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High-Throughput Phenotyping of Exotic Tomato Germplasm For Fruit Size, Shape, and Color Diversity

Adil Hussain, Muhammad Daniyal Junaid, Javaria Tabassum, Muhammad Arshad Javed

Department of Plant Breeding and Genetics, University of the Punjab, Lahore, 54590, Pakistan
***For correspondence**: mdaniyaljunaid@gmail.com*

Abstract

Tomato (*Solanum lycopersicum* L.) is a globally important crop known for its nutritional value and culinary versatility. Consumer preferences for tomatoes are largely influenced by fruit shape, size, and color, making these traits essential targets in breeding programs. This study utilized high-throughput phenotyping to evaluate fruit morphological traits across 81 tomato genotypes using Tomato Analyzer software. The software quantified 47 parameters, including fruit size, shape indices, blockiness, asymmetry, end shapes, angles, eccentricity, and color, through machine learning and geometrical techniques. Conducted at the University of Punjab, Quaid-e-Azam Campus, Lahore, data were extracted from images of fully mature tomato fruits. The results revealed significant phenotypic diversity among genotypes. The first two principal components explained 75.6% of total variance, with PC1 (50.2%) representing a gradient from small, elongated fruits to large, round fruits, and PC2 (25.4%) capturing variations in fruit end shapes and internal structures. Strong correlations between size parameters and shape indices suggested potential inverse relationship for these traits. This study highlighted the efficiency of high-throughput phenotyping in characterizing complex fruit traits, offering a significant improvement over traditional method. The identified morphological diversity provides a valuable resource for breeding programs aimed at developing market-specific tomato cultivars. Moreover, this comprehensive dataset lays the foundation for genetic studies on fruit morphology, facilitating advancements in tomato crop improvement.

Key Words: *Tomato phenotyping, High-throughput phenotyping, Principal Component Analysis (PCA), Tomato Analyzer, Breeding program*