01	-0.134	0.18
TSS	-0.003	0.007	0.004	-0.01	0.007	-0.012	0.007	0.015	0.008	-0.195	**-0.062**	-0.002	-0.24
pH	-0.081	-0.04	-0.044	-0.026	0.5601	-0.015	-0.044	-0.033	-0.088	-0.187	-0.015	**-0.367**	-0.4

Residual = 0.0170

CONCLUSION

To enhance the yield of marketable fruits, selection based on traits such as fruit clusters per plant, marketable fruit per plant, individual fruit weight, and fruit weight per plant may be effective. Studies exploring the link between fruit output and twelve other traits have found substantial inter-correlation in the variables, along with strong positive correlations with fruit output per hectare, thereby supporting this conclusion. The correlation coefficient's division into direct and indirect effects showed that the primary factors influencing yield were the number of fruit clusters per plant, the number of marketable fruits per plant, the weight of each individual fruit, and the overall weight of all the fruits per plant. These traits ought to be given priority over the selection process in order to increase tomato cultivar output. Consequently, the most useful characteristics for selection intended to improve fruit output per hectare among the tomato genotypes under evaluation are fruit clusters per plant, number of marketable fruits per plant, individual fruit weight, and total fruit weight per plant.

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Conflict of Interest
I hereby certify that the work I have submitted is free from any conflicts of interest.

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