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CLONAL ROOTSTOCKS: A BOON FOR APPLE GROWERS OF HIMALAYAN HILL STATES OF INDIA

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ABSTRACT

While seedling rootstocks are still utilized in apple propagation, the availability of improved clonal rootstocks offers a range of benefits for modern orchards. These clonal rootstocks fulfill the requirements of orcharding enterprises, including uniformity, control over tree size, early fruiting, efficient yields, resistance to pests and diseases, and adaptability to challenging soil and climatic conditions. They play a crucial role in determining the success or failure of an orchard. The Geneva series rootstocks (G11, G16, G.41, G.935, G.202, G.210, G.214, G.890, G.969) developed through planned crossing and hybridization present promising opportunities for orchardists in the Himalayan states of India to produce high-quality apples that command premium prices in the market. Meeting the rising demand for clonal rootstocks in establishing high-density orchards requires the establishment of more certified nurseries and tissue culture laboratories, both publicly and privately, across various locations in the Himalayan states. These efforts will cater to the growing need and contribute to the success of the apple industry in the region.

INTRODUCTION

The cultivated apple (*Malus* × *domestica* Borkh.) originated in Central Asia and is the most widely grown temperate fruit, known as "King of temperate fruits". Because of its heterozygous nature, apples grown from seeds are not be able to maintain the distinctness, uniformity and stability of the cultivar. Use of clonal rootstocks have been a great alternative to propagate apple fruit trees in order to maintain the genotype stability with promising traits of interest. Conventionally, the majority of the trees in apple orchards were propagated on rootstocks raised from seeds. Due to its heterozygous nature, the performance behavior of the seedling rootstocks varies from one to another and their usage as rootstocks also causes delay in the crop cycle and variation in fruit size, color as well as yield in the scion cultivars grafted over it which directly reduces the production of Grade-A quality apples used for export and fetches comparatively lower price in the market. The apple growers who are still relying on the traditional way of growing apple

using seedling rootstock are facing difficulties in getting a higher price in the apple mandi (Market yard to sell apples), whereas the modern orchardists who have established apple orchards using clonal rootstocks over the last few decades are getting higher productivity per unit area as well as a higher price due to the uniformity and stability of scion cultivars.

During the early 20th century, there was a remarkable change occurred in fruit industry across the globe which indirectly encouraged the fruit breeders across the world to breed apple rootstock cultivars with uniformity in its morphological characters to provide compact growth and higher productivity to scion cultivars by accommodating higher number of plants per unit area. Several rootstocks were developed either by selection or hybridization in major research institutes across the world to meet the demand of growing global apple industry. Use of clonal rootstocks encourages dwarfing growth of scion cultivars and this practice got popularized among the modern orchardists who wanted to increase the productivity as well as quality of produce of their orchards. Now a days the apple growers of Himachal Pradesh and Jammu and Kashmir (UT) are largely relying on the use of clonal rootstocks by importing from other countries. These clonal rootstocks play an essential role in fruit tree growth by establishing the ideal root system which improves the efficiency of absorption of nutrients and water from soil when provided through drip irrigation practices. Apart from that, they have a short juvenile period, imparts uniformity and precocity in bearing, resilience to biotic and abiotic stress and most importantly it has the ability produce a larger percentage of superior quality fruits among the total produce (Demirkser *et al*., 2009). Therefore, the usage of clonal rootstocks in apple orchards is now considered as an effective strategy towards reducing the tree size, enhancing precocity as well as in improving the production efficiency (Dolgov and Hanke, 2006). The popularity of clonal rootstocks increased exponentially among the modern orchardist because it eliminates the variability in scion cultivar characteristics which was a limiting factor towards quality and uniform produce since the beginning of use of seedling rootstocks for growing apple. With the proper selection and use of rootstocks variety according to the requirement of the specific location, the cultivation of several varieties of apple can be expanded into unsuitable, marginal locations as well as sustainability in production and quality of fruit can also be enhanced.

ADVANTAGES OF CLONAL ROOTSTOCKS OVER SEEDLING ROOTSTOCKS:

1. ***Tree size:*** The sizes of seedlings trees vary greatly. This often results in either big vacant spaces in the orchard or trees that crowd one another; neither of which condition is ideal. On the other hand, the clonal rootstocks will often be of conventional size. This can help the grower properly design his orchard.

Fig.1: One year's old M9 clonal apple rootstocks ready to get dispatched to the apple grower's field

2. ***Tree behavior:*** It is impossible to predict the productivity and bearing age of a tree on seedling rootstock. One tree on the seedling may produce exceptional crops with extremely good fruit quality, while another tree on a related seedling plant may produce poor harvests. However, the clonal rootstocks are well-known for their true to type behavior.
3. ***Response to climatic factors:*** Every rootstock reacts to varied agro-climatic situations differently. Response of seedling rootstock differs with different seedlings. On the other hand, the grower can make the best investment choice since it is known if clonal rootstocks are resistant to or susceptible to the local climatic and soil conditions.
4. ***Resistance to disease and pests:*** Rootstocks from seedlings may or may not be immune to specific disease and pests, whereas, clonal rootstocks have greatest resistance to disease and pest and meets every orchardist's demand (Howard, 1997 and Ananda, 1999).

ROOTSTOCK CULTIVARS CURRENTLY BEING USED BY THE APPLE GROWERS OF INDIA:

Use of apple clonal rootstocks is gaining popularity as a method of overcoming production and productivity challenges (soil, climate, and pests), as well as modifying market demand (fresh or processed), shortening the juvenility phase, and improving fruit quality (Demirkeser *et al.*, 2009). It has been determined that the several clonal rootstocks, including M 9, M 7, MM 106, MM 111, and Merton 793 are promising for the climate conditions of apple growing belts of India. The orchardists in India are currently

showing a significant interest towards establishing high density apple plantations. Therefore, the need for apple clonal rootstocks is rising high due to the higher productivity of quality fruits under high density plantation of apples. Recently, a number of apple clonal rootstocks were introduced. The introduction of rootstocks cultivars viz. Bud 9, M9, T337, Bud 10 and MM 118 to India is giving the orchardists various options towards growing the plants by using various planting distance and training system and on different soil types and altitudes.

Table 1. Clonal rootstocks currently being used by the apple growers of India

ROOTSTOCKS	ORIGIN	PARENTAGE	NATURE	SALIENT FEATURES
M 27	East Malling Research Station, England	M 13 x M 9	Ultra Dwarf	Suitable for HDP
M 9	East Malling Research Station, England	Pedigree Unknown	Dwarf	Viral disease resistant and suitable for HDP
MM 106	John Innes Research Institute with East Malling Research Station, England	Northern Spy x M1	Semi-Dwarf	Good anchorage, Good number of roots, Good for slightly heavy to light soils, Resistant to wooly apple aphid
MM 111	John Innes Research Institute with East Malling Research Station, England	Merton 793 x Northern Spy	Semi-Vigorous	Resistant to collar rot and apple wooly aphid, tolerant to drier soil conditions
Merton 793	John Innes Research Institute with East Malling Research Station, England	M 2 x Northern Spy	Vigorous	Tolerant to apple replant disorder, Phytophthora and heavy clay soils, But susceptible to Fire blight
Northern Spy	East Bloomfield NewYork, USA	Chance Seedling	Semi-Vigorous	Moderately resistant to Phytophthora and heavy soils, Resistant to wooly apple aphid

PROMISING FUTURE ROOTSTOCKS CULTIVARS NEED TO BE INTRODUCED IN INDIA:

The following rootstocks cultivars (Table.2) need to be introduced in India to fulfil the demand and fulfill future needs of apple growers.

Table 2. Clonal rootstocks cultivars released in last 20 years from Cornell University, Ithaca, New York and Cornell Research Foundation, Ithaca, New York, US) (All rootstocks developed by planned crossing and hybridization

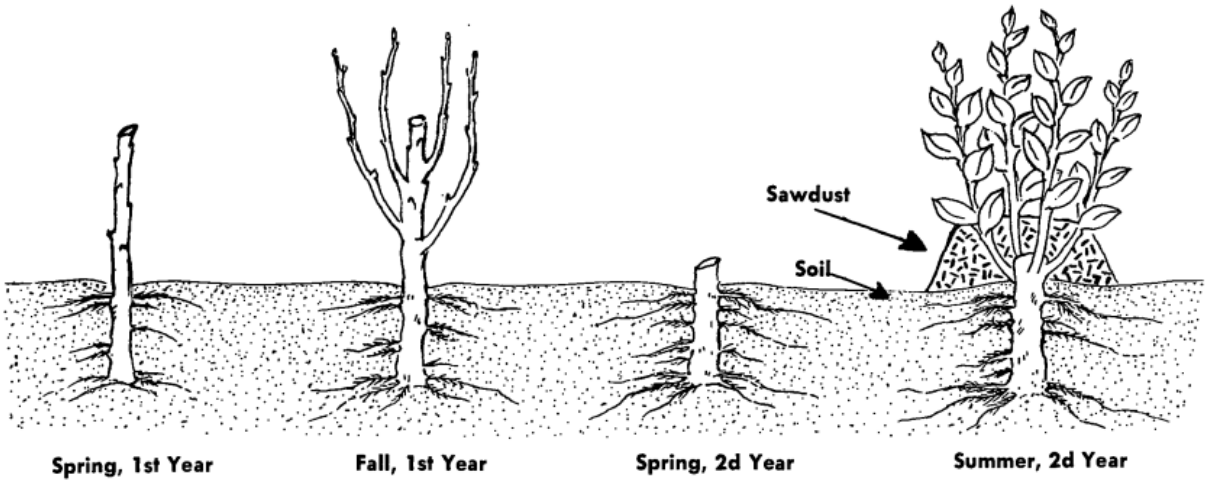
Name of Rootstock	Origin	Inventor	Characteristics	References
G11	Cornell Research Foundation,	James N. Cummins and Herbert S.Aldwinckle	Geneva 11 is a dwarfing apple rootstock that will directly challenge the 'Malling 26 rootstock. Tolerance towards crown and root rots and moderately resistant to fire blight.	Cummins *et al.*, (1999)

	Inc., Ithaca, N.Y.			
G16	Cornell Research Foundation, Inc., Ithaca, NY (US)	James N. Cummins; Herbert S. Aldwinckle	Geneva 16 is moderately susceptible to woolly aphids. Leaves and fruit of "Geneva 16" are immune to apple Scab (*Venturia in aequalis*)	Cummins *et al.*, (2002)
G.41	Cornell Research Foundation, Inc., Ithaca, NY (US)	James Cummins, Herbert Sanders Aldwinckle, Terence Lee Robinson, Gennaro Fazio	G.41 is less dwarfing than the super-dwarfing Malling 27 and more dwarfing than the non-dwarfing parent Robusta 5. Unlike Malling 27, G.41 is resistant to fire blight and precocious.	Cummins *et al.*, (2006)
G.935	Cornell Research Foundation, Inc., Ithaca, NY (US)	James Cummins, Herbert Sanders Aldwinckle, Terence Lee Robinson, Gennaro Fazio	G.935 is in the same dwarfing market class as Malling 7, it is distinguishable from Malling 7 because "G.935 is resistant to fire blight and precocious whereas Malling 7 is susceptible and non-precocious.	Cummins *et al.*, (2006)
G.202	Cornell Research Foundation, Inc., Ithaca, NY (US)	James Cummins, Herbert Sanders Aldwinckle, Terence Lee Robinson	G.202 is more yield efficient than M.26. Further, G.202 is resistant to fire blight, crown rot, and root rot, and immune to the woolly apple aphid, whereas M.26 are susceptible.	Cummins *et al.*, (2006)
G.210	Cornell University, Ithaca, Geneva NY (US)	James Cummins, Herbert Sanders Aldwinckle, Terence Lee Robinson, Gennaro Fazio	G.210 is in the same dwarfing market class as Malling 7, it is distinguishable from Malling 7 because G.210 is precocious and highly productive whereas Malling 7 is less pre cocious and less productive.	Cummins *et al.*, (2013)
G.214	Cornell University, Ithaca, Geneva, NY (US)	Gennaro Fazio; James Cummins; Herbert Sanders Aldwinckle; Terence Lee Robinson	G.214 is in the same dwarfing market class as Malling 9, it is distinguishable from Malling 9 because G.214 is resistant to fire blight whereas Malling 9 is susceptible.	Fazio *et al.*, (2013)
G.890	Cornell University, Ithaca, Geneva NY (US)	Cummins, Herbert Sanders Aldwinckle, Terence Lee Robinson, Gennaro Fazio	G.890 is in the same dwarfing market class as M7, and MM. 106 it is distinguishable from M7 and MM-106 because G.890 is resistant to fire blight whereas M7 and MM-106 are susceptible and also e it is tolerant to the biotic replant disease complex.	Cummins *et al.*, 2013
G.969	Cornell University, Ithaca, N.Y. (US)	James Cummins; Herbert Sanders Aldwinckle, Terence Lee Robinson, Gennaro Fazio	The apple tree rootstock G.969 is less dwarfing than Ottawa 3 and more dwarfing than the non-dwarfing parent Robusta 5' Resistant to fire blight (Erwinia amylovora) and crown rot (Phytophthora cactorum).	Cummins *et al.*, 2013

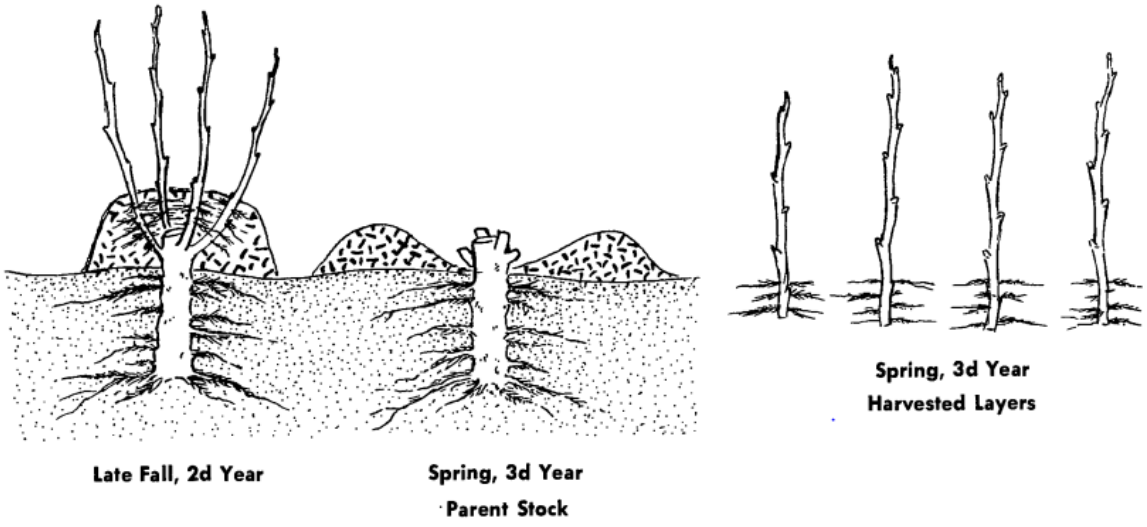
PROPAGATION OF CLONAL ROOTSTOCKS:

Through cuttings, mound layering (stooling) as well as micropropagation clonal rootstocks can be propagated in apples. Out of these above three methods initiation of roots by use of cuttings is still a very difficult task. One of the simplest and least expensive methods of vegetative multiplication of clonal rootstocks is by hardwood cuttings (Ercisli *et al.*, 2003) but are rarely utilized due to low success rate than mound layering. The rooting in clonal rootstock can also be enhanced with the application of plant growth regulators viz. IBA and growing conditions. Rooting is also affected by a variety of endogenous components including growth hormone balance as well as exogenous factors including humidity, air quality, and light conditions in the rooting environment (Hartmann *et al*., 2009). The most popular technique for multiplying apple rootstocks among these is mound layering (Webster, 1995). Now a days the propagation of apple rootstocks is being carried out through micropropagation using meristems tissue, leaves as well as dormant bud. The standardization of micropropagation practices using various ex-plants is need of the hour to do successful tissue culture and growth of seedlings .

Fig.2: Propagation of clonal rootstocks through cuttings



(Fig. 3a)



(Fig.3b)

Fig.3a & 3b : Visual description of the steps involved in Mound layering (stooling) for the propagation of apple rootstocks

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Fig. 4: Propagation of clonal rootstocks cv. M 9 through micropropagation

CONCLUSION

Modern orchard management systems must integrate a variety of production practices in order to increase fruit yield, prolong tree life and boost management effectiveness. Among the various components, the use of desired rootstock is very crucial. The popularity of high-density apple plantations has greatly raised the need for clonal apple rootstocks in recent years. Numerous high-density plantation demonstrations have been effective and orchardists are now convinced of the advantages of clonal rootstocks in high-density apple orchard plantations. Importing thousands of clonal rootstocks from foreign countries can fulfill the demand of growers within a short period of time whereas it can lead to introduction of new diseases along with it, so to bring long term sustainability in fulfilling the demand of clonal rootstocks, its better to be self-sufficient. The raising demand of clonal rootstocks for the apple growers of Himalayan states of India can be fulfilled through establishment of a higher number of certified nurseries and tissue culture laboratories through public as well as private organizations across various locations of these Himalayan states of India.

REFRENCES

Ananda S A. 1999. New promising rootstocks and propagation techniques for temperate fruits. Paper presented in the National Seminar on Himalayan Horticulture Hort-Vision 2020, held in Shimla on 2-4 December- 1999.

Cummins J and Aldwinckle H S. 1999. Apple tree rootstock named 'G.11' (US Patent No. USPP11070.P2) USPP11070.pdf

Cummins J and Aldwinckle H S. 2002. Apple tree rootstock named 'G.16' (US Patent No. USPP12443.P2) USPP12443.pdf

Cummins J, Aldwinckle H S and Robinson T L. 2006. Apple tree rootstock named 'G.202' (US Patent No. US20060130195.P1) US20060130195P1.pdf

Cummins J, Aldwinckle H S, Robinson T L and Gennaro F. 2006. Apple tree rootstock named 'G.41' (US Patent No. USPP17139.P3) USPP17139.pdf

Cummins J, Aldwinckle H S, Robinson T L and Gennaro F. 2006. Apple tree rootstock named 'G.935' (US Patent No. USPP17063.P3) USPP17063.pdf

Cummins J, Aldwinckle H S, Robinson T L and Gennaro F. 2013. Apple tree rootstock named 'G.969' (US Patent No. USPP24073.P3) USPP24073.pdf

Cummins J, Aldwinckle H S, Robinson T L and Gennaro F. 2013. Apple tree rootstock named 'G.210' (US Patent No. USPP23337.P3) USPP23337.pdf

Cummins J, Aldwinckle H S, Robinson T L and Gennaro F. 2013. Apple tree rootstock named 'G.890' (US Patent No. USPP23327.P3) USPP23327.pdf

Demirkeser T H, Kaplankiran M, Toplu C and Yildiz E. 2009. Yield and fruit quality performance of Nova and Robinson mandarins on three rootstocks in Eastern Mediterranean. *African Journal of Agricultural Research* **4(4)**:262-268.

Dolgov S V and Hanke M V. 2006. Transgenic fruit tree rootstocks. *In Tree Transgenesis*. Springer, Berlin, Heidelberg. 335-50p.

Ercisli S, Esitken A, Cangi R and Sahin F. 2003. Adventitous root formation of kiwifruit in relation to sampling date, IBA and *Agrobacterium rubi* inoculation. *Plant Growth Regulators* **41**:133-37.

Gennaro F, Cummins J, Aldwinckle H S and Robinson T L. 2013. Apple tree rootstock named 'G.214' (US Patent No. USPP23516.P3) USPP23516.pdf

Hartmann H T, Kester D E, Fred T D, Robert L and Geneve R L. 2009. *Plant Propagation: Principles and Practices*, 7 edition,Prentice, Hall, New Delhi 880 p.

Howard, B. H. 1997. Propagation. In (R. C. Rom and R. F. Carlson Ed) Rootstock for fruit crops. John Wiley and Sons. New York pp. 29-77.

Webster A D. 1995. Temperate fruit tree rootstock propagation. *New Zealand Journal of Crop and Horticultural Science* **23(4):** 355-372.

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