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Research Article

Unlocking various correlation traits for growth and yield improvement in tomato (Solanum lycopersicum L.)

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ABSTRACT

The aim of the study was to understand the relationships among yield-related characteristics in eight different tomato genotypes. This research analyzed the correlations between these traits across the selected genotypes. Analysis of variance showed significant variations among all traits examined. Branches per plant were positively correlated to plant height, clusters per plant, flowers per cluster, fruit length, fruits per cluster, fruit setting percentage, fruit weight, and overall fruit yield per plant. Height of plants has shown positive relationship with clusters per plant, fruit length, fruit weight, fruits per cluster, fruits per plant, and yield per plant. Clusters per plant have positive association with flowers per cluster, fruits per cluster, fruit length, fruit weight, and yield per plant. Additionally, flowers per cluster were positively correlated with fruit length. Fruits per cluster demonstrated positive correlation with fruits per plant, fruit length, fruit weight, and fruit yield per plant. Fruits per plant also exhibited a positive correlation with fruit setting percentage, fruit weight, and total yield per plant. Furthermore, fruit length was positively linked to fruit weight and yield per plant. Lastly, the fruit setting percentage showed a positive association with both fruit weight and fruit yield, while fruit weight had a strong positive association with yield per plant.

Keywords: Correlation; yield traits; tomato; vegetable; growth attributes; Solanum lycopersicum.

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INTRODUCTION

Tomato (*Solanum lycopersicum* L.), a solanaceous vegetable having chromosome number 2n = 24, is cultivated worldwide. Tomato originated in Peru (Peralta et al., 2008), is primarily a self-pollinated annual crop. It is widely grown and economically significant vegetable crop globally (Varela et al., 2003), having economic significance in horticultural industry (He et al., 2003). It is valued for its rich nutritional profile, serving as major source of vitamins A, B, and C, along with essential minerals. Additionally, tomatoes are abundant in lycopene, beta-carotene, and other bioactive compounds that function as potent natural antioxidants (Canene-Adams et al., 2005). Cellular metabolic processes generate oxygen free radicals, which can damage cells and their components. The antioxidants in tomatoes help to neutralize these free radicals, thereby protecting the cells from oxidative damage (Li et al., 2014). Many researchers reported higher sugar contents and vitamins in tomatoes compared to other vegetables (Alam et al., 2024). Lycopene content in tomato fruit increases 500 times. As lycopene reduces the risk of certain types of cancer, it

enhances the fruit's nutritional value (Bai and Lindhout, 2007). Tomato is cultivated in Pakistan throughout whole year, especially in spring season. In Pakistan, tomato was cultivated over approximately 17,457 hectares, producing 142,199 tonnes (MNFSR, 2023). Nonetheless, compared to other countries, the average yield per hectare is still much lower. Tomato yield, a quantitative characteristic regulated by several genes (Lungu, 1978). When choosing desirable attributes for breeding programs, correlation coefficients, which represent the relationship between several traits, are a useful tool. A complicated interaction of different traits results in crop yield (Islam and Khan, 1991). Grasping these relationships is crucial for breeders focused on creating high-yield varieties. Objective of the study was to identify correlations among traits associated with yield, such as plant height, branches per plant, clusters per plant, flowers per cluster, fruits per cluster, fruits per plant, fruit setting percentage, fruit length, fruit weight, width, and overall yield.

MATERIALS AND METHODS

The experiment was performed to investigate the relationship between various traits and their impact on yield enhancement in tomatoes. Mentioned below, tomato genotypes obtained from the Plant Genetic Resources Institute at the National Agricultural Research Centre in Islamabad were utilized for this research.

Table 1**.** Genotypes used for the estimation correlation among yield related traits**.**

S. No	Genotype
1.	BL-1174
2.	LO-2831
3.	LO-3686
4.	LO-3708
5.	G-006231
6.	G-006233
7.	G-017856
8.	G-017859

During the winter nursery period, eight tomato genotypes were sown in glasshouse at the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad. After six weeks, seedlings were moved to pots with 7 kg of sandy loam soil. Those pots were maintained in the glasshouse until mid-March, adopting a completely randomized design having three replications. Each pot contained a single plant, and each replication included five plants of each genotype. The pots were then transferred to an outdoor environment, where standard agronomic and plant protection protocols were followed. NPK fertilizer in ratio of 10: 10: 20 were applied after every 4 weeks. Data from different attributes was recorded. At the maturity average plant height (PH) of each genotype was calculated by measuring the height of each plant from ground to apical bud with the help of measuring tape in centimeters. Average number of branches (BPP) were calculated for each genotype by county branches of all mature plants. Similarly, average clusters per plant (CPP) were calculated for each genotypes by counting the number of branches on all plants Flowers on clusters of plants (FLPC) were counted and the average was calculated. In the same manner average fruits per cluster (FPC) were calculated by counting fruits at maturity from each plant. After counting flowers per cluster and fruits per cluster, the fruit setting percentage (FSP) was calculated.

Five fruits each from different fruiting points of each plant were randomly collected, weighed (FWT) separately and the average was calculated. Vernier-caliper was then utilized for the measurement of length (FL) and width (FW) of the fruits. Width was calculated at the largest diameter of cross-sectioned. The weight of fruits from each picking was recorded from each genotype in each replication. Yield per plant (YPP) was calculated by the addition of yield obtained from all harvests expressed in kilogram (kg). Analysis of variance of the traits was estimated, given by Steel et al. (1997). Whereas, the correlation between the studied attributes was estimated according to Kwon and Torrie (1964).

RESULTS AND DISCUSSION

Growth and Yield Attributes

The findings indicated significant differences in plant height across the genotypes. Based on the average measurements, genotypes G-017856 and LO-1174 achieved 65.80 cm and 55.57 cm being tallest and shortest in height, respectively. Additionally, notable variations were found in BPP, with genotype G-017856 possessing the maximum mean value of 10.77, in contrast to genotype LO-3708, having the lowest 9.33 value. In terms of clusters per

plant, genotype G-006233 displayed the highest mean value of 4.60, while genotype BL-1174 had the lowest at 3.57 (Table 2). Furthermore, significant variations were observed in FPC, where genotype LO-3686 reached a maximum of 5.73, and genotype G-006231 had the minimum at 3.20 (Table 2). FPC also showed considerable variation among the genotypes, with genotype G-006233 recording the highest mean of 3.50, while genotype LO-1174 had the lowest at 3.10 (Table 2). These results underscore the genetic diversity present in the assessed genotypes, which could be beneficial for breeding initiatives focused on enhancing plant characteristics.

Significant variations were observed among all genotypes for FPP. Genotype G-006231 manifested the highest mean value of 14.67 for said trait, whereas genotype LO-2831 had the lowest at 11.07 (Table 2). FPS also varied significantly among genotypes. Genotype G-006233 showed highest value at 76.93%, whereas genotype LO-1174 had the lowest at 67.88% (Table 2). Highly significant differences were observed for FWT, genotype G-006233 showing the highest value of 19.37 g, while genotype BL-1174 had the lowest at 16.30 g (Table 2). FL also showed significant variation. Genotype G-017856 and BL-1174 had the longest and smallest fruits, averaging 4.45 cm, respectively. and 3.33 cm (Table 2). For FW, genotype LO-3708 exhibited the maximum value 3.73 cm, whereas genotype G-006231 had the smallest at 2.55 cm (Table 2). YPP showed highly significant differences among genotypes. Genotype G-006233 produced the highest yield at 0.51 kg per plant, while genotype BL-1174 had the lowest at 0.24 kg per plant (Table 2).

Table 2. Mean values of traits and genotype effects in tomato.

Genotypes	BPP	PH (cm)	CPP	FLPC	FPC	FPP	FL (cm)	FSP (%)	FWT (g)	FW (cm)	YPP (kg)
BL-1174	9.40	55.87	3.57	3.6	3.10	11.97	3.33	67.88	16.30	3.44	0.24
LO-2831	10.17	63.20	4.57	5.33	3.27	11.07	4.34	73.86	17.55	3.24	0.38
LO-3686	10.20	61.93	4.57	5.73	3.23	11.67	4.05	67.89	18.83	3.45	0.41
LO-3708	9.33	58.27	3.60	3.30	3.27	11.80	4.02	72.66	17.43	3.73	0.31
PB-006231	9.50	59.13	3.80	3.20	3.20	14.67	3.46	72.93	17.38	2.55	0.31
PB-006233	10.03	65.60	4.60	3.60	3.50	14.47	3.91	76.92	19.34	3.17	0.51
PB-17856	10.77	65.80	4.53	4.37	3.47	12.07	4.45	73.39	18.79	3.49	0.48
PB-17859	10.00	64.93	4.40	4.33	3.37	13.60	4.15	73.81	18.51	2.81	0.46
Genotype Effects	0.71**	2.66**	0.64**	2.66**	0.05**	0.47**	0.47**	30.71**	3.10**	0.45**	0.00**

** = P < 0.01; *= P<0.05

Correlation

Correlation analysis was worked out to determine the positively or negatively correlated contrasting traits to develop higher yielding varieties with improved characters. In this context, several studies were performed in the last few decades regarding the use correlation analysis techniques to determine positively correlated key traits. Strong positive correlations were observed between BPP and several key traits, including PH (0.779), CPP (0.806), FLPC (0.532), FPC (0.563), FL (0.568), FW (0.629), and YPP (0.670). Positive correlation between BPP and PH as reported (Mahapatra et al.,2013). A positive relationship between branches/plant and fruit yield/plant was reported (Singh et al., 2006). PH exhibited a high positive correlation with CPP (0.889), FPC (0.669), FPP (0.543), FL (0.582), FW (0.767), and YPP (0.906). Positive correlation between BPP and FWT with FPP has been reported (Denton and Nwangburuka, 2011). CPP showed a significant positive correlation with FLPC (0.650), FPC (0.548), FL (0.559), FWT (0.718), and YPP (0.851). CPP was positively correlated with YPP (Sivaparsad, 2008). FLPC revealed a strong significant positive correlation with the FL (0.543). Positive correlation between FLPC and YPP was identified (Ece and Darakei, 2007).

Several studies have demonstrated significant correlations between fruit traits and yield per plant, providing valuable insights for plant breeders. Significant positive correlations were recorded between FPC and FPP (0.531), FL (0.489), FWT (0.654), and FPP (0.708). FPP showed positive correlation with FSP (0.702), FWT (0.575), and YPP (0.691). Significant correlation between FPP and YPP was established (Anjum et al., 2009; Rajaguru et al., 2010). FL proved a highly significant positive association with both FWT (0.471) and YPP (0.566). High positive correlation between FL and FYP was observed (Das et al., 1998; Prasad and Mathura, 1999). Average fruit length was positively correlated with fruit width (Arun et al., 2004). FSP positively correlated with FWT (0.469) and YPP (0.515). In contrast, some studies have highlighted negative correlations. A negative correlation between FSP and FWT was previously recorded (Linda & Scott, 1992). However, Suresh & Gulsan (1989) found a positive correlation between the FSP, YPP, and FWT, indicating that the relationship between these traits can vary depending on genetic and environmental factors.

Several studies have also examined the relationship between fruit weight and yield. FWT exhibited a highly significant positive correlation with YPP (0.844) (Table 3), highlighting its important role in determining overall crop productivity.

FWT was both genotypically and phenotypically positively correlated to YPP (Hidayatullah et al., 2008). A strong positive correlation between FWT, FPP, and YPP was observed (Blay et al., 1999). Similar conclusions were reported by Prasad & Mathura (1999), and Dhankar et al. (2001), all of whom observed positive correlation between FWT and YPP. It was further established that FWT has positive correlation with both FW and FL (Arun et al., 2004). FWT has positive correlation with YPP and FL (Golani et al., 2007).

These relationships show the interrelated nature of plant attributes and their key importance in breeding programs aimed at improving quality and yield. The results offer significant insights for tomato breeders in their efforts to develop enhanced, high-yield cultivars. These results emphasize the correlation analysis in plant breeding because it allows breeders to make informed decisions to improve crop growth and yield.

Table 1. Correlation matrix for yield and related traits in tomato.

Plant attributes	BPP	PH	CPP	FLPC	FPC	FPP	FL	FSP	FWT	FW
PH	0.779**									
CPP	0.806**	0.889**								
FLPC	0.532**	0.374	0.650**							
FPC	0.563**	0.669**	0.548**	0.082						
FPP	0.307	0.543**	0.326	-0.316	0.531**					
FL	0.568**	0.582**	0.559**	0.543**	0.489*	0.179				
FSP	-0.033	0.382	0.154	-0.265	0.367	0.702**	0.197			
FWT	0.629**	0.767**	0.718**	0.295	0.654**	0.575**	0.471**	0.469*		
FW	0.055	-0.193	-0.084	0.175	-0.014	-0.332	0.244	-0.181	-0.058	
YPP	0.670**	0.906**	0.851**	0.325	0.708**	0.691**	0.566**	0.515**	0.844**	-0.128

** = P < 0.01; *= P<0.05

CONCLUSION

It is concluded that various yield-related attributes studied during the current study provide valuable insights for plant breeders working on tomato breeding. Different plant parameters, viz., branches/plant, plant height, clusters/plant, flowers/cluster, fruit length, and fruit setting percentage, showed positive correlation toward fruit growth and yield of the studied crop. These findings highlight the intricate relationships among plant traits and underscore the importance of correlation analysis in optimizing breeding strategies for improved fruit yield and quality.

AUTHOR'S CONTRIBUTION

IA: Conceptualization, Formal analysis, Methodology, Investigation, Data curation, Writing – Review & editing. TA: Conceptualization, Visualization, Software, Data curation, Writing – Review & editing. MU: Data curation, Review & editing. NS: Review & editing. HUK: Review & editing. SSH: Review & editing.

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AVAILABILITY OF DATA AND MATERIAL

Information regarding procedures and data is available on request from the corresponding author.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

All authors give their consent for the publication of this article.

CONFLICT OF INTERESTS

The authors declare no competing interests.

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