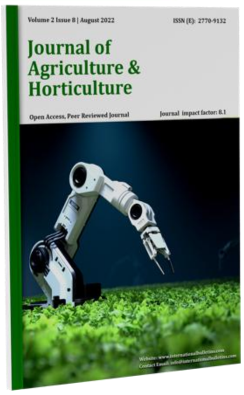
JAH
ISSN: 2770-9132
JOURNAL OF AGRICULTURE & HORTICULTURE
International scientific journal
JAH
IF = 9.3



COMPARATIVE ASSESSMENT OF BIOLOGICAL COMPETENCE AND ECONOMIC EFFICIENCY OF PEACH (PRUNUS PERSICA [L.] BATSCH) VARIETY-ROOTSTOCK COMBINATIONS IN UZBEKISTAN CONDITIONS

Mirnosir Isroilov
Scientific-Research Institute of Horticulture, Viticulture and Winemaking named after Academician M.Mirzaev (Tashkent, Uzbekistan)
Ixtiyor Namozov
Professor of the department "Plodovoe vinogradstvo", (doctor of science) Tashkent State Agrarian University
https://doi.org/10.5281/zenodo.18239829

Abstract. The optimization of scion-rootstock interactions is a fundamental determinant of productivity in modern pomology. This study presents a multi-criteria evaluation of four peach rootstocks (Peach seedling, Almond seedling, GF677, Garnem) and five peach varieties (Big Bang, Lola, Krasniy Moskva, Anjir shaftoli, Nektarin krasniy) cultivated under specific pedoclimatic conditions. Utilizing a biometric scoring system, we analyzed growth vigor, stress tolerance (drought and heat), compatibility, and yield parameters. The results demonstrate that the clonal rootstock GF677 exhibits superior adaptability, achieving the highest mean general characteristic score (4.5/5.0), significantly outperforming generative rootstocks. Among the cultivars, 'Anjir shaftoli' and 'Big Bang' displayed the highest yield potential (4.8/5.0). Furthermore, the study identifies specific high-value combinations, with 'Anjir shaftoli' grafted on GF677 achieving the highest generalized assessment score (9.10/10), classifying it within the elite Group I of variety-rootstock combinations. These findings provide a scientific basis for recommending specific vegetative rootstocks for establishing high-density, stress-resilient peach orchards.

Keywords: Prunus persica, clonal rootstocks, GF677, scion-rootstock compatibility, pomology, biometric analysis, drought resistance.

1. Introduction

The sustainable intensification of modern fruit production necessitates a paradigm shift from traditional extensive systems to high-density precision horticulture, where the optimization of the rootstock-scion interface serves as a fundamental determinant of orchard productivity and longevity. While historical approaches largely relied on seedling rootstocks due to their availability, contemporary pomology has increasingly recognized that the rootstock is not merely a physical anchor but a complex biological regulator capable of modulating the scion's physiological processes, including water use efficiency, nutrient uptake, and hormonal signaling (Marini & Fazio, 2018; Uğur et al., 2023). Consequently, the breeding and selection of rootstocks have evolved to address specific pedoclimatic challenges, utilizing advanced tools such as artificial neural networks and genetic algorithms to optimize propagation protocols for elite clonal rootstocks like Garnem (G × N15) (Arab et al., 2016).

A primary driver for the adoption of vegetative (clonal) rootstocks over generative (seedling) counterparts is the necessity for genetic uniformity and enhanced abiotic stress tolerance. As global climate patterns shift, orchards are increasingly subjected to water deficits and thermal stress, making the physiological capacity for drought resistance a critical selection criterion. Research indicates that specific rootstock genotypes can significantly alter the gene expression related to water-deficit stress in the scion, thereby enhancing the tree's resilience (Rickes et al., 2019). Furthermore, advanced remote sensing energy balance models applied to Prunus rootstock collections have demonstrated significant variability in crop evapotranspiration and water status among different genotypes, highlighting the importance of selecting rootstocks like GF677 or Garnem that maintain favorable water relations under stress (Bellvert et al., 2021).

Beyond survival and vegetative vigor, the economic viability of an orchard is inextricably linked to the rootstock's influence on fruit quality and yield dynamics. Long-term performance studies on peach cultivars, such as 'Redhaven', have confirmed that the choice of rootstock exerts a statistically significant impact on cumulative yield and fruit weight over the lifespan of the orchard (Hudina & Veberic, 2022). This influence extends to specific fruit typologies; for instance, flat peach varieties (similar to 'Anjir shaftoli') have shown differential compatibility and productivity responses when grafted onto varying Prunus hybrid rootstocks, necessitating specific compatibility assessments for these high-value market segments (Legua et al., 2012).

Furthermore, the interaction between rootstock and scion is pivotal in defining the qualitative attributes of the fruit, ranging from biochemical composition to post-harvest behavior. Comparative studies between rootstocks propagated by air layering and seed have revealed that vegetative propagation can enhance specific physicochemical quality parameters of the fruit (Picolotto et al., 2010). These physiological interactions are critical for managing ripening phenology and shelf life, as seen in molecular studies of nectarine softening (Ghiani et al., 2011), which is directly relevant to mitigating post-harvest losses such as chilling injury in fresh-cut supply chains (Palumbo et al., 2024).

Despite the extensive literature on rootstock breeding, there remains a need for localized, multi-criteria evaluations of specific variety-rootstock combinations under intensive cultivation conditions. Therefore, the primary objective of this research was to conduct a comprehensive biological and economic assessment of peach varieties—including 'Big Bang' and 'Anjir shaftoli'—grafted onto both generative (Peach, Almond) and vegetative (GF677, Garnem) rootstocks, aiming to identify the most synergistic combinations for industrial implementation.

2. Materials and Methods

The research was conducted by employing a rigorous comparative analysis of four distinct rootstocks, specifically selected to represent both generative and vegetative propagation methods, including the standard Peach seedling, the drought-adapted Almond seedling, the vigorous clonal hybrid GF677, and the nematode-resistant Garnem. These rootstocks were subsequently grafted with five economically significant peach and nectarine varieties—Big Bang, Lola, Krasniy Moskva, Anjir shaftoli, and Nektarin krasniy—creating a diverse genetic matrix suitable for comprehensive agro-biological evaluation.

To ensure a systematic assessment, the study utilized a biometric scoring system based on a 5-point scale, meticulously evaluating the rootstocks across five critical physiological parameters: growth vigor, anchorage strength, drought resistance, heat resistance, and survival compatibility with scion varieties. Simultaneously, the scion varieties were subjected to a parallel 5-point assessment focusing on agronomic and commercial traits, specifically analyzing yield potential, fruit size, ripening phenology, shelf life durability, and overall marketability.

Synthesizing these independent datasets, the methodology further involved a generalized assessment of the variety-rootstock combinations, utilizing a weighted 10-point scale to integrate biological compatibility with economic output. This integration facilitated the stratification of the resulting graft combinations into three distinct hierarchical groups—Group I (Elite), Group II (Standard), and Group III (Acceptable)—thereby providing a structured framework for identifying the most synergistic pairings for intensive orchard management.

3. Results and Discussion

3.1. Agro-biological Assessment of Rootstocks

The analysis of the rootstock data reveals significant disparities in biological performance. The clonal hybrid GF677 emerged as the superior rootstock, demonstrating the highest mean general characteristic score of 4.5 points. Characterized by robust growth vigor (4.4 points) and exceptional survival rates when grafted with other varieties (4.8 points), GF677 proves to be highly compatible and resilient.

In contrast, the Almond seedling, while exhibiting strong anchorage (4.5 points)—likely due to a taproot system—showed the lowest compatibility with scions, scoring only 3.1 points in survival. This suggests that while Almond seedlings may offer physical stability, their physiological affinity with commercial peach varieties is limited compared to hybrids (Table-1).

Garnem performed reliably with a mean score of 3.8, showing moderate growth vigor (3.9) and decent compatibility (4.1), but it lagged behind GF677 in heat resistance (3.6 vs 4.4). The standard Peach seedling control performed admirably with a mean of 3.9, showing balanced traits, though it lacked the exceptional stress tolerance observed in GF677.

Table-1

Classification of important economic and biological characteristics of peach rootstocks, on a 5-point scale

Rootstock name	Growth vigor	Anchorage	Drought resistance	Heat resistance	Survival with other varieties	General characteristics
Peach seedling (st.)	4,2	3,5	3,3	3,9	4,6	3,9
Almond seedling	2,8	4,5	4,1	4,3	3,1	3,8
GF677	4,4	4,6	4,3	4,4	4,8	4,5
Garnem	3,9	4,3	3,2	3,6	4,1	3,8
Mean:	3,8	4,2	3,7	4,1	4,2	4,0

3.2. Economic Characteristics of Peach Varieties

Evaluating the scions independently provided insight into the genetic potential of the varieties.

Yield and Marketability: Both ‘Big Bang’ and ‘Anjir shaftoli’ achieved the highest yield scores (4.8 points). However, they differ fundamentally in post-harvest physiology. While ‘Big Bang’ offers excellent fruit size (4.8), its shelf life is a limiting factor (3.3 points). Conversely, 'Anjir shaftoli' combines high yield with superior shelf life (4.6 points), making it a more versatile candidate for distant markets (Table-2).

Lola: This variety showed the lowest aggregate performance (Mean: 4.0), primarily due to lower marketability (3.8) and shelf life (3.4), suggesting it may be suitable only for local, immediate consumption.

General Performance: The variety 'Anjir shaftoli' achieved the highest general information score (4.6), positioning it as the most economically viable variety in the study, followed closely by 'Big Bang' (4.5).

Table-2

Classification of important economic and biological characteristics of peach varieties, on a 5-point scale

Variety name	Yield	Fruit size	Ripening period	Fruit shelf life	Marketability and market appeal	General information
Big Bang	4,8	4,8	5,0	3,3	4,7	4,5
Lola	4,5	4,4	4,1	3,4	3,8	4,0
Krasniy Moskva	4,3	4,1	4,7	3,9	4,3	4,3
Anjir shaftoli	4,8	4,7	4,4	4,6	4,5	4,6
Nektarin krasniy	4,4	4,5	4,2	4,8	4,1	4,4
Mean:	4,6	4,5	4,5	4,0	4,3	4,4

3.3. Comprehensive Assessment of Variety-Rootstock Combinations

The synthesis of rootstock and scion data resulted in a generalized assessment ranking, which stratified the combinations into three distinct groups.

Group I (Elite Combinations): The top-performing combination was 'Anjir shaftoli' + GF677, achieving a remarkable score of 9.10 points. This synergy likely results from combining the high yield and shelf life of the 'Anjir shaftoli' variety with the vigorous, stress-tolerant root system of GF677. Following closely is 'Big Bang' + GF677 (9.02 points), confirming GF677 as a universal enhancer of scion performance. It is noteworthy that all top 5 combinations involved GF677, highlighting the rootstock's dominance.

Group II (Standard Combinations): This group, ranging from 8.22 to 8.50 points, includes combinations utilizing Peach and Garnem rootstocks. For instance, 'Anjir shaftoli' + Peach seedling scored 8.50. While productive, these combinations lack the "extra" physiological boost provided by the GF677 hybrid vigor.

Group III (Lower Tier Combinations): The lowest ranked combinations involved the Almond seedling and weaker varieties. 'Lola' + Almond seedling scored the lowest (7.80 points). The physiological incompatibility noted in the rootstock analysis (Table-3) manifests here as reduced overall performance.

Table-3

Classification of peach variety-rootstock combinations

#	Name of peach variety-rootstock combinations	Generalized assessment of variety-rootstock combinations, on a 10-point scale	Group of variety-rootstock combinations
1.	Anjir shaftoli +GF677	9,10	I group
2	Big Bang+GF677	9,02	
3.	Nektarin krasniy+GF677	8,90	
4.	Krasniy Moskva+GF677	8,76	
5.	Lola+GF677	8,54	
6.	Anjir shaftoli+Peach seedling	8,50	
7.	Big Bang+Peach seedling	8,42	
8.	Anjir shaftoli+Garnem	8,42	
9.	Anjir shaftoli+Almond seedling	8,36	II group
10.	Big Bang+Garnem	8,34	
11.	Nektarin krasniy+Peach seedling	8,30	
12.	Big Bang+Almond seedling	8,28	
13.	Nektarin krasniy+Garnem	8,22	
14	Krasniy Moskva+Peach seedling	8,16	
15.	Nektarin krasniy+Almond seedling	8,16	
16.	Krasniy Moskva+Garnem	8,08	III group
17.	Krasniy Moskva+Almond seedling	8,02	
18.	Lola+Peach seedling	7,94	
19.	Lola+Garnem	7,86	
20.	Lola+Almond seedling	7,80	

4. Conclusion

The comprehensive analysis conducted within the framework of this study incontrovertibly substantiates the hypothesis that the strategic selection of rootstocks serves as a fundamental determinant in shaping the economic trajectory and biological resilience of industrial stone fruit orchards. Among the evaluated biological assets, the clonal hybrid rootstock GF677 emerged as the unequivocal standard for intensive peach cultivation, having consistently displayed superior adaptability parameters, particularly regarding heat resistance and an exceptional capacity for survival when grafted with diverse scions. In parallel, the investigation into scion potential highlighted the ‘Anjir shaftoli’ variety as the preeminent candidate for commercial propagation, owing to its remarkable equilibrium of agronomic traits, where it successfully harmonizes high yield potential with extended fruit shelf life and superior market appeal.

Consequently, the synthesis of these biological data points directs a clear strategic imperative for maximizing economic efficiency: producers are strongly advised to prioritize the propagation of "Group I" combinations, with a specific emphasis on grafting ‘Anjir shaftoli’ onto the GF677 rootstock. This specific synergy, having achieved the highest generalized assessment score in the study, effectively leverages the robust, stress-tolerant root system of the hybrid to sustain the heavy carpological load of the scion, thereby ensuring the production of high-volume, export-quality fruit capable of withstanding the rigors of post-harvest logistics.

References:

1.Arab, M. M., Yadollahi, A., Shojaeiyan, A., & Ahmadi, H. (2016). Artificial neural network genetic algorithm as powerful tool to predict and optimize in vitro proliferation mineral medium for G × N15 rootstock. Frontiers in Plant Science, 7. https://doi.org/10.3389/fpls.2016.01526

2.Bellvert, J., Nieto, H., Pelechá, A., Jofre-Čekalović, C., Zazurca, L., & Miarnau, X. (2021). Remote sensing energy balance model for the assessment of crop evapotranspiration and water status in an almond rootstock collection. Frontiers in Plant Science, 12. https://doi.org/10.3389/fpls.2021.608967

3.Ghiani, A., Negrini, N., Morgutti, S., Baldin, F., Nocito, F. F., Spinardi, A., Mignani, I., Bassi, D., & Cocucci, M. (2011). Melting of 'Big Top' nectarine fruit: Some physiological, biochemical, and molecular aspects. Journal of the American Society for Horticultural Science, 136(1), 61–68. https://doi.org/10.21273/jashs.136.1.61

4.Hudina, M., & Veberic, R. (2022). The effect of rootstock in long-term performance of the peach cultivar 'Redhaven'. Acta Horticulturae, (1352), 349–356. https://doi.org/10.17660/actahortic.2022.1352.48

5.Legua, P., Pinochet, J., Moreno, M. Á., Martínez, J. J., & Hernández, F. (2012). Prunus hybrids rootstocks for flat peach. Scientia Agricola, 69(1), 13–18. https://doi.org/10.1590/s0103-90162012000100003

6.Marini, R. P., & Fazio, G. (2018). Apple rootstocks: History, physiology, management, and breeding. Horticultural Reviews, 197–312. https://doi.org/10.1002/9781119431077.ch6

7.Palumbo, M., Cefola, M., Pace, B., Ricci, I., Siano, F., Amato, G., Stocchero, M., & Cozzolino, R. (2024). Volatile metabolites to assess the onset of chilling injury in fresh-cut nectarines. Foods, 13(7), 1047. https://doi.org/10.3390/foods13071047

8.Picolotto, L., Fachinello, J. C., Bianchi, V. J., Manica-Berto, R., Pasa, M. d. S., & Schmitz, J. D. (2010). Yield and fruit quality of peach scion by using rootstocks propagated by air layering and seed. Scientia Agricola, 67(6), 646–650. https://doi.org/10.1590/s0103-90162010000600005

9.Rickes, L. N., Klumb, E. K., Benitez, L. C., Braga, E. J. B., & Bianchi, V. J. (2019). Differential expression of the genes involved in responses to water-deficit stress in peach trees cv. Chimarrita grafted onto two different rootstocks. Bragantia, 78(1), 60–70. https://doi.org/10.1590/1678-4499.2017372

10.Uğur, R., Paydaş, S., & Saridas, M. A. (2023). Rootstock breeding and rootstock-scion interaction in Prunus species. Erciyes Tarım ve Hayvan Bilimleri Dergisi, 6(1), 7–10. https://doi.org/10.55257/ethabd.1283481