International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(2): 880-887

Received: 09-01-2018
Accepted: 12-02-2018

Tsering Dolkar
Department of Fruit Science, Sher-e-Kashmir University of Agriculture Science and Technology-Kashmir, Shalimar Campus Srinagar, Jammu and Kashmir, India

Mansoor Ali
Department of Soil Science, Sher-e-Kashmir University of Agriculture Science and Technology-Kashmir, Shalimar Campus Srinagar, Jammu and Kashmir, India

Aqleema Banoo
Department of Plant Pathology, Sher-e-Kashmir University of Agriculture Science and Technology-Kashmir, Shalimar Campus Srinagar, Jammu and Kashmir, India

Divya Slathia
Department of Floriculture and Landscape Architecture, Sher-e-Kashmir University of Agriculture Science and Technology-Kashmir, Shalimar Campus Srinagar, Jammu and Kashmir, India

Lobzang Stanzen
Agrometeorology Section, Division of Agronomy Sher-e-Kashmir University of Agriculture Science and Technology-Jammu, Jammu and Kashmir, India

Stanzin Lakdan
TATA Trust, Leh Ladakh, Jammu and Kashmir, India

Correspondence
Mansoor Ali
Department of Soil Science, Sher-e-Kashmir University of Agriculture Science and Technology-Kashmir, Shalimar Campus Srinagar, Jammu and Kashmir, India

Mitigation of temperate fruit crop problems through use of rootstock

Tsering Dolkar, Mansoor Ali, Aqleema Banoo, Divya Slathia, Lobzang Stanzen and Stanzin Lakdan

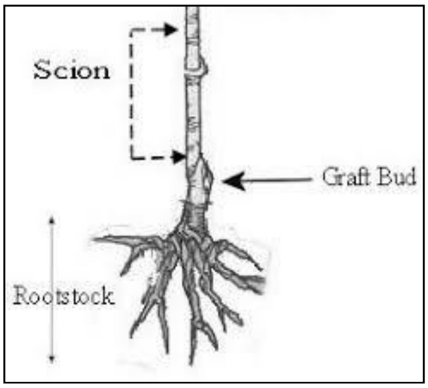
Abstract
The average productivity of temperate fruit crops in India is low as compared to developed countries. The main reasons for low productivity are old and senile orchards, low yielding varieties, poor canopy architecture, poor orchard management and inadequate technological up-gradation and adoption. Rootstocks play a crucial role in determining orchard efficiency in fruit crops. The role of rootstocks and its use in different fruit crops has significant impact on fruit crop production by influencing canopy architecture, nutritional uptake, flowering, yield and fruit quality (Rom and Carlson, 2007). Plants grown on seedling rootstock often tend to develop into large and vigorous architecture, making its management difficult compared to clonal rootstocks. Maintaining an optimal balance between vegetative and reproductive growth is an ongoing concern of research (Bhat *et al*., 2015). For instance, the apple rootstock M 9, M 27, etc induces larger fruit size and good quality fruits by better light interception and good aeration within the canopy than seedling rootstocks. Quince rootstocks also produce better fruit size and quality fruits of pears than seedling or *Pyrus communis* rootstocks (Sharma *et al*., 2009). In temperate fruits, rootstocks provide the principal method of controlling the excessive inherent vigour of the scion cultivar. The vigour of apple, pear, plum and sweet cherry trees can be controlled very effectively by choice of an appropriate rootstock.Rootstocks modify size and shape of the trees by shortening the internodal length, altering the angle of the branches, development of fruit crops and are capable of suppressing growth of the grafted variety, as compared to growth of that variety on its own roots (Webster, 2001). Rootstocks are an essential component in modern fruit production because of their capability of adapting a particular cultivar to diverse environmental conditions andcan also confront biotic and abiotic stresses such as soil pest and disease resistance, better anchorage, better tolerant to thermal stress and nutritional stress.Rootstocks can also reduce or extend the fruit maturation period, improve yield, fruit quality as well as increasing profitability (Kubota *et al*., 2008). They have the advantage of generating uniform orchards, easier to manage and more productive (Hartmann *et al*., 2002). Studies on understanding the mechanisms underlying these effects would help for future rootstock breeding and selection. A better understanding of endogenous growth substances, rootstock scion interactions, soil or climatic factors needed to be studied, which would aid more efficient selection and use of rootstocks in the future (Nimbolkar *et al*., 2016). Development of complex hybrids through hybridization to develop more versatile rootstocks to increase their usefulness and adaptation with respect to compatibility, size control, precocity, productivity and resistance to biotic and biotic factors and therefore more concerted efforts are required to research of temperate rootstocks will help to mitigate as well as exploit the beneficial effects and to overcome the problem facing by the temperate fruit crops.

Keywords: Temperate fruits, mitigation, problems, productivity, rootstocks

1. Introduction
India is the 2nd largest producer of fruits in the world. The average productivity of fruits in India is, however, low as compared to many developed countries. The main reasons for low productivity are:
1. Old and senile orchards,
2. Low yielding varieties,
3. Poor orchard management
4. And inadequate technological up-gradation and adoption

Presently, the continuing decline in the availability of cultivable land, rising energy and land costs together with the mounting demand of horticultural produce, have given thrust to the concept of high density planting (HDP) of horticultural crops. Furthermore, it is of main concern to the growers with small land holdings.

HDP is one of the important methods to achieve high productivity per unit area both in short duration and perennial horticultural crops which is possible by use of rootstock. The lower portion of a fruit tree is called the rootstock. This is the portion of the tree that has been grafted over to a specific variety or cultivar. Different rootstocks provide opportunities for everyone to enjoy the thrill of growing your own fruit. If you have limited growing space you could choose a super-dwarf rootstock that limits the height of your tree to as little as 5 feet! There are possibilities and sizes to match almost any need. Clonal rootstocks have the advantage over seedling rootstocks of uniformity, tree size control, precocity and resistance to soil borne pests and diseases. In some cases they also offer advantages in terms of improved fruit quality. The choice of rootstock in any situation depends upon the choice of training system, spacing, site vigour, scion variety and soil e.g. incidence of soil borne diseases or replant disease. Rootstock choice, therefore, is part of the interrelated management considerations prior to planting the orchard.

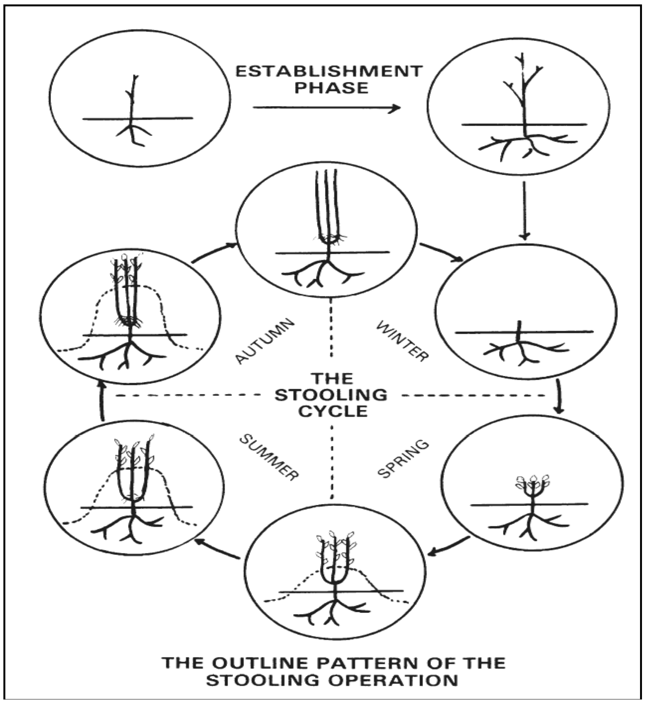


Historical Perspective
Horticulture Research International-East Malling (formerly East Malling Research Station) has a reputation worldwide for the breeding and development of rootstocks for temperate fruit species. This began in the 1920s when two of its former directors (Drs. Wellington and Hatton sorted out the incorrect naming and mixtures then widespread in apple rootstocks distributed throughout Europe. These verified and distinct apple rootstocks were then distributed throughout the world as Types, initially Type I through Type IX (Hatton, 1917) [5]. Later, further types were added to the original nine, though most of these were invigorating rootstocks which have since disappeared largely from commerce. Although distributed under type names, the apple rootstocks rapidly became known under Malling (or M.) designations and eventually the Roman numerals were replaced by the more normal Arabic ones. Only two of these original Malling selections, M.9 (Jaune de Metz) and M.7, are now used extensively by commercial orchardists. In collaboration with the John Innes Institute, then based at Merton, a further series of rootstocks was produced, all exhibiting resistance to the woolly apple aphid (*Eriosoma lanigerum*) (Preston, 1955) [16]. This was, and still remains, a very serious pest in many parts of the southern hemisphere, where it attacks the root systems of apple trees. MM.106 and MM.111, two of the Malling Merton (MM.) series of rootstocks that gained resistance to woolly apple aphid from their Northern Spy parent, are still used extensively throughout the world. A further apple rootstock breeding program at East Malling, using the dwarfing M.9 as one parent, produced two more valuable dwarfing rootstock clones (Preston, 1967) [17]. M.26, the result of a cross between M.16 and M.9, is semi-dwarfing and exhibits better tolerance to winter cold and drought than M.9. M.27, a super dwarfing rootstock originating from a cross betweenM.13 and M.9, is mainly used for vigorous scion cultivars planted in high density planting systems on fertile soils. Other apple rootstocks bred and developed by East Malling in the past, such as the invigorating but precocity-inducing M.25 or the super dwarfing M.20, have to date received only limited and localized adoption by fruit growers around the world. Rootstocks for other temperature fruit species that have been bred and developed by East Malling have also achieved popularity in fruit growing areas throughout the world. Two selections of Angers type quinces (*Cydonia oblonga*), EM Quince A (QA) and EM Quince C (QC), are widely used by pear (*Pyrus communis*) growers in Europe. These stocks reduce the natural high vigor of pears and induce precocious and abundant crops of good-sized fruits. However, although the graft compatibility of these quince rootstocks is good with varieties like Conference and Comice, it is poor with many other varieties. Two rootstocks for sweet cherry have been produced and distributed from East Malling. The invigorating Mazzard stock (*P. avium*) F.12/1, which was originally selected for its resistance to bacterial canker (*Pseudomonas mors prunorum*), has now fallen from favor amongst commercial fruit growers who are seeking more dwarfing rootstocks for this species. Colt, a hybrid between *Prunus pseudocerasus* and *P. avium*, was released in the 1970s as a semi vigorous rootstock for sweet cherries. Colt is much easier to propagate than F.12/1 and, in many situations; it induces better precocity and yield efficiency in the scion.

World's major research institutes involved in clonal rootstock breeding

Country	Name of research institute
Belgium	Centre de Recherches Agronomiques, Gemblox
Czech Republic	Research and Breeding Institute of Pomology, Holovousy
Denmark	Danish Institute of Agricultural Sciences, Department of Fruit, Vegetable an Food Science, Aarslev
France	INRA, Bordeaux
Great Britain	Horticultural Research Institute, East Malling
Germany	University of Giessen Technical University Munich, Institute for Fruit-growing, Weihenstephan Federal Centre for Breeding on Cultivated Plants, Institute for Fruit Breeding, Dresden-Pillnitz
Hungary	University of Horticulture and Food Industry, Budapest
Italy	University of Bologna, Bologna Vivai Battistini dott. Giuseppe, Martorona di Cesena
Poland	Research Institute of Pomology and Ornamentals, Skierniewice
Romania	Fruit Research Institute Pitesti-Marachineni
Russia	Krymsk Breeding Station, Krasnodar Region
Spain	Department of Pomology, Estación Experimental de Aula Dei, Zaragoza
United States of America	Oregon State University, Oregon

Types of rootstocks
1. **Seedling rootstocks**: Rootstocks which develop from seeds.
2. **Clonal rootstocks**: Rootstocks which are multiplied through vegetative means either by stooling, layering, cuttings or by aseptic culture method.



Need for clonal rootstocks
1. Variability
2. Uneven and unpredictable fruit productivity
3. Late bearing
4. Vigorous

Advantages over seedling rootstocks
Clonal rootstocks possess the requisite attributes for meeting the demands of modern orcharding systems like:
- Uniformity
- Tree size control-HDP
- Precocity
- Cropping efficiency
- Cold hardiness
- Tolerance to drought
- Resistance to insect pests and diseases
- Tolerance to high temperature and wet soils
- Adaptability to wide range of soil and climatic conditions.

Attributes of an ideal rootstock
a) Important tonurseryman
i) Ease of propagation
All the rootstocks should be easy to propagate either from layering or cutting techniques.
ii) Good performance in the nursery
- Well establishment
- Good graft compatibility
- Well feathered trees

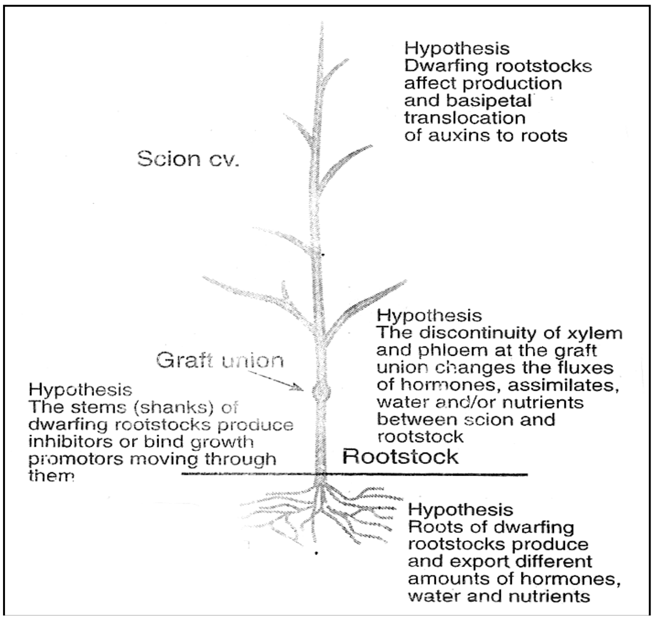
b) Important to fruit producer
- Ability to control scion vigour to the required level
- Ability to induce precocity and abundant cropping
- Tolerance to biotic stress factors
- Tolerance to abiotic stress factors
- Free from suckering

Rootstocks are mainly used to readdress the following problems/purposes:
- Tree size control (no. of plants per unit of area)
- Control juvenility
- Growth and yield
- Nutrient uptake
- Flowering and fruit set
- Fruit quality
- Soil related problems
- Diseases and Pests

Why Use Rootstocks?
Traditionally, rootstocks were used primarily as a method for propagating selected scion cultivars. Tree fruit species do not develop true-to- type when propagated from seed and propagation of selected scion cultivars is possible only by vegetative methods. Propagation of most cultivars of temperate tree fruits is very difficult using traditional stooling /layering or cutting methods, although some cultivars of morello tart cherry *(Prunus cerasus)* and plum *(Prunus domestica)* have always proved an exception to this rule. Horticulturists have used techniques of budding and/or grafting for millennia and the simplest and most reliable method for vegetative propagation of fruit trees has relied on combining a rootstock with the scion cultivar via budding/grafting. Originally, all of the rootstocks used were raised from seeds (either collected in the wild or from fruits harvested from cultivated trees) or from suckers dug up from beneath cultivated trees. The variability in scion performance commonly experienced when using such rootstocks was of little consequence to the early horticulturists whose only objective was to multiply trees of an especially valuable scion selection. Rootstocks still provide fruit tree nurserymen with their primary method of fruit tree scion propagation. Although alternative strategies for tree propagation are now available, they have yet to prove preferable to the use of rootstocks.

Rootstocks Mechanism
Although rootstocks have been used by horticulturists for more than two millennia, we still have little comprehension of how they bring about their many useful effects on the physiology, growth and cropping of fruit trees scions. Several decades ago, when research into rootstock mechanisms was fashionable, considerable effects were made in attempts to relate the effects of rootstocks on tree vigo ur and cropping to disturbances in the translocation of minerals, assimilates and water across the graft union. Unfortunately, none of these studies resulted in a convincing explanation of the effects of rootstocks and in recent years there has been little research efforts in this areas. However, new and exciting studies have focussed, recently, on the effects of rootstocks on the acropetal and basipetal transport of endogenous hormones, auxins, cytokinins, gibberellins and abscisic acid through the rootstock and across the graft union (Soumelidou *et al.*, 1994; Kamboj *et al.*, 1997) [23]. It can be argued that, as great advances have been made in rootstock breeding and selection in the absence of any real understanding of the mechanisms involved, few research resources should be devoted to such studies. Nevertheless, improved understanding of the mechanisms of the effect of rootstocks on the scion will prove essential if the full potential of on-going advances in

molecular biological techniques are to be achieved in the future breeding of new rootstocks.



Control of Tree Vigor

In a few species of temperate fruits, rootstocks provide the principal method of controlling the excessive inherent vigor of the scion cultivar. The vigor of apple, pear, plum and, more recently, sweet cherry trees can be controlled very effectively by choice of an appropriate rootstock. This option has been available for apples and pears for several centuries, but commercially viable dwarfing and semi-dwarfing rootstocks for stone fruit species have been introduced only over the last 80 years or so. How control of vigor by the rootstock is brought about is still not understood, even though such dwarfing rootstocks have been used in apples and pears for centuries. Attempts to explain how rootstocks dwarf trees, which have focused on their effects on supply of mineral nutrients, assimilates and water to the scion, have largely proved unsuccessful. More recent studies aimed at understanding rootstock effects on tree vigor have focused on their influence on the production and movement of endogenous hormones within the stion (rootstock + scion) tree (Soumelidou *et al*., 1994; Kamboj *et al*., 1997; Sorce *et al*., 2002) [23, 22]. Control of excessive scion vigor has become increasingly important in recent years as the economic viability of fruit production has declined in many countries. Trees of reduced stature allow the majority of tree management and hand harvesting to be carried out from ground level. Larger trees demand the use of ladders or expensive mechanical aids, and the cost per unit of quality fruit produced is higher than where dwarf trees, which facilitate improved resource productivity (mainly labor), are used. Also, there are environmental benefits associated with dwarfed trees. Spray targeting and the minimizing of spray drift are much improved on trees of reduced stature.

Table 1: Some important size controlling rootstocks of temperate fruit crops

Crop	Rootstocks
Apple	M 9, M 26, M 27, MM 106, MM 104, MM 111, P2, P22, Bud 9, etc
Pear	Quince A, Quince B, Quince C, Old home x Farmingdale, Oregon 211, Oregon 249
Peach	Peach x almond hybrids (GF677. GF 556), lovell
Cherry	Colt, GiSela5, GiSela 6, F12/1, CAB 6P, CAB11E
Plum	Pixy, St. Julian A, GF 635-2, American Plum
Apricot	P. besseyi and Hybrid P2038

Table 2: Planting density of different apple rootstocks

Rootstocks	Spacing (m)	Trees / ha
MM 111,MM 109	4 X 4	625
MM 106, MM 109	5 x 5	400
MM 106, M 7	3 x3	1111
M9	2x2	2500
M9-T337	1x3	3333

Fruit Quality

By reducing tree size, dwarfing rootstocks produce less vegetative growth and yields, on a per-tree basis, are lower than those for a tree on a vigorous rootstock. However, the smaller tree stature permits trees to be planted at higher densities, thereby enabling much larger yields to be achieved per unit of planted area. Furthermore, the yielding efficiency of the tree increases with the extent of scion differences in tree weight, canopy volume, light interception and trunk cross-sectional area all show an increased yield efficiency associated with dwarfing rootstocks. Producers of apples and pears have recognized for a long time that by choice of suitable rootstock their trees can be induced to crop earlier in their lives (exhibit improved precocity) and crop more abundantly and consistently. More recently it has been shown that certain rootstocks can also influence fruit size and quality. For instance, the apple rootstock M.9 induces larger fruit size than many other rootstocks and this effect cannot be explained in terms of reduced crop loads. Quince rootstocks also often produce better fruit size and quality of pears than when seedling or clonal *Pyrus communis* rootstocks are used. Dwarfing rootstocks usually induce better yield precocity and abundance than more invigorating rootstocks. This is explained by the increased numbers and quality of floral buds produced on dwarfed trees. This, in turn, is likely to be partially attributable to the earlier cessation of shoot extension growth in the summer on trees on dwarfing rootstocks and the redirection of the trees' assimilates and nutrients toward the production of floral buds. Nevertheless, certain invigorating rootstocks also induce better flowering than others (e.g., the apple rootstock M.25) and the reasons for these differences are not understood.

Precocity

Apple trees undergo different phases of development between seed germination and the adult fruiting tree. In the juvenile phase, when no flowers are produced, plants may differ considerably from mature adult trees. The leaves are smaller and usually more finely serrate, and the shoots are thinner and are often produced at right or obtuse angles to the main stem. Bud break is early and leaf fall is late. The onset of the adult phase is marked by the development of flower buds. Between these two phases there is a transition phase when the lower part of the plant is still juvenile and the upper part is adult.

Cuttings from most adult apple trees used as scion cultivars are extremely difficult, if not impossible, to root. Cuttings from young seedlings root readily but rooting is more difficult to achieve as the seedlings age, suggesting that the transition is gradual. The duration of the juvenile phase varies from 3 to 10 or more years, depending on the genotype of the seedlings and the cultural practices. However, any method that restricts growth in the very young seedling does not shorten the duration of the juvenile phase but in fact lengthens it and delays the onset of fruiting. Cultural methods that check the growth of seedlings are effective in hastening flowering only when a certain stage of development has been reached. A long juvenile period is a serious problem in temperate fruit crops. Ambri apple extensively grown in Kashmir valley if India but during past few decades, ambri leading to its extinction from fruit map of India for several reasons. Among them is the long juvenile period (15-17 years). One year old whips were planted at FRC, Shopian. Trees were composed of a seedling rootstock with an interstem of M.9, M.106 and MM.111 with a length of 5, 10, 15 and 20 cm grafted between the rootstock and the scion (ambri apple). Interstock does not consistently bloom and fruit set, although M.9 and MM.106 interstock influenced precocity and only a limited data was observed which showed that interstock influence prebearing age. The trees having M.9 and MM.106 at interstock at 20cm length fruited in the 3rd growing season but yield averaged only 0.04 to 0.19 kg/tree. However trees on MM. 106 (20cm) were more productive than others (Bhat *et al*., 2015) [1].

Table 4: Effect of Interstock Genotype and length of precocity of "Ambri "apple

Type of Rootstock	Length of Rootstock(cm)	% Bloom Year				Cumulative yield (Kg/tree)
		2nd	3rd	4th	Average	
M.9	5	0	0	10	3.3	0.069
	10	0	0	40	10.3	0.088
	15	0	10	70	20.6	0.089
	20	0	20	90	33.3	0.099
None	Seedling rootstock control	0	0	0	0	0.000
MM.106	5	0	0	14	4.66	0.08
	10	0	5	45	15.5	0.088
	15	0	15	75	30.0	0.09
	20	0	25	90	**35.0**	**0.10**
None	Seedling rootstock control	0	0	0	0	0.00
MM.111	5	0	0	5	1.66	0.04
	10	0	0	15	5.0	0.08
	15	0	0	45	15.0	0.088
	20	0	0	70	20.33	0.89
None	Seedling rootstock control	0	0	0	0	0.00

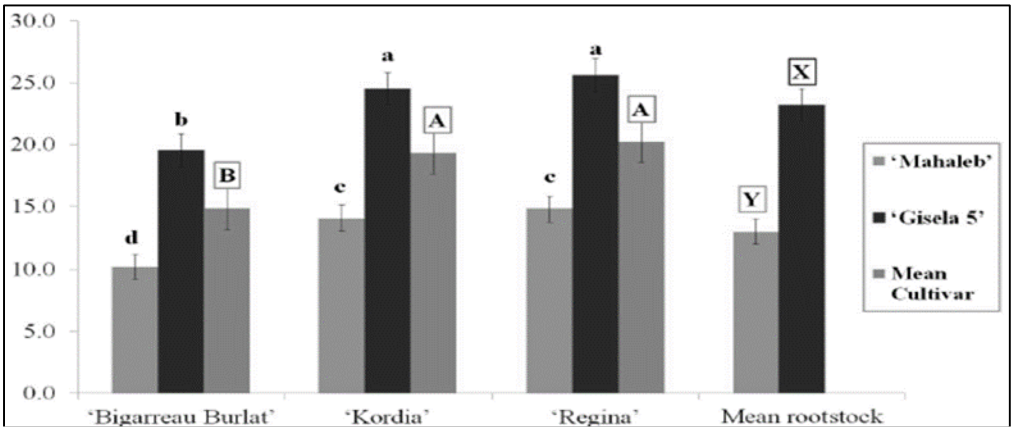
Flowering and Fruit set

One of the great advantages of using rootstocks is that they induce precocious scion flowering. Not only are flowers produced earlier in the tree's life cycle, but also large numbers of flowers are produced per unit tree size. This effect is particularly evident with rootstocks that dwarf scions, but as Webster (1994) points out, these two factors just may be coincidental, rather than biologically linked. However, the ability of dwarfing rootstocks to induce changes in dry weight distribution in favor of reproductive development and, therefore, flower and fruit production suggests a causal link. Rootstocks may influence the number of flowers on a tree through changes in scion architecture, particularly with respect to branch angle (orientation) and shoot development. The production of new shoots may be modified such that flower bud induction is favored rather than vegetative shoots. Developmental changes of this type can be seen on 1-yearold wood as an increased production of short shoots and flower buds. Rootstocks may also induce increases in the number and size of flowering spurs on older wood.

Yield

The yield produced by fruit trees are controlled by many factors although choice of rootstock is an important component in this control. Use of improved clones of the chosen scion cultivar coupled with various management techniques can all improve fruit yields and grade outs significantly.

Pal *et al*., 2017 [15] Data concerning the influence of the rootstock and the cherry cultivar upon cumulative yield of 2014 -2016 growing seasons are presented in Fig. 1. It can be seen that the best cumulative yield in mean value was obtained in variants of cultivars grafted on 'Gisela 5' (23.2 kg/tree) followed by the system where cherry trees are grafted on Mahaleb (13.1 kg/trees) with differences statistically assured between these two variants. Regardless the treatment only between 'Regina', 'Kordia' and 'Bigarreau Burlat' there is differences statistically assured. The best cumulative yield gave 'Regina' (7.6 kg/tree) and the lowest 'Bigarreau Burlat' (5.6 kg/tree). Regarding the combined influence of two experimental factors, the best cumulative yield was obtained at 'Regina' grafted on 'Gisela 5' (20.2 kg/tree) followed by 'Kordia' grafted on 'Gisela 5' (19.4 kg/tree) and the lowest cumulated yield was obtained in the variant on 'Bigarreau Burlat' grafted on Mahaleb (10.2 kg/tree). A strong influence of the rootstock on the yielding precocity but also on the fruit production obtained during the first three years of fructification. Our results confirm those of Stehr (2005) that 'Gisela 5' enhances precocity. The yield for each analyzed year of experiment was almost double in variants where the trees were grafted on 'Gisela 5'.



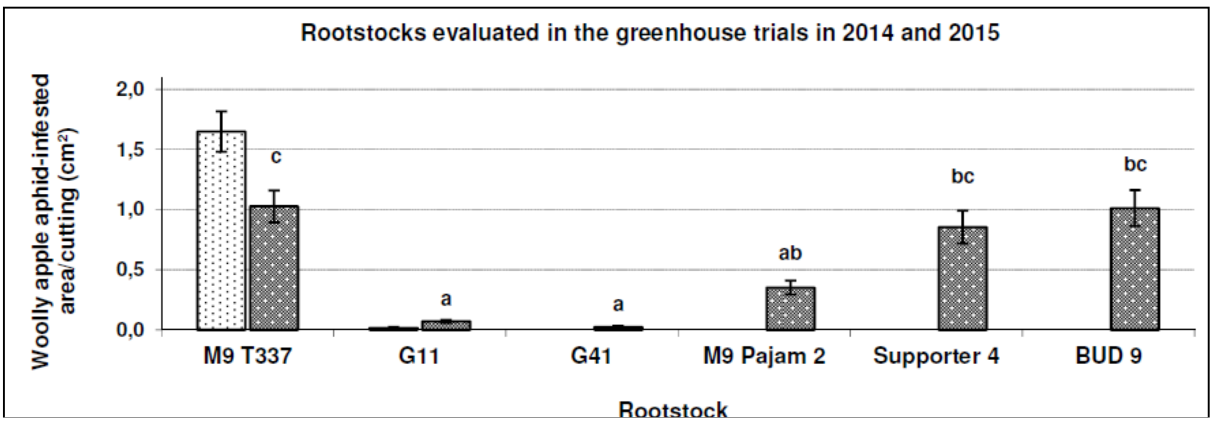
Biotic and abiotic factors and Clonal rootstocks

Rootstocks are also used to adapt scion cultivars to soils or climatic conditions that are otherwise not fully suited to their cultivation. Areas of production that experience sustained periods of very low (sub-zero) winter temperatures need rootstocks that are tolerant to winter cold. Similarly, climatic areas or soils subject to transient drought conditions require rootstocks capable of competing with weeds and/or grasses for reduced water reserves and/or inducing efficient water use by the scion cultivar. Transient waterlogging and anaerobic soils are also occasionally a problem, although only a few stone fruit rootstocks are able to tolerate this problem. Rootstocks prove extremely useful in providing tolerance to high levels of free calcium in soils and the associated problem of lime-induced chlorosis. Unfortunately, as with most other rootstock effects on scion growth and performance, there is only limited understanding of how rootstocks provide tolerance to cold, drought and high pH.

Some clonal rootstocks available in different fruit crops including apple, pear, cherry, apricot etc. can withstand different biotic and abiotic stresses. Webster *et al.* (2000) has observed that J-9 clonal rootstock of apple perform better under drought conditions (Table-16) for crown volume and yield. Godini *et al.* (2008) [3] have recorded 100 per cent survival of Lapin cherry on Avima Argot and CAB.11E clonal rootstock of cherry in different years of observations. Mariana G.F.8-1 plum rootstock resisted to water logging for 145 and 50-60 days respectively in winter and summer periods as reported by Rom and Carlson (1981). Cummunis (1982) reports wide tolerance of Robusta-3 apple rootstock against crown rot, fire blight, apple scab, powdery mildew, latent viruses and wooly apple aphid whereas different quince rootstocks used for pear have shown tolerance to pear decline and crown gall There are many pest and disease problems associated with fruit production in temperate regions. The most important diseases that affect apple rootstocks are fire blight, which is caused by the bacterium Erwinia amylovora (Burr) and crown (collar) rot, caused by Phytophthora cactorum. There is rootstock variability in resistance to key economic soil-borne diseases such as Phytophthora sp. and resistance to important pests such as woolly apple aphid (Eriosoma lanigerum Hausm.) This has been improved through the use of breeding programmes (Rom and Carlson 1987) [18]. In the case of woolly apple aphid, the cultivar 'Northern Spy' is resistant and has therefore been extensively used as a parent in breeding programmes, i.e. the resistant Malling-Merton (MM) rootstocks.

Wooly Apple Aphid Causal organism: *Eriosoma langerum*

Fig 4: Infested by woolly apple aphid per cutting on the different rootstocks



Cuttings were grown in the greenhouse, uniformed to 2-3 shoots per cutting, disposed in a randomized block design, artificially infested with the target pest by using 1 approx. 3 cm-long piece of shoot infested with woolly apple aphid per cutting, and individually covered with insect-proof and anti-hail net immediately after artificial infestation; untreated control: not included. Assessments: woolly apple aphid infested area per cutting (cm²) in all trials. Clear differences among rootstocks in the area infested by woolly apple aphid per cutting emerged (Fig. 4), with infestation levels being lowest for the Geneva® rootstocks G11 und G41. Reduced infestation levels in comparison the standard rootstock M9 T337 were observed also for M9 Pajam 2, while no reduction in the infestation was observed for the other rootstocks tested. Potential rootstock resistance or tolerance to woolly apple aphid may thus be excluded for Supporter 4, BUD 9, and M9 T337. Only M9 T337 and G11 were tested, and therefore no statistical analysis was performed, while in 2015 six rootstocks were evaluated. Woolly apple aphid infestation levels differed considerably among the tested rootstocks. Notwithstanding the extremely high initial artificial infestation and conditions being favourable to pest development, the Geneva® rootstock showed almost no infestation. Further investigations are warranted to evaluate the field performance of these rootstock as well as the influence of different rootstock-variety combinations on woolly apple aphid infestations in the open field.

Fire blight: *Erwinia amylovora* Jensen *et al*., 2015 [7]

Rootstock-dependent differences in fire blight susceptibility of 'Gala' scions. Significant differences in the relative size of the necrotic regions were observed within 15 days of inoculation of the 'Gala' shoot tips with two different strains of E. amylovora (Figure 4). For both strains, 'Gala'/G.30 and 'Gala'/M.111 were the least susceptible and 'Gala'/B.9 and 'Gala'/M.27 were the most susceptible. Interestingly, strain-dependent differences in fire blight susceptibility were observed for 'Gala'/M.7 and 'Gala'/M.9F56 trees. 'Gala'/M.7 susceptibility to E. amylovora strain Ea581a was similar to that of the most susceptible trees ('Gala'/B.9 and 'Gala'/M.27), while 'Gala'/M.9F56 susceptibility to strain Ea581a was similar to that of the most resistant trees ('Gala'/G.30 and 'Gala'/ MM.111). The results were reversed with E. amylovora strain HKN06P1, with 'Gala'/M.7 susceptibility being similar to that of the most resistant trees and 'Gala'/M.9F56 susceptibility being similar to that of the most susceptible trees. E. amylovora strain Ea581a is a moderately virulent isolate, while HKN06P1 is a hypervirulent isolate.

Blossom blight symptoms Shoot blight symptoms

Fig 5: Susceptibility of grafted 'Gala' scions on seven different apple rootstocks

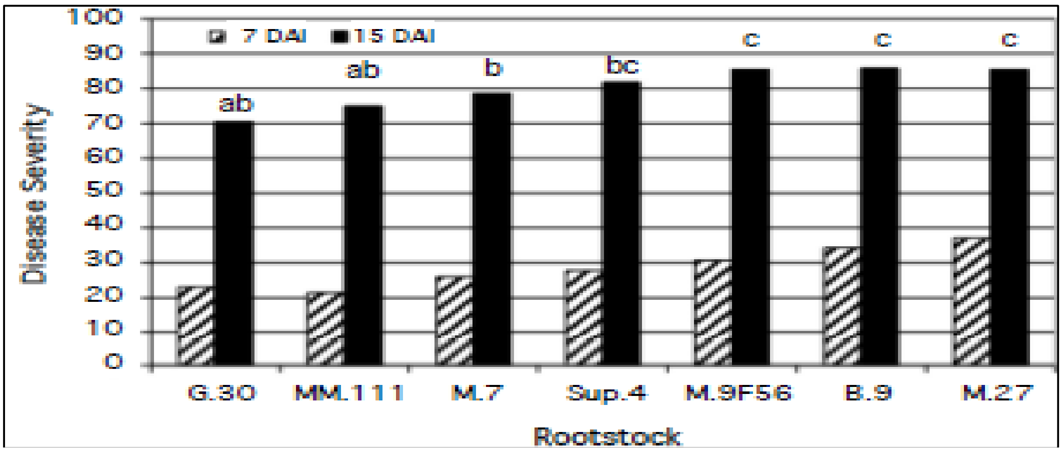


Table 10: Some new apple root stocks

Name of rootstocks	Remarks
Geneva-11	Moderately susceptible to wooly apple aphid. Fire blight resistance is excellent.
Geneva -16	Reported to be highly fire blight resistant. Produces a tree size between M 9 and M 26. G16 should only be budded or grafted to certified, virus-free scion wood due to its virus hypersensitivity
Geneva 41	Fire-blight resistant and producing a tree similar to EMLA 9 but with better productivity.
Geneva 202	Reportedly very fire-blight resistant and highly resistant to wooly apple aphid. Reported to produce a tree similar in size to EMLA 26.
Geneva 210	Resistant to woolly apple aphid and highly resistant to fire blight. Tolerant to replant disease complex and crown and root rot.
Geneva 214	Resistant to woolly apple aphid and highly resistant to fire blight. Tolerant to replant disease complex and crown and root rot. Yield efficiency better than M.9.

Conclusion

- Clonal Rootstocks play an important role in tree physiology, so selecting right rootstock is critical.
- Clonal rootstocks are important for maintaining or increasing productivity of fruit trees.
- Clonal rootstocks provides an inexpensive and simple method of raising uniform trees of selected scion varieties.
- Clonal rootstocks can also adopt a scion variety to suit variable and often unfavourable soil and climatic conditions.

- Dream of higher productivity & quality, profitability & sustainability under integrated/organic fruit farming can be seen through the eyes of clonal rootstocks in coming times.

References

1. Bhat ZA, Pandit AH, Wani MW, Rather JA. Effect of interstock on juvenility and tree size of Ambri apple. Acta Horticulture. 2015; 903:435-437
2. Cummins JN, Aldwinckle HS. New resistant rootstocks from Geneva. Fruit Variety Journal. 1994; 48:39.
3. Godini A, Palasciano M, Pacifico A. A nine year study on the performance of 12 cherry rootstocks under non-irrigated conditions in Italy. Acta Horticulturae. 2008; 795:191-198.
4. Hartmann HT, Kester DE, Davies J, Geneve RL. Plant Propagation: Principle and practices. Prentice Hall, Upper Saddle River, New Jersey, USA. 2002; 7:880-885
5. Hatton R. Paradise apple stocks. Journal Royal Horticulture Society. 1917; 42:361-399
6. Ikinci. A, Bolat I, Sezai Ercisli S, Kodad O. Influence of rootstocks on growth, yield, fruit quality and leaf mineral element contents of pear cv. 'Santa Maria' in semi-arid conditions. Biological Research. 2014; 47:71-79
7. Jensen PJ, Halbrendt N, Gennaro F, Makalowska I, Altman N, Praul C *et al*. Rootstock-regulated gene expression patterns associated with fire blight resistance in apple. BMC Genomics. 2015; 13:9-16
8. Kamboj JS, Blake PS, Quinlan JD, Baker DA. Identification and quantitation by GC-MS of zeatin and zeatin riboside in xylem sap from rootstock and scion grafted apple trees. Plant Growth Regulation. 1999; 28:199-205
9. Kelderer ME, Lardschneider M, Schütz R. Efficacy evaluation of different methods for the control of woolly apple aphid (*Eriosoma lanigerum* [Hausmann]) in organic apple growing. Proceeding to the 12th International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit-Growing. 2016; 32:1232-1245
10. Kubota C, McClure MAN, Kokalis-Burelle MG, Rosskopf EN. Grafting: History, Use and Current Technology Status in North America. American Society for Horticultural Science. 2008; 43:1664-1669
11. Mitre V, Mitre I, Sestras AF, Sestras RE. Effect of root pruning upon the growth and fruiting of apple trees in high density orchards. Bulletin UASMV Horticulture. 2012; 69**:**254-259.
12. Mushtaq SA. Influence of rootstock on growth, nutrient status and quality characteristics of exotic apple varieties. Sher-e-kashmir University of Agricultural Sciences and Technology. Thesis Fruit Science, 2014.
13. Nimbolkar PK, Awachare C, Reddy YTN, Chander S, Hussain F. Role of rootstocks in fruit production. Journal of Agricultural Engineering and Food Technology. 2016; 3:183-188
14. Ozturk A, burhan ozturk B. The Rootstock Influences Growth and Development Of 'Deveci' Pear. Turkish Journal of Agricultural and Natural Sciences. 2014; 1:1049-1053
15. Pal MD, Mitre I, Asanica AI, Sestraș A, Adrian G. The Influence of Rootstock on the Growth and Fructification of Cherry Cultivars in a High Density Cultivation System. Botanical Horticulture Agrobotanics. 2017; 45:451-4
16. Preston AP. Apple rootstock studies: Malling Merton rootstocks. Journal of Horticulture Science. 1955; 30:25-33.
17. Preston AP. Apple rootstock studies: Fifteen years results with some MIX crosses. J. Hort. Sci. 1967; 42:41-50.
18. Rom RC, Carlson RF. Rootstocks for fruit crops. John Wiley and Sons, New York, 1987.
19. Rom RC, Carlson RF. Rootstocks for fruit crops. New York, Wiley and Sons, 2007, 494
20. Sakalauskaite J, Kviklys D, Lanauskas J, Duchovskis P. Biomass production, dry weight partitioning and leaf area of apple rootstocks under drought stress. Scientific works of the Lithuanian institute of Horticulture and Lithuanian University of Agriculture Sodininkyste. 2006; 25:283-291
21. Sharma S, Rehalia AS, Sharma SD. Vegetative growth restriction in pome and stone fruits. Agricultural Reviews 2009; 30(1):13-23
22. Sorce C, Massai R, Piciarelli P, Lorenzi R. Hormonal relationships in xylem sap of grafted and ungrafted *Prunus* rootstocks. Scientia Horticulture. 2002; 93:333-342.
23. Soumelidou K, Morris DA, Barrely NH, Barnett JR. Auxin transport capacity in relation to the dwarfing effect of apple rootstocks. J Hort. Science. 1994; 69:719-725.
24. Webster AD. Rootstock and interstock effects on deciduous fruit tree vigour, precocity, and yield productivity *New* Zealand Journal of Crop and Horticultural Science. 2001; 23:373-382
25. Webster AD, Hollands MS. Orchard comparisons of 'Cox's Orange Pippin' grown on selections of the apple rootstock M.9. Journal of Horticulture Science and Biotechnology. 1999; 74:513-521