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Role of Rootstocks in Fruit Production

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Abstract

Rootstocks play an essential role in improving orchard efficiency in fruit crops. The process of budding or grafting allows the combination of desirable characteristics from two different plants, which can influence the overall growth and performance of the tree. The impact of rootstocks on fruit quality, including physical characteristics and internal chemical composition, has been extensively studied in temperate fruit crops such as apple, pear, and cherry, whereas comparatively less information is available for tropical and subtropical fruit crops. These differences can be explained by examining the relative importance of rootstocks in controlling tree size, inducing precocity, improving yield, and influencing orchard management practices. Variations in annual phenological cycles, fruit respiration patterns, crop load, and canopy management also contribute to the differences observed between temperate and tropical fruit crops. This review focuses on the influence of rootstocks on scion growth, vigour, and growth habit, as well as on scion precocity, flowering intensity, fruit set, and yield efficiency in major fruit crops that are commercially cultivated in India.

Keywords: Rootstock, Scion interaction, Grafting, Fruit crops.

Introduction

At present, horticulture is considered a promising sector for increasing agricultural production while improving household nutritional security and farmers' income through diversification, employment generation, value addition, and export opportunities. However, despite its potential, low productivity per unit area remains a major challenge in many horticultural crops, and the impact of climate change has further aggravated this issue. Therefore, it is essential to address problems related to both biotic and abiotic stresses and their influence on horticultural crop performance. Rootstocks play a vital role in fruit crop production as they significantly influence canopy architecture, nutrient uptake, flowering behavior, yield, and fruit quality. In addition, rootstocks can help plants withstand several biotic and abiotic stresses such as soil-borne pathogens, temperature extremes, salinity, and nutrient deficiencies. The use of suitable rootstocks is an effective strategy to reduce production losses by minimizing the adverse effects of environmental stresses on the scion. Rootstocks are fundamental in determining orchard efficiency because they are responsible for water and mineral absorption and provide anchorage to the tree while also influencing tree size. Research conducted in several countries has highlighted the importance of rootstocks in crops such as apple, pear, citrus, mango, and grapes, particularly in relation to vigor control, nutrient absorption, salinity tolerance, moisture stress management, and yield efficiency. Nevertheless, many rootstocks with great potential for commercial use have not yet been fully exploited in most fruit crops in India.

Hence, identifying and utilizing suitable rootstocks with desirable characteristics under specific environmental conditions is crucial. A rootstock that performs well with a particular variety and environment may not necessarily be suitable for another variety or growing condition

Role of Rootstock in Mango

Mango (*Mangifera indica* L.) is one of the most important tropical fruit crops in the world and is popularly known as the "king of fruits" in India. Several efforts have been made to standardize suitable rootstocks for different scion varieties, including the use of polyembryonic types for managing tree vigour, improving tolerance to salinity and drought, and enhancing fruit yield and quality. Studies on the growth and bearing behaviour of 'Dashehari' mango grafted on its own seedling rootstock indicated that it exhibited the most vigorous growth and produced the highest yield compared with other polyembryonic rootstocks. A long-term study conducted at the Indian Institute of Horticultural Research (IIHR), Bengaluru, on the performance of 'Alphonso' mango revealed that nucellar seedlings of 'Muvandan', 'Bappakai', and 'Olour' served as vigorous rootstocks in decreasing order of vigour, whereas the 'Vellaikulumban' seedling induced a dwarfing effect when compared with 'Alphonso' grafted on its own seedling rootstock. Fruit yield and productivity are critical factors in mango cultivation, particularly because productivity remains relatively low in many mango-growing countries. Research has shown that the yield and yield efficiency of the cultivar 'Kensington Pride' were highest when grafted on 'Sg. Siput' rootstock, whereas poor performance was observed on 'Sabre' rootstock, indicating the possibility of manipulating scion productivity through suitable rootstock selection. In Venezuela, 'Sinamaica' rootstock demonstrated excellent adaptability to the agro-ecological conditions of the Maracaibo plains and produced higher yield and production efficiency with cultivars such as 'Criollo de Mara', 'Manzana', and 'Sensation' Among the rootstocks evaluated in India, 'Bappakai' was found to be the most suitable rootstock for 'Dashehari', followed by 'Muvandan' and 'EC-95862'. Similarly, 'Langra' grafted on 'Bappakai' rootstock recorded the highest number of fruits per plant, followed by 'Vellaikulumban' and 'Chandrakaran'.

Role of Rootstock in Citrus

Role of rootstocks in citrus is one of the most debatable and discussed issues and its selection is a major consideration under planning of any citrus orchard. One thing can be safely said that choosing the right rootstocks is fundamental to the success of the orchard.

Role of Rootstock in Grapes

Grapevines are capable of growing in soils with a relatively wide pH range (4.5–6.5); however, highly acidic soils can create serious growth problems. Studies evaluating vine growth under low soil pH conditions have reported varying responses among different *Vitis* species and cultivars. Among them, *Vitis labrusca* cultivars 'Concord' and 'Catawba', along with rootstocks such as 'SO4' and '3309C', and the hybrid cultivar 'Seyval', showed greater tolerance to strongly acidic soils, whereas *Vitis vinifera* cultivars like 'White Riesling' and 'Chardonnay' were found to be more sensitive. Therefore, the use of acid-tolerant rootstocks such as 'SO4' and '3309C' has been recommended to improve vine performance under acidic soil conditions. Based on tolerance to increasing salt concentrations (0, 50, 85, 120, and 155 mM NaCl), grape rootstocks have been classified into different groups. Rootstocks such as 41B, R. Lot, 110R, 140R, and 161-49 are considered sensitive; 13-5 and Ramsey are moderately tolerant; while 196-17, CH-1, CH-2, and Superior are regarded as tolerant. Furthermore, hybrids derived from *Vitis berlandieri* × *Vitis rupestris*, including '110R', '140Ru', and '1103P', are recommended for drought-prone regions where water availability limits grapevine productivity. These rootstocks possess deep and efficient root systems that enhance water uptake and confer improved

drought resistance. Similarly, hybrids of *Vitis berlandieri* × *Vitis riparia* have also been reported to exhibit relatively high tolerance to drought stress. However, the classification of drought resistance among rootstocks may vary depending on environmental conditions and geographical regions.

Role of Rootstocks in Guava

Currently, guava is generally propagated through seedlings obtained from open-pollinated seeds rather than through uniform clonal rootstocks. Several *Psidium* species have been evaluated as potential rootstocks, including *P. cattleianum*, *P. guineense*, *P. molle*, and Philippine guava. Among these, trees grafted on *P. cattleianum* rootstock exhibited the greatest plant height and produced the highest yield. In contrast, *P. pumilum* showed a dwarfing effect on the scion; however, fruits produced on this rootstock contained the highest number of seeds along with greater total soluble solids (TSS) and total sugar content. Trees grafted on *P. cujavillis* produced the largest fruits with the highest ascorbic acid content, although the fruits were rough-skinned and lacked uniformity. Most of the evaluated rootstocks were found to be resistant to guava wilt disease caused by *Fusarium solani* and *Macrophomina phaseoli*, except the cultivar 'Allahabad Safeda'. Further studies reported that an aneuploid rootstock, No. 82, significantly reduced the vigour of 'Allahabad Safeda', resulting in decreased plant height, plant spread, and tree volume. Despite the dwarfing effect, this rootstock recorded higher yield efficiency, indicating its potential use as a dwarfing rootstock for guava cultivation

Role of Rootstock in Pear

Fewer rootstocks' choices are available for pears than for apples. Domestic pear seedlings (Pyrus communis) are still the most acceptable rootstocks for pear cultivars in terms of vigour, hardiness, and compatibility. However, all pear trees on seedling roots are susceptible to fire blight. Seedlings of Pyrus calleryana are adapted to many soil conditions and produce semi-vigorous growth. It is resistant to fire blight, but it's not sufficiently winter hardy. Pyrus betulaefolia seedlings are also adapted for many soil conditions and it's a winter hardy. The trees are vigorous, larger than 'Bartlett seedling', and moderately tolerant to fire blight. Pyrus ussurensis can be used as resistant to fire blight, pear psylla, and cold hardy.

Role of Rootstocks in Apple

There is considerable diversity in the planting material used for raising apple rootstock seedlings in India. In the Kashmir region, a wild indigenous crab apple locally known as 'Trel' is commonly used as a rootstock, while in Himachal Pradesh, seedlings of 'Crab C' serve a similar purpose. The first systematic apple rootstock trial in India was initiated in 1937 at Chaubattia using cultivars 'Red Delicious', 'Jonathan', and 'Rymer'. These cultivars were evaluated on several rootstocks including Crab C, M2, M13, Merton 779, Merton 793, and a local seedling selection derived from 'Ribston Pippin'. Later, during the early 1960s, clonal rootstocks belonging to the Malling (M) and Malling-Merton (MM) series were introduced from the East Malling Research Station in England. In Himachal Pradesh, rootstocks such as M7, M9, M26, MM106, and MM111 were found to perform well, whereas in Jammu and Kashmir, M2, M4, M7, and M9 were recommended. For Uttarakhand, Merton 779, MM106, and M13 were identified as suitable rootstocks for commercial cultivation.

Role of Rootstock in stone fruits

In India, temperate stone fruits such as peach, plum, apricot, and almond are commonly propagated on their own seedling rootstocks, whereas cherry plants are generally raised on seedlings of 'Paja' (*Prunus cerasoides*). 'Behmi' (*Prunus mira*) is widely used as a rootstock for

almond cultivation in many regions. Studies on almond rootstocks under saline soil conditions have indicated that leaf water potential and osmotic potential were significantly affected by salinity in GF677 and bitter almond rootstocks, while the GN15 rootstock showed comparatively less reduction. This suggests that GN15 has greater selectivity for potassium (K^+) and calcium (Ca^{2+}) ions over sodium (Na^+), thereby providing better tolerance to salinity stress. Peach seedlings are most commonly used as rootstocks for peach cultivation, although seedlings of plum, apricot, and almond may also be utilized for this purpose. For plum (*Prunus domestica*), selections such as 'Brompton' and 'Common Plum' are commonly used, while 'St. Julien', 'Common Mussel', and 'Damson' from *P. insititia*, and 'Myrobalan' from *P. cerasifera* are also widely employed as rootstocks. In addition, seedlings of peach (*P. persica*), apricot (*P. armeniaca*), almond (*P. amygdalus*), and hybrids such as Marianna plum (*P. cerasifera* × *P. munsoniana*) are utilized as rootstocks in several countries. In India, peach, apricot, behmi (a natural hybrid of almond and wild peach), and plum seedlings are commonly used for this purpose.

Conclusion

The influence of rootstocks and interstocks on plant growth, flowering, fruit set, yield efficiency, and fruit quality in fruit crops is complex and not yet fully understood. Comprehensive research aimed at clarifying the mechanisms responsible for these effects would greatly assist in the development, breeding, and selection of improved rootstocks. A deeper understanding of factors such as endogenous plant growth regulators, rootstock–scion interactions, and the role of soil and climatic conditions is essential for the efficient selection and utilization of rootstocks in fruit cultivation. Rootstocks can modify several physiological processes including nutrient transport, hormone signaling, and plant growth patterns, which ultimately influence flowering, fruit set, and productivity.