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POPULAR ARTICLE

CLONAL ROOTSTOCKS IN ENHANCING PRODUCTIVITY OF APPLE UNDER NORTH-WESTERN HIMALAYAN REGIONS OF INDIA

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ABSTRACT

Clonal rootstocks are produced through vegetative propagation, account for the better light interception, have a high level of resilience to biotic and abiotic stress, yield early crops, and have a great deal of economic viability. However, the overall productivity of apple in India is quite low, as In India till date usage of clonal rootstock is at very small scale when compared to major apple-growing countries like Europe and America, where about 80 % of its apple cultivation is done on clonal rootstocks. In India high, density plantation is a new concept and the use of clonal rootstocks and harnessing their potential in terms of pest and disease resistance, precocity, and the production of high-quality fruit will directly contribute to improving apple productivity in the years to come.

INTRODUCTION

The apple is one of the most significant fruit crops cultivated in temperate areas of the world between 30 ˚ and 50 ˚ latitudes in both hemispheres (Westwood, 1993). In India, the apple cultivation is mainly confined to the North Western Indian Himalayan regions. However, these areas do not fall under the world's temperate zone, but due to high-altitude snowfall occurrence in these areas led to the prevailing temperate climate of the region which helps in meeting the chilling requirements of the crop. In India, commercial cultivation is confined mainly to the states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand, and some parts of Sikkim, Arunachal Pradesh, Nagaland and Meghalaya with productivity of 8.8 MT/ha (Anonymous, 2020) which is quite low when compared with major apple growing countries

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like America and European countries, having productivity upto 50 to 60 MT/ha. The one of the main factor is that most of the apple orchards in India are still on seedling rootstocks and are planted in low densities, while in other major apple-growing regions (Europe and America), apple plantations are in high density plantations on clonal rootstocks (Table 1). In addition, the huge canopy area and improper management of the canopy in low density plantations results in inadequate light penetration and distribution into the canopy and produces fruits of poor quality.

Table 1. Status of use of clonal rootstocks in major apple producing countries

Country	Dwarf rootstocks	Per cent use of dwarf clonal rootstocks
China	M. 9, M. 26, SH. series, GM. 256 etc.	12 %
USA	M. 9, B. 9, M .26, MM. 106, MM. 111, G.16 etc.	50-55 %
Poland	M. 9–T337, B. 9, P Series, etc.	>80%
Italy	M. 9, M. 26, M.4, M.2, MM. 106 etc.	~90 %
Russia	B. 9, B. 118, B. 54-146 etc.	No data obtained
France	M. 9, M. 2, M. 5, M. 4, M. 26, CG. 30 etc.	~90 %
UK	MM. 106, M. 9, M. 26, M. 27, MM. 111, M. 4, M.25 etc.	~90%
Netherlands	M.9 T337, M. 1, M. 2 etc.	>70 %
Germany	M. 9, M. 4, M. 5, M. 7 etc.	~90 %
Japan	JM series, M. 26, MM. 106, M. 9, M. 7, MM. 111 etc.	>75 %

Note: M – Malling series (UK); CG or G - Geneva series (USA); P – Poland series (Poland); B – Budagovsky (Russia); JM series – Japan and GM series – China; SH – Shao series (China) (Source: Wang et al. 2019)

CLONAL ROOTSTOCKS FOR APPLE

Rootstocks produced through vegetative propagation known as clonal rootstocks, on the other hand, ensure homogenous trees with identical cropping properties and, in the case of apples, a variety of size-controlling clonal rootstocks (dwarf to vigorous) are available (Table 2). The genetically dwarf to semi-dwarf clonal rootstocks in apple, however, offer a great deal of potential for close planting, but the semi-vigorous and vigorous clonal rootstocks can also

be a valuable source for enhancing productivity where high density plantation is not practical. Advantages of using clonal rootstocks in apple:

- ✓ Uniformity
- ✓ Tree size control
- ✓ Precocity and Productivity
- ✓ Better nutrient uptake and nutrient use efficiency
- ✓ Improved fruit quality
- ✓ Resistance to some pest and diseases
- ✓ Tolerance to abiotic stresses like drought, cold

Table 2. Some promising clonal rootstocks for apple under Indian conditions

Rootstock	Parentage	Origin	Features
Dwarf			
M. 9 ('Jaune de Metz')	Chance seedling found in France	Reselected at HRI- East Malling, UK	✓ Most popular dwarfing rootstock ✓ Induces excellent yield precocity and efficiency ✓ Poor anchorage ✓ Can be us as interstock
M. 9 EMLA	Sub-clone of M. 9	UK	✓ The first M.9 sub-clone freed of all known major and latent viruses
M. 9 T337	Sub-clone of M. 9	The Netherlands	✓ Most often used of the virus-free sub-clones produced by NAKB ✓ Brings good productivity, good fruit size and good colour
B. 9	M. 8 × Red Standard	Michurinsk College, Russia	✓ Vigour between M. 9 and M. 26 ✓ Good yield efficiency, ✓ Anchorage slightly better than M 9 ✓ Winter hardy ✓ Greater resistance to crown rot
G. 41	M. 27 × Robusta 5	Cornell University,	✓ Vigour similar to M 9 T337; ✓ Very resistant to fire blight;

		Ithaca, NY (US)	✓ Tolerant to crown and root rot
Semi-dwarf			
MM. 106	Northern Spy × M. 1	East Malling, UK	✓ 60% the size of trees on apple seedling ✓ High yield efficiency ✓ Good anchorage ✓ Resistant to woolly apple aphid but susceptible to collar and crown rot
M. 7	Not known	East Malling, UK	✓ Tree 55 to 65% the size of apple seedling ✓ Similar to slightly more invigorating than MM. 106 ✓ Field tolerant to collar rot and fire blight
M. 116	MM. 106 × M. 27	HRI-East Malling, UK	✓ Resistant to collar rot, mildew and specific apple replant disease
Semi-vigorous			
MM. 111	Northern Spy × M. 1	East Malling UK	✓ Slightly more invigorating than MM. 106 ✓ Good anchorage ✓ Resistant to woolly apple aphid ✓ Easy to propagate ✓ Most tolerant of droughty soil conditions
EMLA 111	Northern Spy × Merton 793 [Northern Spy and M.2(Doucin)]	UK	✓ Virus free ✓ Semi-vigorous ✓ Two-thirds the size of a standard tree ✓ Anchored and tolerant of drought conditions
Vigorous			

Merton (MI) 793	M. 2 × Northern Spy	John Innes Institute, UK	✓ Tree slightly smaller than apple seedling ✓ Resistant to woolly apple aphid ✓ Very suitable for replant apple problem

(M –Malling; MM – Malling Merton; B – Budagovsky; EMLA – East Malling Long Ashton; G – Geneva; MI – Merton Immune)

REQUIREMENTS FOR USE OF CLONAL ROOTSTOCKS

1. Dwarf and semi-dwarf Rootstock (M. 9, M. 9 T337, Bud. 9, G. 41, M. 116, M. 7)

- ✓ Deep soil, assured irrigation and flat land
- ✓ Support system for dwarf rootstocks

2. Semi- vigorous and vigorous rootstocks (MM.111, EMLA 111 and Merton 793)

- ✓ Deep soil and land with gentle slope

PROPAGATION OF CLONAL ROOTSTOCKS

Clonal rootstocks are usually propagated by vegetative means viz., mound layering, cuttings and through micro-propagation of clonal rootstocks in apple, which involve inducing part of the rootstock stem to produce adventitious roots while still attached to the mother plant (Webster, 1995). Cocopeat and sawdust are often used as a rooting medium for earthing up stool layer beds (Dvin et.al., 2011; Patial 2018). In particular, the application of plant growth regulators, particularly synthetic auxin (IBA - a rooting hormone) at concentrations of 2500–3000 ppm in apple clonal rootstock propagation through asexual means, plays a crucial role in the establishment of roots and the development of a fibrous root system (Hartmann et.al., 2015). The growth medium and auxin concentration act together synergistically to promote vegetative growth and responses in rooting by providing ambient conditions such as adequate moisture, fast uptake of nutrients, maintenance of root zone temperature, and pH.

SCOPE

In India, high density planting, which permits for more trees per hectare (2000–4000 trees), is a novel concept that has just been around for the past 5–7 years. In comparison to traditional planting methods, high density planting has a lot of potential for increasing fruit yield and productivity even while enhancing precocity. The main requirement for high density orcharding

is the control of tree growth. The utilization of dwarfing rootstocks accounts for efficient high density orcharding by controlling tree size by reducing scion shoot growth (Parry and Rogers, 1972). Utilizing clonal rootstocks has become more common as a strategy to get around production and productivity obstacles (soil, climate, and pests), as well as to influence market demand (fresh or processed), shorten the juvenility phase, and increase fruit quality (Demirkeser et al., 2009). Furthermore, especially when planted in dense plantings, these clonal rootstocks are crucial for maintaining a proper canopy in order to encourage precocity, quality, and productivity (Table 3).

Table 3. Recommended stionic combination, planting densities and training system in high density planting in apple

Sr. No.	Clonal rootstocks (Type)	Planting Distance (row to row x plant to plant)	Training system	Number of trees
1.	Dwarfing rootstocks EMLA 9/M. 9/M. 9 T337 Geneva 41/Bud. 9 (Size: 25 % of standard tree)	2.5 m x 1.0 or 1.5 m (Standard cultivar)	Tall Spindle Vertical Axis	4000 or 2666
2.	Semi-Dwarfing rootstocks EMLA 7, M. 7, EMLA 106/MM 106, M 116 (Size: 45 – 60 % of standard tree)	2.5 m x 1.0 or 1.5 m (Spur cultivars) Or 3.0 m x 2.5 m (Standard cultivar)	Tall Spindle Vertical Axis Vertical axis	4000 or 2666 1333
3.	Semi-vigorous MM.111	3.0 m x 2.5 m (Spur cultivar)	Vertical axis	1333

Note: Optimal tree spacing depends on rootstock vigour, scion vigour and soil fertility

ACHIEVEMENTS USING CLONAL ROOTSTOCKS UNDER HIGH DENSITY PLANTATION IN INDIA

The several clonal rootstocks, such as M 9, M 7, MM 106, MM 111, and Merton 793, have been evaluated and shown to be promising for the climatic conditions, especially in

Himachal Pradesh. However, under the World Bank-funded HP-HDP project in Himachal Pradesh, new clonal rootstocks have recently been introduced, including M 116, EMLA 111, M 9 T337, EMLA 106, EMLA 7, Bud series, and Geneva series. These rootstocks have specific resistance to biotic and abiotic stress, which will account for increasing apple productivity in the coming years. Some achievements have been made with respect to clonal rootstock usage under high density plantation. Studies conducted at Mashobra on sixteen- years-old trees of Vance Delicious grafted on MM 106 and planted at a density of 2222 trees/ha produced as high as 75 MT/ha (Anonymous, 1996). The concept of high density planting in apple has been successfully demonstrated at Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh), India and was recommended for commercial adoption for the growers (Dhiman et al., 2018; Ladon et al., 2022). On the basis of long term studies, they obtained highest production of 24 MT/ha (Dhiman et al., 2018) after fourth year of planting and 41.52 Mt/ha (Ladon et al., 2022) after seventh year of planting at a spacing of 2.5 m x 1.0 m (4000 trees/ha) in cv. Jeromine on M 9 rootstocks and trained with tall spindle system of training. Similarly, Bhatia and Kumar (2009) while studying the performance of new apple cultivars, 'Red Fuji' and 'Scarlet Gala' on different rootstocks under high density plantation recorded highest yield of 16.9 t/ha and 15.6 t/ha, respectively with EMLA 111 clonal rootstock at a planting density of 1111 trees/ha (3.0 x 3.0 m). Under Kashmir conditions, apple cultivars such as Golden Delicious, Vista Bela and Mollies Delicious grafted on M 9 rootstock with a planting density of 2222 trees/ha (1.5 m x 3.0 m) and trained to central leader system exhibited significantly higher yields of 47.40, 42.50 and 33.50 MT/ha, respectively after 8 years of plantation (CITH, 2011). Bhat et al. (2011) recorded better fruit quality and higher productivity under high density plantation of Starkrimson/MM 106 with a higher yield efficiency of 0.36-0.39 kg/cm^2 in comparison to 0.25-0.28 kg/cm^2 in low density plantation.

CONCLUSION

Modern intensive orchards rely on dwarfing clonal rootstocks which are genetically designed to optimize maximum light interception, produce early crops and great economic viability. High density planting is a novel concept in India that considers for the exclusive use of clonal rootstocks and the utmost use of their capabilities in terms of pest and disease resistance, precocity, and the production of high-quality fruit. These traits will directly improve apple productivity in the coming years.

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