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RESEARCH ARTICLE

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Character Association Studies of Tomato (*Solanum lycopersicum* L.)

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Abstract

Tomatoes are an important vegetable grown all over the world. Association study of yield and related traits plays a vital role in improving the production of tomato cultivars. Eighteen tomato genotypes were selected and sown in the field area of the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, using a randomized complete block design with three replications. Data was collected on various yield-related traits to find the associations between yield and yield-related traits. The results showed significant variations among genotypes for traits such as plant height, stem diameter, number of fruits per plant, fruit length, number of clusters per plant, number of fruits per cluster, fruit diameter, average fruit weight, fruit flesh thickness, pericarp thickness, and number of locules. Correlation analysis unveiled both positive and negative correlations between these traits, providing insights into their interrelationships. Furthermore, path coefficient analysis elucidated the direct and indirect effects of each trait on fruit yield per plant. Results indicated that traits such as plant height, stem diameter, number of fruits per plant, number of clusters per plant, fruit flesh thickness, fruit diameter, fruit length, fruit weight, pericarp thickness, and number of locules significantly influenced fruit yield per plant. These findings contribute to the understanding of trait associations and can guide the development of high-yielding tomato varieties through targeted breeding efforts.

KEYWORDS
Tomatoes, Trait associations, Tomato breeding, High-yielding varieties, Genetic improvement

1 | INTRODUCTION

Tomato (*Solanum lycopersicum* L.) holds a distinguished status as one of the most important and widely consumed vegetable worldwide, renowned for its adaptability, high yield potential, and versatility in both fresh and processed food industries (Nwosu et al. 2014). Originating from Peru and Ecuador within the Solanaceae family with chromosome number 2n=24, tomatoes primarily undergo self-pollination. The life cycle of these herbaceous plants might be described as annual or as a short-lived perennial, serving as a rich source of essential minerals and vitamins, particularly abundant in vitamin C (Ramesh et al. 2021). The concentration of lycopene in ripe tomato fruit increases 500-fold. There is evidence that a diet high in lycopene, an antioxidant, can reduce the risk of developing several types of cancer in humans. Tomatoes are used directly as raw vegetables in sandwiches and salads (Li et al. 2006). Several processed items like paste, puree, soup, pickles, ketchup, jelly, juices, drinks, whole peeled tomatoes, etc., are prepared on a large scale and enjoy high acceptance as food ingredients. Additionally, tomato soup is esteemed for its benefits in aiding constipation and acting as a potent appetizer (Berry and Uddin, 1991).

In 2023, global tomato production soared to 190 million metric tons, with key contributors including China, India, Turkey, the United States, Italy, Egypt, Spain and Mexico. China led the pack, boasting a staggering yield of 64.5 million tons (Khan et al. 2023). India, on the other hand, devoted around 0.87 million hectares to tomato farming, reaping a bountiful harvest of 17.50 million tons at a commendable productivity rate of 20.11 tons per hectare (Meena and Bahadur, 2015). Across Pakistan, all four provinces play a role in tomato cultivation (Ali et al. 2020), with approximately 57.8 thousand hectares of land utilized for this purpose by 2020, resulting in a production output of 0.59 million tons. Nonetheless, Pakistan's tomato production doesn't command a significant position on the global scale (Wahid et al. 2017).

Yield is a complex trait governed by the complex interaction of numerous contributing characteristics. Identifying correlations among diverse quantitative features is pivotal for devising selection methods to enhance yield components, offering insights into the relationships between parameters. Effective selection processes should prioritize understanding the relative strength of each character's correlation with yield (Mellidou et al. 2020). It is commonly known that a wide range of independent variables and their interactions have an impact on yield. Examining the relationships between quantitative parameters offers a conceptual foundation for improving yield components through selection technique refinement. Using the route coefficient approach, it is possible to examine the direct and indirect contributions of various components in order to assist the assessment of the overall link to yield. (Alam et al. 2019).

To enhance the potential yield of tomatoes, a systematic breeding approach is imperative. Thorough examination and evaluation of tomato genotypes are essential for enhancing both the genetic and agronomic qualities of the crop. Successful selection between multiple characteristics simultaneously acquired in a breeding plan necessitates correlation analysis and coefficient estimation to assess correlation, both genotypic and phenotypic, among different variables. This research also aids in identifying features suitable for indirect selection, as selecting one or more traits correlates with responses to numerous other traits (Hemalatha et al. 2017). Depending on the material being studied and the experimental design used, we can determine the degree and direction of the association between traits by using genotypic and phenotypic coefficients of correlation (Alam and Paul, 2019).

The correlation coefficients have long been a useful tool in breeding programs for selecting desirable features, as they represent the degree of relationship between characters. The yield of tomatoes, like other crops, is the end result of an intricate chain of interconnected factors. Therefore, it is crucial to conduct a comparative analysis of significant characters in order to choose the most desirable ones. The correlation coefficient by itself is insufficient to provide a comprehensive understanding of the underlying cause of the relationship. In such situations, path coefficient analysis is a highly successful method. Hence, this study was conducted to assess the relationships between desired characteristics and their direct and indirect impacts on crop yield.

However, yield is a complex characteristic, and improving it directly presents a difficulty. To improve plant productivity, a crop breeding strategy should include not only the total yield but also the specific factors that directly or indirectly impact output (Charishma et al. 2021). Path coefficient analysis is a method used to measure the direct influence of one variable on another. It also enables the separation of the correlation coefficient into direct and indirect effects. Path analysis dissects the correlation coefficients into direct and indirect effects of a set of dependent variables on the independent variables, facilitating the identification of superior genotypes. The technique of path coefficient analysis was first introduced by Wright in 1921 and subsequently demonstrated by Dewey and Lu (1959) as a means of differentiating between the direct and indirect impacts of various factors. This is a standardised assessment of the partial regression coefficient. This method measures the immediate influence of one variable on another and enables the separation of the correlation coefficient into direct and indirect effects. Singh et al. (2018) have suggested that this technique requires a causal relationship between the variables. Production components have been employed to optimise crop yield in various plants, such as wheat, brinjal, chilli, and cucumber. According to Maurya et al. (2020), analysing the relative significance of several variables in relation to crop output can aid in identifying high-yielding genotypes within genetically varied populations. This information can be utilised for indirect yield selection. The present study aimed to investigate the correlation and route coefficient analysis in a wide range of indeterminate tomato germplasm. This would facilitate the discernment of correlations among various attributes of tomatoes. Thus, the study has been formulated in accordance with the previously indicated background. Given the existing knowledge, a recent experiment was carried out to evaluate the genetic variation and determine the correlation between certain traits and tomato yield.

Maximizing the use of favourable traits is crucial for synthesizing optimum genotypes and increasing the yield potential. The variability in tomatoes is anticipated to be substantial due to the significant variations in both the form and size of the fruits. Research on genetic characteristics and correlations between traits aids in the identification and implementation of optimal breeding methods. Several researchers have documented various genetic characteristics in tomatoes, focusing on a limited number of features. Correlation studies can determine the extent of the relationship or association between these features and yield. Based on the information provided, the current study was conducted with the following goals: (1) The objective is to assess the genetic diversity in the initial generation resulting from the crossbreeding of exotic hybrids. (2) The goal is to create inbred lines that have a high capacity for producing crops and are resistant to both wilts and viruses. (3) To examine the correlation between characters.

The correlation between yield and biochemical attributes can provide useful information on the effect of selection for one character on the other traits of interest. Resolving the correlation into various direct and indirect contributions of different component characters helps to understand the reason for apparent correlation. The regression analysis reveals the dependence of yield on various components which can be utilized to construct selection indices in the form of multiple regression equation. Correlation coefficients and path analysis help to elucidate an effective model for phenotypic selection and interpret the intrinsic nature of observed associations. Associations among characters and cause-effect relationships can be efficiently used in the selection program. The breeding goals always envisage high expression of all or most of the desirable traits in a single genotype. In view of this, the knowledge of correlation among quantitative and qualitative traits is useful in different ways. Firstly, it helps to predict the response of other characters when we select for one. The implications positive/negative or no correlation can help in selection of suitable parents for hybridization and formulation of appropriate selection procedure for simultaneous improvement for more than one character. Secondly, for complex characters like yield, selection based on highly correlated components characters is more effective than direct selections.

2 METERIAL AND METHOD

Plant Material

The objective of the study was to investigate the associations between yield and related traits. The experiment was conducted at the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad. The seeds of eighteen genotypes of tomato (Florida Mk-1, LO-2840, Pioneer-2761, Immune Trior Beta, Quinte, Wheat lays, St-11, No.2, Sundar-F1, M-82, BGH-24, Yaqui, Step-434, CLN-2366, Bambino-F1, 6234, CCN-2413, and LA-2711) were collected from the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad.

Experimental Conditions

In winter 2023, the seeds of selected genotypes were sown in trays using peat moss and all ideal conditions were applied for proper seed germination and growth. After forty days, the healthy seedlings were transferred to the field having plot size of 3.6 x 3.0 meters under normal condition. The experiment was designed in a randomized complete block design with three replications. The seedlings were planted with a plant-to-plant distance of 60.96 cm and row to row distance was maintained at 76.20 cm. For optimal plant development, standard cultural practices and plant protection measures were used properly.

Data Collection

For data collection, healthy and matured plants from each genotype in each replication were selected randomly to minimize environmental errors and biasness. The plant height was measured from the base of the stem to the apical bud in centimeters using a measuring tape. Stem diameter was measured from the thickest part of the stem using a vernier caliper in millimeters.

The number of fruits, number of clusters and number of fruits per cluster were counter manually from each plant of each genotype. After collecting the fruits from each plant, 15 completely ripened fruits were selected, and their fruit length and fruit diameter was measured in millimeters using a vernier caliper. To measure the fruit flesh thickness, 5 healthy and completely ripened fruits were selected, and their flesh thickness was measured in millimeters using a vernier caliper. At maturity, five completely matured fruits were randomly selected to measure the pericarp thickness using a vernier caliper.

After harvesting fruits, 10 completely matured fruits were randomly selected, and their fruit weight was measured in grams using a weighing balance. The total fruit yield was measured by using the formula:

Total fruit yield = Average fruit weight x *Number of fruits per plant*

To measure the number of locules, five completely matured fruits were selected and their locules were measured by cutting the fruits horizontally using a sharp knife through the middle. This cut will expose the internal structure of the fruit, and the cross-section area exposed the locules which were counted manually.

The data were subjected to a mean comparison test with standard error of the mean. Pearson correlation and Path coefficient analysis were performed to determine the association of different parameters with yield (Dewey and Lu, 1959).

3 RESULTS AND DISCUSSIONS

To increase production, it is very important to find the associations between yield and yield-related components in tomato genotypes. These yield-related parameters can help in the development of high-yielding varieties. The collected data had gone through different statistical analyses and gave the following results. Plant height revealed that the genotype CLN-2366 had the highest plant height of (45.33 cm), followed by Florida Mk-1 (44.33 cm) and LA-2711 (43.167 cm), as shown in **Error! Reference source not found.**. Similarly, the lowest plant height was observed in Step-434 and Yaqui (31.5 cm and 33.83 cm, respectively). The average range of plant height was from 31.5 cm to 45.33 cm. The results of stem diameter indicated that the Yaqui genotype exhibited the largest stem diameter (1.4 mm) among all other genotypes, followed by Step-434 (1.33 mm) and Florida Mk-1 (1.33 mm). The lowest stem diameter was observed in

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Table 1: Table of comparison of different genotypes and association parameters

Genotypes	PH	SD	NoF/P	NoC/P	NoF/C	FL
Florida Mk-1	44.33 ± 0.92	1.33 ± 0.017	47.83 ± 0.44	6.33 ± 0.16	3.16 ± 0.33	0.75 ± 0.058
LO-2840	37.5 ± 0.28	0.88 ± 0.06	49.16 ± 0.33	9.83 ± 0.44	4.83 ± 0.66	0.6 ± 0.029
Pioneer-2761	40.83 ± 0.66	0.25 ± 0.014	49 ± 0	12.16 ± 0.33	3.16 ± 0.16	1.45 ± 0.058
Immune Trior Beta	36.66 ± 0.44	0.23 ± 0.017	49.33 ± 0.92	10.66 ± 1.16	5.66 ± 0.60	0.3 ± 0.029
Quinte	41.83 ± 0.66	0.19 ± 0.02	43.5 ± 0.57	5.83 ± 0.66	6 ± 0.28	1.23 ± 0.017
Wheat lays	36.83 ± 0.33	0.2 ± 0.025	39.33 ± 0.16	8.5 ± 0.57	1.66 ± 0.16	1.03 ± 0.017
St-11	42.66 ± 0.44	0.9 ± 0.043	36.16 ± 0.33	12.5 ± 0.57	2.83 ± 0.66	1.18 ± 0.044
No.2	40.16 ± 0.33	0.53 ± 0.017	33.5 ± 0.57	14.83 ± 0.88	3.33 ± 0.60	1 ± 0.05
Sundar-F1	36.33 ± 0.16	1.08 ± 0.007	30.33 ± 0.16	8.5 ± 1.15	6.83 ± 0.44	1.22 ± 0.017
M-82	34.16 ± 6.08	1.14 ± 0.05	39.5 ± 0.57	9.5 ± 0.57	5.66 ± 0.33	1.23 ± 0.017
BGH-24	40 ± 0.28	1.07 ± 0.052	35.83 ± 0.44	11.5 ± 0.5	7.83 ± 0.33	1.13 ± 0.017
Yaqui	33.83 ± 0.33	1.4 ± 0.05	55.16 ± 0.33	9 ± 0.76	4.83 ± 0.66	0.97 ± 0.06
Step-434	31.5 ± 0	1.33 ± 0.017	47.33 ± 0.16	13.5 ± 1	5.16 ± 0.66	1.2 ± 0.029
CLN-2366	45.33 ± 0.16	1.18 ± 0.033	49.83 ± 0.33	13.66 ± 0.44	3.66 ± 0.44	1.38 ± 0.067
Bambino-F1	41.66 ± 0.66	1.07 ± 0.052	49.33 ± 0.60	8.5 ± 0.57	6 ± 0.28	1.3 ± 0.029
6234	39.33 ± 0.16	0.51 ± 0.033	48.16 ± 0.66	10.33 ± 0.72	3.5 ± 0.57	1.12 ± 0.033
CCN-2413	41 ± 0.28	0.3 ± 0.05	36.83 ± 0.33	9.16 ± 0.88	2.66 ± 0.44	1.28 ± 0.067
LA-2711	43.16 ± 0.88	0.79 ± 0.082	43.33 ± 0.92	8.83 ± 0.66	1.5 ± 0.28	0.98 ± 0.067

Genotypes	FD	FFT	PT	FW	NoL	FY/P
Florida Mk-1	0.84 ± 0.07	3.17 ± 0.33	0.09 ± 0.01	31.33 ± 0.17	3 ± 0.29	5.5 ± 1.15
LO-2840	0.81 ± 0.01	4.83 ± 0.67	0.09 ± 0.01	26 ± 0.29	1.67 ± 0.17	9.33 ± 0.6
Pioneer-2761	2.13 ± 0.02	3.17 ± 0.17	0.19 ± 0	71 ± 0.29	4.67 ± 0.44	11.5 ± 0.57
Immune Trior Beta	0.94 ± 0	5.67 ± 0.6	0.09 ± 0.01	32.5 ± 0.58	2.83 ± 0.33	3.5 ± 0.57
Quinte	0.18 ± 0.03	6 ± 0.29	0.19 ± 0	4.5 ± 0.58	1.5 ± 0	7 ± 0.28
Wheat lays	0.96 ± 0.02	1.67 ± 0.17	0.09 ± 0.01	34.67 ± 0.44	1.82 ± 0.16	12.66 ± 0.6
St-11	0.7 ± 0	2.83 ± 0.67	0.09 ± 0.01	26.33 ± 0.17	1.78 ± 0.17	6.83 ± 0.88
No.2	1.18 ± 0.04	3.33 ± 0.6	0.09 ± 0.01	25.83 ± 0.83	3.17 ± 0.33	10.83 ± 0.33
Sundar-F1	2.02 ± 0.14	6.83 ± 0.44	0.19 ± 0	27.33 ± 0.60	1.62 ± 0.12	13.83 ± 0.33
M-82	1.18 ± 0.04	5.67 ± 0.33	0.19 ± 0	21 ± 0.29	2.33 ± 0.17	5.5 ± 0.57
BGH-24	0.78 ± 0.03	7.83 ± 0.33	0.19 ± 0	23.17 ± 0.60	1.5 ± 0	8.5 ± 0.57
Yaqui	1.43 ± 0.02	4.83 ± 0.67	0.19 ± 0	29.33 ± 0.17	2.17 ± 0.44	9.33 ± 0.6
Step-434	1.33 ± 0.04	5.17 ± 0.67	0.09 ± 0.01	35 ± 0.5	2.83 ± 0.17	12.5 ± 0.28
CLN-2366	1.63 ± 0.02	3.67 ± 0.44	0.09 ± 0.01	41.33 ± 0.44	2.83 ± 0.33	6.83 ± 0.88
Bambino-F1	1.43 ± 0.1	6 ± 0.29	0.09 ± 0.01	38.5 ± 0.58	2.83 ± 0.17	14.5 ± 0.57
6234	1.43 ± 0.02	3.5 ± 0.58	0.19 ± 0	33.17 ± 0.89	4.33 ± 0.44	6.5 ± 0.57
CCN-2413	1.33 ± 0.04	2.67 ± 0.44	0.19 ± 0	24.83 ± 0.60	2.17 ± 0.17	7.5 ± 0.5
LA-2711	1.18 ± 0.04	1.5 ± 0.29	0.09 ± 0.01	29.83 ± 0.67	2.5 ± 0.58	11 ± 0.5

Pioneer-2761 (0.25 mm), Immune Trior Beta (0.23 mm), Quinte (0.198 mm), and Wheat lays (0.2 mm).

The **Error! Reference source not found.** shows that the genotype Yaqui exhibits the maximum number of fruits per plant (55.17), followed by Wheat Lays (49.83) and Immune Trior Beta (49.33). Genotypes No. 2 and Sundar-F1 have the lowest number of fruits per plant (33.5 and 30.33 fruits, respectively). The results also indicate that most of the genotypes exhibit more than forty-nine fruits per plant. The number of clusters per plant suggests that the plant with the highest number of clusters is No.2 (14.83). This is followed by Wheat Lays (13.67 clusters) and Step-434 (13.5 clusters). However, Quinte and Florida Mk-1 were the least performing genotypes (5.83 and 6.33, respectively). Similarly, the Yaqui exhibits the highest number of fruits per cluster, with a value of (55.17). This is followed by the CLN-2366 (49.83), and the Immune Trior Beta (49.33). However, the genotypes Sundar-F1 and No.2 had the lowest performance (30.33 and 33.5, respectively). All genotypes exhibited satisfactory performance in terms of the number of clusters per plant and the number of fruits per cluster.

Error! Reference source not found. shows that Pioneer-2761 has the greatest fruit length (1.45 mm) compared to all other genotypes, followed by Wheat Lays and Bambino-F1 (1.38 mm and 1.3 mm, respectively). The genotypes with the lowest performance include Immune Trior Beta, which has a fruit length of (0.3 mm), the smallest among all genotypes. It is followed by LO-2840 with a fruit length of (0.6 mm) and Florida Mk-1 (0.75 mm). The genotype Pioneer-2761 exhibited the largest fruit diameter (2.133 mm). This was followed by Sundar-F1 with a diameter of (2.016 mm) and CLN-2366 with a diameter of (1.63 mm). These particular genotypes had the greatest fruit diameter compared to all other genotypes. The genotypes with the lowest performance were Quinte, with a fruit diameter of (0.183 mm), and St-11 (0.7 mm).

The results revealed that Pioneer-2761 had the highest flesh thickness among all genotypes (1.15 mm). The genotypes Florida Mk-1, Sundar-F1, CLN-2366, and LA-2711 all have a flesh thickness of (0.61 mm). These genotypes exhibit equivalent performance concerning flesh thickness. The lowest flesh thickness was recorded in the 6234 and CCN-2413, measuring (0.31 mm) apiece. Regarding pericarp thickness, the genotypes Pioneer-2761, Quinte, Sundar-F1, M-82, BGH-24, Yaqui, 6234, and CCN-2413 demonstrated the highest levels of performance. The pericarp thickness of the other genotypes is less than others.

The **Error! Reference source not found.** shows that Pioneer-2761 has the greatest average fruit weight (71 grams). This genotype had superior performance compared to all others. Additional genotypes like CLN-2366 and Bambino-F1 also showed good performance, with weights of 41.33 and 38.5 grams respectively. The genotype with the lowest performance was Quinte, with an individual weight of 4.5 grams. Other genotypes, such as M-82 and BGH-24 also showed low performance, with yields of 21 g and 23.16 g, respectively. The results demonstrate that Pioneer-2761 and 6234 exhibit the greatest average number of locules, with values of 4.67 and 4.33, respectively, among all genotypes. This indicates that these two genotypes are exhibiting strong performance. The Florida Mk-1 had average performance, including three locules. The genotypes with the lowest performance were Quinte and BGH-24, both of which contain 1.5 locules.

The yield of a crop is the most crucial characteristic. The **Error! Reference source not found.** shows that BGH-24 shows the highest total fruit yield among all genotypes (7.83 kilograms). This is followed by Sundar-F1 (6.83 kilograms), Quinte and Bambino-F1, each with (6 kilograms). Immune Trior Beta (5.67 kg), M-82 (5.67 kg), and LO-2840 (4.83 kg) show moderate performance. The LA-2711 and Wheat lays had the lowest total yield of (1.5 and 1.67 kilograms, respectively).

4.2. Correlation

The correlation analysis provided explains the relationships between various plant and fruit characteristics, offering a visual representation of how these traits are interconnected (Chattha et al., 2024). The most significant relationship was found between fruit weight and the number of locules, with a coefficient of 0.72, which is a highly positive correlation (Figure 1). This suggests that fruits with more locules tend to be heavier. Similarly, flesh thickness also shows a strong positive correlation with the number of locules (0.54) and with fruit weight (0.74). This indicates that fruits with thicker flesh are not only heavier but also have more locules. Additionally, fruit length is positively correlated with fruit weight (0.72), implying that longer fruits generally have more weight. In contrast, there are some notable negative correlations such as plant height has a slight negative correlation with yield per plant (-0.2), indicating that taller plants may not necessarily have higher production. Another negative correlation is observed between fruit weight and pericarp thickness (-0.31), suggesting that as the pericarp thickness increases, the overall fruit weight may decrease. These negative correlations highlight potential trade-offs in plant and fruit development, where certain desirable traits might come at the cost of others. Moderate correlations are also found, such as the relationship between fruit diameter and fruit weight (0.31), where larger fruits in terms of diameter tend to have more weight. Additionally, the number of fruits per cluster shows a moderate positive correlation with the total number of fruits per plant (0.41), indicating that plants producing more fruits in clusters tend to have a higher overall fruit number. Understanding these relationships can be crucial for breeding and selection, allowing for the optimization of desirable traits in future crops.

Path Coefficient Analysis

Path analysis is mostly used to determine the nature of the relationship between the yield and its contributing traits, which is used for the selection of genotypes. Path coefficient analysis indicated that yield per plant is affected by many traits. **Error! Reference source not found.** shows that plant height,

Table 2: Direct and Indirect Effects of Different Parameters on Fruit Yield per Plant

	PH	SD	NoF/P	NoC/P	NoF/C	FD	FL	FW	FFT	PT	NoL
PH	-0.171	0.026	0.028	0.051	-0.048	0.016	0.094	0.008	0.035	-0.071	-0.192
SD	0.024	-0.186	-0.002	-0.014	0.048	0.102	0.022	-0.059	-0.025	-0.073	0.247
NoF/P	0.051	-0.003	-0.094	-0.070	0.010	0.093	-0.047	0.199	0.003	-0.047	-0.146
NoC/P	0.015	-0.005	-0.011	-0.584	-0.017	0.052	0.091	0.241	0.034	0.395	-0.138
NoF/C	0.058	-0.063	-0.007	0.069	0.141	-0.069	-0.025	-0.148	-0.023	-0.139	0.189
FD	-0.008	-0.057	-0.026	-0.091	-0.029	0.335	0.150	0.426	0.092	-0.005	-0.410
FL	-0.033	-0.009	0.009	-0.109	-0.007	0.103	0.488	0.143	0.030	-0.135	-0.093
FW	-0.003	0.021	-0.036	-0.270	-0.040	0.273	0.134	0.521	0.098	0.051	-0.399
FFT	-0.044	0.034	-0.002	-0.144	-0.024	0.228	0.106	0.378	0.136	-0.115	-0.356

PT	-0.021	-0.023	-0.008	0.393	0.033	0.003	0.112	-0.046	0.027	-0.586	-0.226
NoL	-0.062	0.087	-0.026	-0.152	-0.050	0.259	0.086	0.393	0.091	-0.251	-0.529

PH: Plant height, SD: Stem diameter, NoF/P: Number of fruits per plant, NoC/P: Number of clusters per plant, NoF/C: Number of fruits per plant, FD: Fruit diameter, FL: Fruit length, FW: Fruit weight, FFT: Fruit flesh thickness, PT: Pericarp thickness, NoL: Number of locules

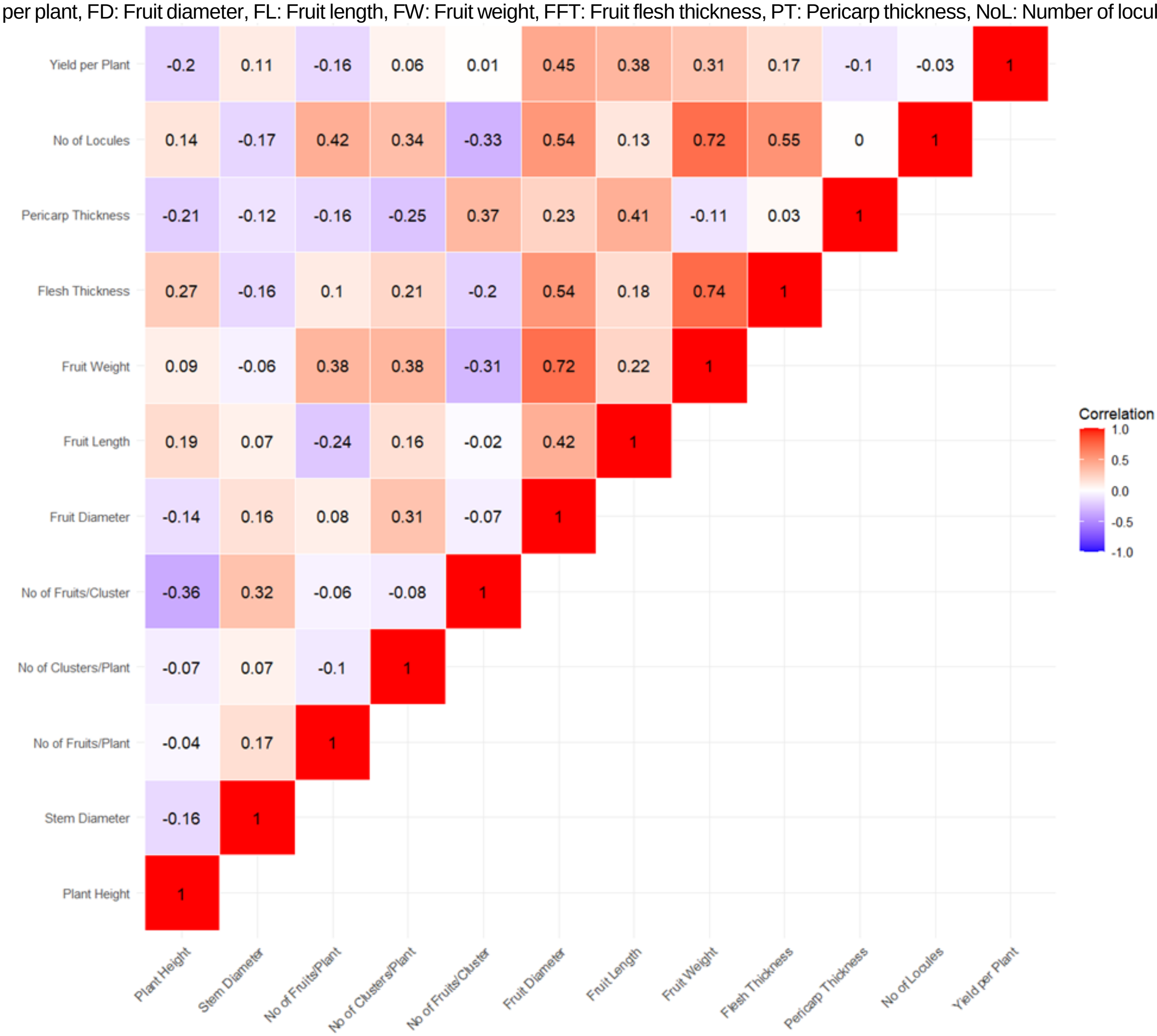

Fig. 1*:* Pearson Correlation Analysis between Parameters

stem diameter, number of fruits per plant, number of clusters per plant, and pericarp thickness had negative direct effects on fruit yield per plant. This indicates that if these traits increase then yield per plant decreases but there are also indirect effects on yield per plant from these traits which suggest that they can positively affect yield by enhancing other traits. Other traits such as number of fruits per cluster, fruit diameter, fruit length, fruit weight, fruit flesh thickness, and number of locules have positive effects on fruit yield per plant (Chattha et al., 2024). These traits directly involve in enhancing the yield per plant.

Conclusion

The aim of the study was to identify the associations between yield and yield-related components in tomato genotypes to aid in the development of high-yielding varieties. The results showed that BGH-24 showed the highest fruit yield among all genotypes. This is followed by Sundar-F1, Quinte, and Bambino-F1. The LA-2711 and Wheat lays had the lowest total yield. The other traits also showed different variations between these genotypes. Overall, the study concluded that significant variability exists among tomato genotypes in terms of yield and yield-related traits. The correlations and path analyses underscore the complex interplay between these traits, suggesting that selecting genotypes with desirable combinations of these characteristics could enhance tomato breeding programs aimed at developing high-yielding varieties. These findings provide a foundation for future studies to further refine the selection criteria for high-yielding tomato genotypes.

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