New Apple Rootstock Alternatives for the Southern Hemisphere

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Enhancing apple productive efficiency and improving fruit quality depend greatly on new growth-controlling rootstocks. Recognition of this is evident from the high priority placed on the development of new rootstocks in almost all pipfruit industries worldwide. The New Zealand apple industry has traditionally used semi-intensive production systems with the intermediate vigor rootstocks MM.106 and M.793. The adoption of intensive planting systems incorporating dwarfing rootstocks has been slower in New Zealand than in European and other Northern Hemisphere regions.

The slower adoption of more intensive orchard systems can be attributed to high yields, by world standards obtained from semi-intensive production systems under New Zealand conditions, a lack of availability of dwarfing rootstocks, concerns over pest and disease resistance of currently available dwarfing rootstocks and a lack of experience (Palmer, 1999). However, New Zealand growers have begun to plant more intensively to maximize early fruit production, long-term orchard yields and fruit quality using M.9, M.26 and Mark rootstocks in new plantings.

HortResearch established a new series of rootstock evaluation trials for apples in several regions of New Zealand in the early 1990s to evaluate the productive efficiency and fruit quality of new rootstocks. This paper describes the results from the rootstock evaluation trial established in 1994 in Hawke's Bay, New Zealand.

TABLE 1

Apple rootstock trial planted in 1994, Hawke's Bay, NZ.

Rootstock clones	Origin
AR.86-1-20	East Malling, UK
AR.86-1-25	East Malling, UK
AR.10-3-2	East Malling, UK
CG.202 (CG.4202)[a]	Cornell University, New York, USA
CG.210 (CG.6210)[a]	Cornell University, New York, USA
MM.106	East Malling, UK
M.26	East Malling, UK

[a]Numbers within the brackets refers to new numbering system adopted for the same rootstocks.

NEW ZEALAND'S ROOTSTOCK EVALUATION PROGRAM

In addition to enhancement of productive efficiency and fruit quality, new rootstocks that provide resistance to a range of pests and diseases will offer the best alternatives for the orchardist. This is particularly important with a worldwide shift toward integrated fruit production systems and the reduced use of pesticides in fruit production. In the early part of the last century, woolly apple aphid caused serious damage to apple trees in the Southern Hemisphere until the introduction of the resistant rootstocks Northern Spy, followed later by MM.106 and M.793 (Palmer, 1999).

The rootstocks that are currently available in the Southern Hemisphere for intensive production systems (M.9, M.26 and Mark) do not have resistance to woolly apple aphid. All new rootstocks introduced to New Zealand's evaluation program are tested and selected for woolly apple aphid resistance.

Phytophthora crown rots and fire blight are diseases that can severely affect tree performance and ultimately result in tree death in the Southern Hemisphere. In addition to woolly apple aphid, *phytophthora* and fire blight resistance are further pest and disease criteria for rootstocks in the evaluation program. The move toward more intensive production systems and the introduction of new cultivars and rootstocks also mean many orchards are being replanted into old apple orchard soils. With the redevelopment of older orchards, replant problems are likely to be encountered

. . . growth retardation induced by replant soil may be considerably ameliorated by semi-dwarfing compared to intermediate vigor rootstocks.

and therefore the performance of new rootstocks in replant situations is also assessed.

Three regional trial sites located at HortResearch's research orchards in Hawke's Bay, Nelson and Central Otago are used to evaluate new rootstocks. These are the three major regions of apple production in New Zealand.

THE HAWKE'S BAY ROOTSTOCK TRIAL

In the spring of 1994, 1-year-old Royal Gala trees were planted at HortResearch, Hawke's Bay Research Center. The trial site covered equal areas of new soil (where pipfruit had not previously been planted) and old apple orchard soil to allow evaluation of the rootstocks under both new soil and replant conditions. Replant soil was not fumigated to monitor rootstock adaptation to replant conditions. Trees were trained as the central leader slender pyramid system and were planted in a split plot design with soil status as the main plot and rootstock as the subplot.

The trial included five rootstocks for evaluation against New Zealand industry standards of MM.106 and M.26 (Table 1). Trees were grafted on rootstock clones thought to be of intermediate and semi-dwarfing vigor with improved pest and disease resistance characteristics. The AR series rootstocks which originate from Horticulture Research International (HRI), East Malling, have been reported to have tolerance to apple replant disease and greater resistance to *phytophthora* than MM.106 and M.26 (Webster et al., 1986). The CG series rootstocks have been reported to be resistant to fire blight and *phytophthora* (Robinson et al., 1997). At the time of planting the CG rootstocks were designated CG.202 and CG.210. Subsequently these rootstocks have been redesignated as CG.4202 and CG.6210. For the purposes of this article, the rootstocks are referred to by their original numbers as it is under these names that the rootstocks have become familiar to the New Zealand industry. All these new rootstock clones under evaluation are resistant to woolly apple aphid.

Tree Growth and Vigor

After five seasons, the rootstocks can be grouped into three distinct vigor classes. Trees on AR.86-1-25 and AR.86-1-20 rootstocks have grown to a comparable size to the intermediate vigor of MM.106 (Table 2). Tree vigor on CG.210 and CG.202 is equivalent to the smaller tree size of the semi-dwarf M.26. Tree vigor of trees on AR.10-3-2 has been intermediate between these two size classes and may be termed small-intermediate. These size classes were determined by differences in trunk cross-sectional area (Fig. 1) and canopy volume (Table 2).

Considerable differences in rootstock growth responses to replant soil conditions have been observed after 5 years of growth (Table 2, Fig. 1). Generally, replant soils had a greater effect on tree growth on the more vigorous rootstocks. Tree size (canopy volume) was reduced by 30 to 40% for the intermediate vigor rootstocks (MM.106, AR.86-1-25, AR.86-1-20), by 36% for the small-intermediate (AR.10-3-2) and by 10 to 25% for the semi-dwarfing rootstocks (M.26, CG.202, CG.210) when grown on replant soil compared to new soil.

Tree Productivity and Fruit Quality

After five seasons (the third crop), there were substantial differences in the cumulative yield per tree between rootstocks and

TABLE 2

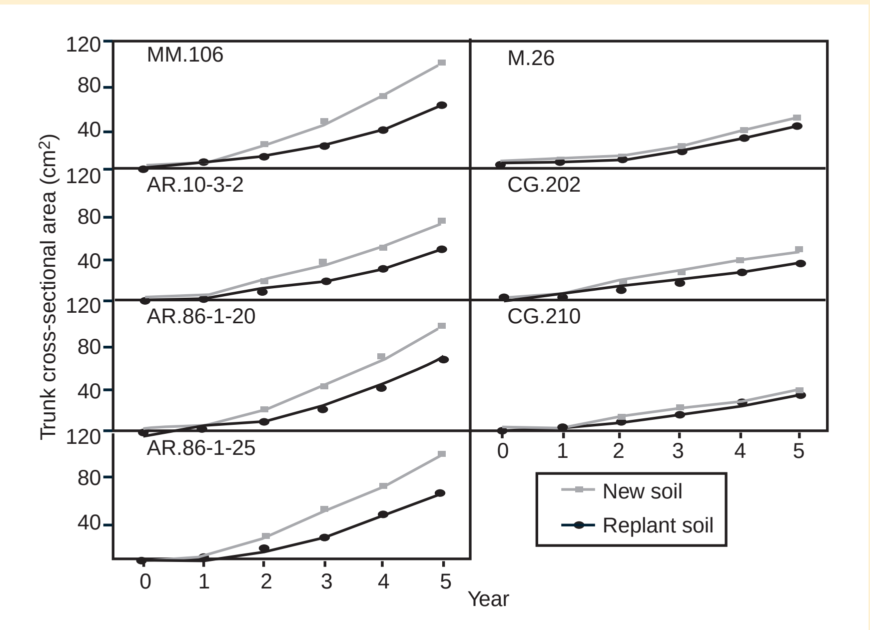
The effect of rootstock and soil on Royal Gala tree canopy volume and height after five growing seasons.

Rootstock		Tree canopy volume (m^3) new soil	Tree canopy volume (m^3) replant soil	Tree height (m) new soil	Tree height (m) replant soil
AR.86-1-25		15.0	9.0	5.1	4.7
AR.86-1-20		15.6	10.9	5.4	4.9
MM.106		14.8	9.3	5.4	4.7
AR.10-3-2		10.8	6.9	4.7	4.3
CG.210 (CG.6210)		5.8	5.2	3.7	3.7
CG.202 (CG.4202)		6.1	4.6	3.9	3.4
M.26		5.7	4.7	3.8	3.4
P	rootstock	0.001		0.001	
	soil	0.001		0.001	
	rootstock x soil	0.01		ns	
SED	rootstock	0.92 (0.65)		0.17 (0.12)	
	soil	0.43		0.08	
	rootstock x soil	1.30 (0.92)		0.24 (0.17)	

Numbers in brackets refer to SED comparisons with MM.106 and M.26 which have a higher number of observations.

FIGURE 1

The influence of rootstock and soil on the trunk cross-sectional area growth of Royal Gala after five growing seasons.



soil conditions (Table 3). The intermediate vigor rootstocks produced the highest cumulative yields per tree on new soil.

Although the cumulative yield of trees grown on the semi-dwarf rootstocks in new soil was lower than the intermediate vigor rootstocks by 20%, the canopy volume was smaller by 60%. Under replant soil conditions, the reverse trend occurred with semi-dwarf rootstocks producing substantially higher cumulative yields compared to the intermediate vigor rootstocks. This was despite the semi-dwarf rootstocks having smaller canopy volumes.

Rootstocks were also compared using cumulative yield efficiency which normalizes for differences in tree size, with a higher efficiency referring to a higher yield per unit of tree size. The semi-dwarf rootstocks produced the highest yield per unit of trunk cross-sectional area on both new and replant soil, with CG.210 producing the highest efficiency overall (Table 3). The cumulative yield efficiency of all rootstocks was reduced by replant soil. AR.10-3-2 performed well on new soil with a higher cumulative yield efficiency than the intermediate vigor rootstocks. However on replant soil, yield efficiency was reduced to be comparable to that of the intermediate vigor rootstocks. Cumulative yield efficiency of the three intermediate vigor rootstocks was similar on new soil but MM.106 appeared to be more efficient to replant soil than the AR clones.

Mean fruit weight was affected by rootstock although this was influenced by differences in crop density between rootstocks (Fig. 2). Significantly the semi-dwarf rootstocks have produced large fruit size at higher crop densities than intermediate vigor rootstocks. We plan to investigate the influence of rootstock and soil type on fruit size in the next fruit season by setting a range of crop densities on the trees to better describe the relationship between crop density and fruit size for the rootstocks under evaluation. Fruit packout to date has not been influenced by rootstock or soil condition. In the fifth season after planting, trees achieved on average a packout of 85% for exportable fruit (ENZAFRUIT New Zealand [International] export grade standards).

TABLE 3

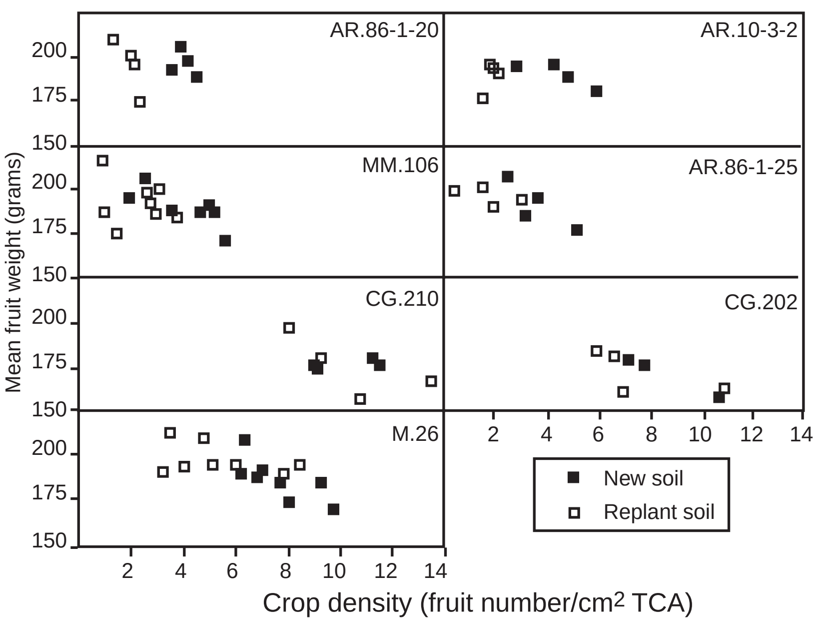
The effect of rootstock and soil on Royal Gala apple cumulative yield and cumulative yield efficiency after five growing seasons.

		Cumulative yields (kg/tree)		Cumulative yields efficiency(g/cm^2)	
Rootstock		**new soil**	**replant soil**	**new soil**	**replant soil**
AR.86-1-25		127	47	1256	737
AR.86-1-20		155	45	1578	675
MM.106		126	58	1306	976
AR.10-3-2		116	34	1639	709
CG.210 (CG.6210)		105	92	2858	2726
CG.202 (CG.4202)		119	67	2634	2158
M.26		97	61	2428	1812
P	rootstock	ns		0.001	
	soil	0.001		0.001	
	rootstock x soil	0.01		ns	
SED	rootstock	11.4 (8.1)		195.5 (138.3)	
	soil	5.4		92.2	
	rootstock x soil	16.2 (11.4)		276.5 (195.5)	

Numbers in brackets refer to SED comparisons with MM.106 and M.26 which have a higher number of observations.

FIGURE 2

The relationship between crop density and mean fruit weight for rootstock during the fifth growing season.



CONCLUSIONS

After five seasons, the rootstocks have been separated into three distinct vigor classes: intermediate (MM.106, AR.86-1-25, AR.86-1-20), small-intermediate (AR.10-3-2) and semi-dwarf (M.26, CG.210, CG.202). A greater selection of rootstocks over a range of vigor ensures that Southern Hemisphere producers can improve orchard performance when matching rootstock to soil, site or scion cultivar. The information on comparative rootstock responses in both new and replant soils clearly shows growth retardation induced by replant soil may be considerably ameliorated by semi-dwarfing compared to intermediate vigor rootstocks.

The semi-dwarf rootstocks have also produced significantly higher yields per unit of tree size on both soil types compared to the intermediate vigor rootstocks while still producing very good fruit size. To date, CG.210 has been the most productive rootstock in both new and replant soil. MM.106 appears to be more tolerant to replant soil than the AR selections under the replant conditions in the Hawke's Bay trial.

Total canopy development and productivity potential will not be complete until these trees are 7 to 8 years old, which will then provide a comprehensive comparison. These new rootstocks, particularly those of semi-dwarfing vigor, exhibit enhanced productive efficiencies and fruit quality, while improving the range of resistance to important Southern Hemisphere pests and diseases.

ACKNOWLEDGMENTS

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