

Effects of grafting onto wild rootstocks on growth, yield, and fruit quality traits in commercial greenhouse tomato cultivars

Sibgol Khoshkam[a*]

[a] *Assistant Professor, Agricultural and Horticultural Research Department, Southern Kerman Province Agricultural and Natural Resources Research Center, Agricultural Research, Education and Extension Organization. Iran*

Article Info

Article type:
Research Article

Article history:
Received 22 January 2026
Accepted 19 February 2026
Published online 9 June2026

Keywords:
Tomato
Grafting
Wild Rootstock
Yield
Fruit Quality
Greenhouse

ABSTRACT

Objective: This study aimed to evaluate the effects of grafting three commercial tomato cultivars—Daphnis, Seba, and Falcato—onto three wild rootstocks: Lycopersicon pimpinellifolium, L. chilense Dunal, and L. peruvianum. The objective was to enhance production sustainability and improve tomato performance under greenhouse conditions.

Methods: The experiment was conducted using a completely randomized design comprising 12 treatments and three replications. Key traits evaluated included yield, number of clusters per plant, number of fruits per cluster, fruit weight, flower drop, firmness, pH, vitamin C, total acidity, total soluble solids (TSS), and the TSS/total acidity ratio.

Results: Grafting significantly affected most measured traits, resulting in an approximate 24% increase in yield compared to non-grafted controls. Among the treatments, rootstocks L. pimpinellifolium and L. chilense exhibited the most substantial positive effects on yield and specific quality indices. The highest fruit weight of 188.5 g was recorded for the graft combination Daphnis × L. pimpinellifolium. Additionally, a strong correlation was found between total acidity and TSS (r = 0.934).

Conclusions: The findings suggest that utilizing wild rootstocks is an effective strategy to enhance both the quantitative and qualitative production of greenhouse tomatoes, highlighting the potential for improved sustainability in tomato cultivation.

Cite this article Khoshkam, S. (2026). Effects of grafting onto wild rootstocks on growth, yield, and fruit quality traits in commercial greenhouse tomato cultivars. *Journal of Plant Ecophysiology*, 3 (6), 31-35. https://doi.org/10.5281/zenodo.20491911

© The Author(s).
Publisher: Jiroft Branch, Islamic Azad University.
DOI: https://doi.org/10.5281/zenodo.20491911

* Corresponding Author name: Sibgol Khoshkam
E-mail address: s.khoshkam@areeo.ac.ir

1 Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops cultivated in greenhouse and open-field production systems. Due to its nutritional, economic, and industrial value, it represents a major share of global horticultural production. However, sustainable tomato production under greenhouse conditions faces several challenges, including soil-borne diseases, restricted root growth, nutritional imbalance, and environmental stresses. In this context, grafting has received considerable attention as an effective technology in greenhouse vegetable production, particularly for tomato.

Wild and interspecific rootstocks, owing to their more extensive root systems, higher efficiency in water and nutrient uptake, and greater tolerance to biotic and abiotic stresses, can enhance scion growth and yield. Moreover, grafting may also influence fruit quality traits in some cases, although the magnitude and direction of these effects depend on the rootstock–scion combination and environmental conditions. Recent studies have shown that rootstock vigor and root system characteristics play a key role in the yield and quality of grafted tomatoes (Fullana-Pericàs *et al.*, 2022; Pico *et al.*, 2022). It has also been reported that grafting can improve stress tolerance, extend postharvest shelf life, and modulate certain chemical attributes of the fruit (Rouphael *et al.*, 2022; Zhao *et al*., 2021).

Given the importance of selecting appropriate rootstocks for commercial cultivars and the limited information available on the performance of wild rootstocks under greenhouse conditions in southern Kerman, this study was conducted to evaluate the effects of grafting three commercial tomato cultivars onto three wild rootstocks on plant growth, yield, and fruit quality.

2 Materials and Methods

2-1. Experimental Site

This research was conducted in 1401 (2022–2023) under greenhouse conditions in southern Kerman, Iran.

2-2. Plant Materials and Treatments

Three commercial tomato cultivars—Daphnis, Seba, and Falcato—were used as scions, and three wild species—*Lycopersicon pimpinellifolium*, *L. chilense* Dunal, and *L. peruvianum*—were used as rootstocks. In addition, each cultivar was also grown as a non-grafted control. Accordingly, the experiment consisted of 12 treatments.

2-3. Grafting Procedure and Cultivation Conditions

Grafting was performed using the cleft grafting method. After grafting, seedlings were maintained under acclimatization/healing conditions and then transferred to the greenhouse. Planting, crop management practices, and training operations were carried out according to the standard commercial greenhouse tomato production program used in the region.

2-4. Experimental Design and Evaluated Traits

The experiment was arranged as a completely randomized design (CRD) with three replications. The measured traits included:

Fruit yield, Number of clusters per plant, Number of fruits per cluster, Fruit weight, Flower drop, Dry-to-fresh weight ratio, Fruit length and diameter, Length-to-diameter ratio, Fruit firmness, pH, Vitamin C content, Total acidity (TA), Total soluble solids (TSS), TSS/TA ratio

2-5. Statistical Analysis

Data were analyzed using analysis of variance (ANOVA), and mean comparisons were performed using Duncan's multiple range test at the 5% probability level. In addition, Pearson correlation, cluster analysis, and principal component analysis (PCA) were applied to evaluate relationships among traits and to classify/separate the treatments.

Table 1. Summary of the most important quantitative and qualitative results for growth, yield, and fruit quality traits of tomato under different grafting treatments

Trait	Best treatment / key finding	Value
Yield	Daphnis grafted onto *L. chilense*	73.10 kg m^{-2}
Yield	Seba grafted onto *L. chilense*	71.90 kg m^{-2}
Yield	Falcato grafted onto *L. chilense*	70.90 kg m^{-2}
Yield increase in grafted plants	Compared with non-grafted control	24%
Fruit weight	Daphnis grafted onto *L. pimpinellifolium*	188.5 g
Fruit length	Falcato (non-grafted control)	8.4 cm
Fruit diameter	Falcato grafted onto *L. pimpinellifolium*	8.0 cm
Highest TSS	Falcato grafted onto *L. pimpinellifolium*	5.73
Highest TSS/TA	Falcato grafted onto *L. pimpinellifolium*	10.4
Strongest correlation	TA with TSS	0.934

Table 2. Significant correlation coefficients between selected quantitative and qualitative traits of tomato fruit under different grafting treatments

Traits	Correlation coefficient ®
Number of clusters per plant × Number of fruits per cluster	0.407
Number of clusters per plant × Vitamin C	0.616
Number of clusters per plant × Total acidity (TA)	0.456
Number of clusters per plant × TSS	0.427
Number of fruits per cluster × Fresh-to-dry weight ratio	0.500
Number of fruits per cluster × Fruit firmness	0.612
Number of fruits per cluster × Vitamin C	0.618
Number of fruits per cluster × Total acidity (TA)	0.612
Total acidity (TA) × TSS	0.934
Length-to-diameter ratio × Fruit length	0.602

Table 3. Summary of cluster analysis and principal component analysis (PCA) results at two sampling times (Esfand and Farvardin)

Analysis	Result
Cluster analysis	The **15 evaluated traits** were classified into **two main groups**.
Distinctive trait	**Fruit weight** was separated independently from the other traits.
PCA (Esfand sampling)	**Five principal components** explained **75.546%** of the total variance.
PCA (Farvardin sampling)	**Five principal components** explained **76.291%** of the total variance.

Multivariate analysis interpretation

The multivariate analyses indicated that the evaluated traits followed a structured, non-random pattern. Based on cluster analysis, the 15 measured traits were grouped into two main clusters, suggesting the presence of internal similarities and relationships among subsets of traits. Notably, fruit weight formed a separate, independent group, indicating that it behaved differently from the other traits and likely played a distinctive role in differentiating the grafting treatments.

Furthermore, the principal component analysis (PCA) demonstrated that only five principal components accounted for a large proportion of total variability, explaining 75.546% of the variance in Esfand and 76.291% in Farvardin. These results imply that much of the phenotypic variation among traits can be summarized by a limited number of underlying factors, and that PCA was a suitable tool for visualizing trait relationships and distinguishing treatment responses.

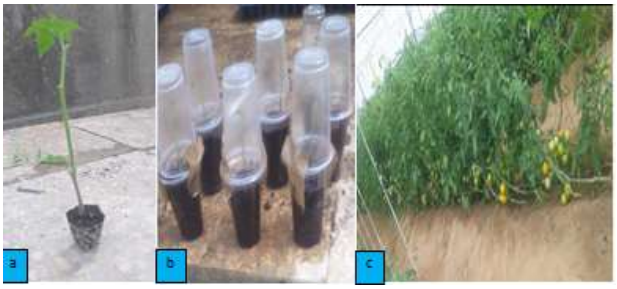


Figure 1. Grafted tomato plants at different stages: **(a)** immediately after grafting, **(b)** during the acclimatization process, and **(c)** after establishment under greenhouse conditions.

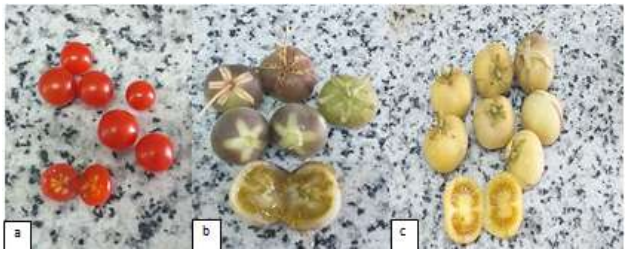


Figure 2. Lycopersicon pimpinellifolium (a), Lycopersicon chilense Dunal (b), and Lycopersicon peruvianum (c).

3 Results

3-1. Yield and yield components

Grafting had a significant effect on yield and its components. The highest yields were observed in several grafted treatments. According to the dataset, when L. chilense was used as the rootstock, the yields of Daphnis, Seba, and Falcato were 73.10, 71.90, and 70.90 kg m^{-2}, respectively. Overall, the yield of grafted plants was reported to be approximately 24% higher than that of non-grafted plants.

In addition, the number of clusters per plant and the number of fruits per cluster were higher in grafted treatments than in the controls. This indicates that the yield improvement in grafted plants was not solely due to increased fruit weight, but was also associated with improvements in yield components.

3-2. Physical fruit traits

Rootstocks significantly affected fruit length, diameter, and shape. Fruit length reached 8.13 cm in some treatments, including Daphnis grafted onto L. pimpinellifolium. Fruit diameter was reported to be about 8.0 cm in certain combinations, such as Falcato grafted onto L. pimpinellifolium. The length-to-diameter ratio also varied among treatments; for example, in Seba grafted onto L. chilense, it changed from 0.7 in Esfand to 1.2 in Farvardin.

3-3. Fruit quality traits

Among quality-related traits, fruit firmness, pH, and vitamin C were influenced by grafting. The highest pH was recorded in Daphnis grafted onto L. pimpinellifolium, while the lowest pH was observed in non-grafted Daphnis. The highest vitamin C content was observed in Falcato grafted onto L. pimpinellifolium, whereas the lowest was found in Falcato grafted onto L. chilense. Fruit firmness was also higher in Daphnis grafted onto L. pimpinellifolium and L. chilense than in the other treatments.

3-4. Total acidity (TA), TSS, and TSS/TA ratio

Grafting had a significant effect on fruit chemical attributes. The highest TSS was recorded in Falcato grafted onto L. pimpinellifolium (5.73). The TSS/TA ratio in this combination increased to approximately 10.4. These results suggest that certain rootstocks, in addition to enhancing yield, may also improve sensory-related and quality characteristics of tomato fruit.

3-5. Fruit weight, dry-to-fresh weight ratio, and flower drop

The highest fruit weight was observed in the Daphnis × L. pimpinellifolium combination, with values of 186.2, 184.0, and 188.5 g across three harvests. In contrast, fruit weight was lower in some combinations, such as Falcato grafted onto L. pimpinellifolium. The lowest flower drop was also reported for L. pimpinellifolium. These findings indicate that part of the yield advantage associated with wild rootstocks may be related to reduced flower drop and improved fruit retention.

3-6. Trait correlations

Significant positive correlations were observed among several evaluated traits. The number of clusters per plant was positively correlated with the number of fruits per cluster ($r = 0.407$), vitamin C ($r = 0.616$), total acidity ($r = 0.456$), and TSS ($r = 0.427$). The number of fruits per cluster also showed positive correlations with the fresh-to-dry weight ratio ($r = 0.500$), fruit firmness ($r = 0.612$), and vitamin C ($r = 0.618$). The strongest correlation was found between total acidity and TSS ($r = 0.934$).

3-7. Cluster analysis and principal component analysis (PCA)

Cluster analysis classified the 15 traits into two main groups and identified fruit weight as a distinctive trait separated from the others. Traits such as number of fruits per cluster, fruit firmness, pH, TSS, yield, and the length-to-diameter ratio contributed more strongly to explaining variability among treatments.

4 Discussion

The results of this study indicated that grafting onto wild rootstocks can effectively improve tomato yield and certain fruit quality indices. The yield increase in grafted plants is likely attributable to the superior capacity of wild rootstocks to develop a vigorous root system, enhance the absorption of water and mineral nutrients, improve hormonal balance, and mitigate the effects of environmental stress. This interpretation is consistent with the findings of Fullana-Pericàs *et al*. (2022), who reported that rootstock growth traits influence biomass allocation, yield, and fruit mineral quality in grafted tomato.

The superiority of L. pimpinellifolium in some combinations—particularly with respect to higher fruit weight, reduced flower drop, and improved quality indices—may be related to better compatibility with the commercial scions used in this study. The favorable performance of L. chilense also suggests that this rootstock has high potential for sustaining reproductive growth and increasing fruit set and yield. Similarly, Pico *et al*. (2022) demonstrated that root system architecture in interspecific rootstocks is directly associated with yield components.

Regarding fruit quality, the observed increases in TSS, vitamin C, and fruit firmness in certain grafted treatments suggest that grafting effects are not limited to quantitative yield improvement. Higher firmness can be a major advantage for postharvest shelf life and transportation. Increases in TSS and vitamin C may also enhance nutritional quality and market acceptance. However, quality responses were not consistent across all treatments, highlighting that grafting outcomes depend strongly on the specific rootstock–scion combination, as emphasized in recent reports (Rouphael *et al.*, 2022; Zhao *et al*., 2021).

The positive correlations between yield-related and quality traits are also of practical importance. The strong correlation between TSS and total acidity suggests that certain rootstock–scion combinations may modify flavor-related attributes in a coordinated manner. Moreover, the positive correlation of fruit number per cluster with firmness and vitamin C indicates that, in this study, higher productivity was not necessarily associated with reduced fruit quality. These findings are valuable for selecting suitable rootstocks for commercial tomato production.

5.Conclusion

The grafting of commercial tomato cultivars onto wild rootstocks under greenhouse conditions has been shown to markedly enhance both productivity and fruit quality. This horticultural technique exploits the agronomic advantages of wild Solanum species, which often possess superior vigor, stress tolerance, and nutrient uptake capabilities. As a result, grafted plants frequently exhibit improved yield performance and better post-harvest or market-related quality characteristics compared with non-grafted controls. Among the rootstocks evaluated, *L. pimpinellifolium* and *L. chilense* demonstrated particularly favorable effects. These rootstocks contributed to increased total yield and fruit weight, while also reducing flower drop, an important factor in improving fruit set and overall productivity. In addition, several fruit quality indices were enhanced, indicating that the benefits of grafting extend beyond quantity to encompass attributes valued in commercial production.

These findings suggest that grafting onto selected wild rootstocks may serve as an effective and practical strategy for sustainable greenhouse tomato production. By improving resource efficiency and reducing losses associated with flower abscission and stress sensitivity, this approach can help growers achieve more stable outputs under intensive cultivation systems. Accordingly, the use of *L. pimpinellifolium* and *L. chilense* can be recommended as promising rootstocks for the advancement of greenhouse tomato cultivation.

Refrences

Barrett, C. E., *et al*. (2023). Rootstock-mediated improvement of fruit quality and stress tolerance in greenhouse vegetables. *Horticulturae, 9*(4), 1–15.

Fullana-Pericàs, M., Conesa, M. À., Soler, S., & Pérez-Alfocea, F. (2022). A systematic assessment of how rootstock growth characteristics impact grafted tomato plant biomass, resource partitioning, yield, and fruit mineral composition. *Frontiers in Plant Science, 13*, 948656.

Kumar, P., *et al*. (2024). Grafting in tomato: Physiological basis, yield advantages and fruit quality responses under protected cultivation. *Scientia Horticulturae, 324*, 112678.

Pico, B., *et al*. (2022). Root system architecture of interspecific rootstocks and its relationship with yield components in grafted tomato. *Horticulture, Environment, and Biotechnology, 63*, 1–14.

Rouphael, Y., *et al*. (2022). Grafting and rootstock effects on vegetable quality: Recent advances and future perspectives. *Plants, 11*(8), 1002.

Zhao, X., *et al*. (2021). Rootstock effects on yield and fruit quality in grafted tomato under protected cultivation. *Agronomy, 11*(9), 1794.