Cornell-Geneva Rootstocks in New Zealand Apple Production Systems for the 21st Century

D.S Tustin, J.W. Palmer and M.D White

HortResearch, New Zealand

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HISTORICAL CONTEXT

Apple production in New Zealand has had a long dependence on the use of pest- and disease-resistant rootstocks. Since the 1920s, woolly apple aphid (WAA) resistant rootstocks, initially Northern Spy, later replaced by MM.106 and Merton 793, have been extensively used as an important part of integrated orchard management. Merton 793 rootstock has been very important in regions with soils with high incidence of Phytophthora root rot. Since the mid-1980s, increasing interest in intensive planting systems caused a shift in rootstock preference toward the dwarfing rootstocks M.26, M.9 and Mark, all which lacked WAA resistance and which were highly susceptible to fire blight. Researchers considered that future intensive integrated apple production under the benign NZ maritime climate would require new rootstocks combining the advantages of dwarfing with enhanced pest and disease resistance to replace the classical M.9 and M.26 dwarf rootstocks.

The search for new rootstocks with these combined features quickly identified the Cornell-Geneva apple rootstock breeding program as a major program with breeding objectives closely aligned to the New Zealand requirements. Initial contacts began in 1986 when Dr. Stuart Tustin visited with Dr. Jim Cummins and together evaluated advanced breeding selections in field trials at Geneva for suitability for the New Zealand industry needs. A test and evaluation research collaboration developed from this visit and the first advanced selections from the Cornell-Geneva program were imported into quarantine in New Zealand in 1987.

These clones were established as stoolbeds on release from quarantine and produced the first nursery trees for rootstock evaluation trials. Three clones were selected for initial testing based on continuing evaluations by Dr. Cummins at Geneva. The first trial that included CG rootstocks was established in 1994 in Hawkes Bay region.

In 1990, Andy McGrath of McGrath Nurseries undertook negotiations with Cornell which established the exclusive New Zealand rights for commercial development of rootstocks from the program. Collaboration with HortResearch enabled McGrath Nurseries to undertake a phased commercialization plan, using ongoing trial results arising from both New Zealand and Geneva evaluations.

The CG rootstock breeding program with emphasis on resistances to major economic pests and diseases is one valuable source of potential new rootstocks well adapted for reduced input, sustainable production systems.

THE NEW ZEALAND CG APPLE ROOTSTOCK EVALUATION TRIALS

Of the CG rootstock clones first imported to NZ, CG.202 and CG.210 were selected as highest priority for evaluation based on Geneva results indicating some dwarfing characteristics and resistance to WAA, fire blight and phytophthora crown rot.

In 1994, their first evaluation began within a rootstock trial planted in Hawkes Bay to evaluate performance of new disease-resistant rootstocks from USA and UK, grown in new and replant soils. The trial was planted in soil newly planted in apples and in unfumigated replant soil, because future plantings will increasingly include replacing old orchards with new, more intensive planting systems. The trial included three new resistant rootstocks from East Malling, UK. Because of the anticipated vigor range, the rootstocks used as standards were MM.106 and M.26.

Annual growth in trunk cross-sectional area and mature tree size of Royal Gala apple grown on CG.202 and CG.210 were very similar to Royal Gala grown on M.26 rootstock (Fig. 1, Table 1). CG.202 appeared to produce slightly more vigorous trees when grown in new soil but similar tree size to M.26 in replant soil. Both CG.210 and M.26 showed very little decline in tree size when growth was compared in new and replant soil, whereas there was some reduction in tree size with CG.202 grown in replant soil conditions.

Productivity from mature, 8-year-old trees on CG.202, CG.210 and M.26 was proportional to tree canopy size when growing in new soil. However the productivity of trees on CG.202 and M.26 was depressed when grown in replant soil. Trees on CG.210 did not show the same drop in productivity and appeared most tolerant

TABLE 1

Trunk cross-sectional area, canopy size and tree height of Royal Gala apple trees after eight years of growth on rootstocks planted in new or untreated replant soil.

	Trunk cross-sectional area (cm^2)		Canopy volume (m^3)		Tree height (m)	
Rootstock	New	Replant	New	Replant	New	Replant
CG.202	84.6	58.9	7.8	3.9	4.3	3.6
CG.210	64.7	64.8	4.4	4.7	3.5	4.0
M.26	70.4	66.7	4.9	4.6	3.7	3.5
AR 10-3-2	125.2	104.9	10.5	10.6	4.8	4.8
AR86-1-20	177.7	142.8	14.0	13.9	5.2	5.2
AR86-1-25	185.4	132.6	14.8	12.8	5.1	5.2
MM.106	175.2	121.2	13.9	11.1	5.2	4.7
Significance						
Rootstock	P<0.001		P<0.001		P<0.001	
Soil	P<0.001		P<0.05		NS	
Rootstock X Soil	P<0.001		NS		NS	

of replant soil. Most of the differences in mean fruit weight among rootstocks appeared to be associated with differences in crop load, although fruit size from M.26 was generally larger. However mean fruit size from CG.202 and CG.210 was in a similar range as fruit from trees on MM.106 rootstock (Table 2).

After eight years, cumulative yield and cumulative yield efficiency of trees on CG.202 and CG.210 rootstocks were equivalent to trees on M.26 rootstock under new soil conditions. However yield efficiency of the two CG rootstocks was superior to M.26 in replant soils. These results provided a strong indication of the potential of CG.202 and CG.210 as highly productive, semi-dwarfing rootstocks well adapted for use on replant soils.

TABLE 2

Yield, fruit number per tree and mean fruit weight from mature Royal Gala apple trees in their eighth year, growing on rootstocks planted in new or untreated replant soil.

	Yield per tree (kg)		Fruit number per tree		Mean fruit weight	
Rootstock	**New**	**Replant**	**New**	**Replant**	**New**	**Replant**
CG.202	75	50	448	280	168	178
CG.210	55	63	321	370	173	172
M.26	65	44	349	242	186	184
AR10-3-2	83	63	512	392	164	161
AR86-1-20	114	89	663	508	173	174
AR86-1-25	116	86	698	509	168	169
MM.106	104	82	609	480	171	170
Significance						
Rootstock	P<0.001		P<0.001		P<0.001	
Soil	P<0.001		P<0.001		NS	
Rootstock X Soil	NS		NS		NS	

TABLE 3

Cumulative yield and cumulative yield efficiency of 8-year-old Royal Gala apple trees on rootstocks planted in new or untreated replant soil.

	Cumulative yield[1] (kg/tree)		Cumulative yield efficiency[2] (g/cm^2)	
Rootstock	**New**	**Replant**	**New**	**Replant**
CG.202	354	240	4244	4076
CG.210	304	288	4712	4435
M.26	302	226	4423	3432
AR10-3-2	410	243	3243	2336
AR86-1-20	558	334	3145	2331
AR86-1-25	509	306	2741	2285
MM.106	500	324	2897	2715
Significance				
Rootstock	P<0.001		P<0.001	
Soil	P<0.001		P<0.001	
Rootstock X Soil	P<0.05		NS	

[1]Cumulative yield is mean yield per tree cumulated over eight seasons.
[2]Cumulative yield efficiency is accumulated yield/TCA at eight years of age.

TABLE 4

Effect of cultivar and rootstock on TCA (cm^2) after five growing seasons in Nelson.

Rootstock	Royal Gala	Sciros	Rootstock mean
CG.202	43.3	47.3	45.3
CG.210	40.7	32.8	36.8
M.26	48.9	45.2	47.1
EMLA.26	52.7	43.8	48.2
Cultivar mean	46.4	42.3	

Numbers sharing the same letter in rootstock mean column are not significantly different at 5% level, LSD=4.10.

TABLE 5

Effect of cultivar and rootstock on accumulated yield (kg) per tree up to the fifth growing season in Nelson.

Rootstock	Royal Gala	Sciros	Rootstock mean
CG.202	174	134	154
CG.210	149	115	132
M.26	146	107	126
EMLA.26	155	110	133
Cultivar mean	156	116	

Numbers sharing the same letter in rootstock mean column are not significantly different at 5% level, LSD=16.8.

A second evaluation trial was established in Hawkes Bay in 1995, primarily to commence evaluation of CG.179. Although proving to be significantly more dwarfing than M.26 or CG.210, weak tree structure and spindly growth characteristics resulted in CG.179 being discarded as a potential new resistant dwarfing rootstock.

Performance evaluation of CG.202 and CG.210 was extended to South Island regions of Nelson and Central Otago in 1997, in trials comparing performance with M.26 and EMLA.26 using two cultivars, Royal Gala and Sciros (Pacific Rose™).

After five years from planting, some differences among rootstocks were evident. Trees on CG.210 are slightly smaller than M.26 whereas on CG.202 trees are comparable or slightly larger than M.26. Trees on M.26 and EMLA.26 are similar in size (Table 4). The choice of cultivar caused small differences in the size ranking among rootstocks using trunk cross-sectional area measurement. However differences in canopy volume among rootstock/cultivar combinations were small and not significant.

Crop yield and fruit size in the fifth year did not differ significantly among rootstocks with mean yield for Royal Gala of 41 kg per tree and a mean fruit weight of 177 g compared to a mean yield per tree of 39 kg for Sciros with mean fruit weight of 212 g. Since the trees have now produced four crops it is possible to compare accumulated yield and yield efficiency expressed in terms of accumulated yield.

Trees on CG.202 have the highest yields for both cultivars (Table 5), reflecting their larger tree size. Otherwise there was little difference in accumulated yield between CG.210, M.26 and EMLA.26. Cumulative yield efficiency was similar for the two CG rootstocks and significantly outperformed M.26 and EMLA.26 (Table 6).

Tree growth and cropping characteristics to date from the Nelson trials have confirmed the high productivity and semi-dwarfing performance of CG.202 and CG.210 found in the original Hawkes Bay evaluation.

FURTHER DEVELOPMENTS

Once NZ licensees were established for the Cornell-Geneva rootstocks, importation of additional clones has been undertaken by the licensee nurseries. New clones with multiple resistances and putative dwarfing vigor closer to M.9 have been selected in collaboration with HortResearch. There is strong interest in development of apple rootstocks with size control similar to M.9 but with broad-based resistance to key economic pests and diseases for the NZ apple industry. A new rootstock trial, located in both Hawkes Bay and Nelson, was established in 2001 to evaluate the clones CG.007 and CG.011 compared against M.26, M.9 and CG.210. These two new clones are expected to produce trees closer in size to M.9 and at least smaller than M.26.

THE POTENTIAL ROLE OF THE CG ROOTSTOCKS IN THE FUTURE NEW ZEALAND APPLE INDUSTRY

The New Zealand apple industry is export dependent and must continuously evolve in response to changing demands of international markets and consumers. In the more affluent northern hemisphere markets, especially Europe, increasing requirements for environmental integrity in food production and guarantees of food safety are strong drivers of change in fruit production methods. The NZ apple industry is investing heavily in progressive development of sustainable fruit production methods that are environmentally acceptable. For example, today 9% of NZ apple orchards are in transition or are certified as organic production. The future apple industry will be based on new technologies of sustainable fruit production methods. Truly sustainable production systems must ultimately be both economically and environmentally sustainable.

Reduced or controlled input cropping systems will depend on developing new biological technologies as sustainable alternatives to conventional crop management for productivity, fruit quality and crop protection. Dwarf tree intensive production systems have many attributes that positively contribute to sustainable fruit production. However there is a particular need for more durable rootstocks better adapted for sustainable systems than M.9 and M.26. The CG rootstock breeding program with emphasis on resistances to major economic pests and diseases is one valuable source of potential new rootstocks well adapted for reduced input, sustainable production systems.

At the outset we did not expect CG.202 and CG.210 to be perfect solutions for improved dwarfing rootstocks. However with the industry shift toward sustainability issues, the special characteristics of CG.202 and CG.210 have gained heightened significance. The vigor range and performance of rootstocks like CG.202 and CG.210 seem very suitable for apple intensive planting systems in the future, especially in reduced input production systems, organic production and replanting old orchard sites under such conditions.

There is still the goal to find new clones with dwarfing vigor similar to M.9 combined with multiple resistances. The evaluation in New Zealand of new rootstocks from the CG rootstock breeding program has provided some important new rootstock options, well adapted for future NZ sustainable apple production systems. These rootstocks also appear very suited for combination with disease- and pest-resistant cultivars being developed in the HortResearch apple cultivar breeding program.

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TABLE 6

Effect of cultivar and rootstock on accumulated yield efficiency (g/cm^2) up to the fifth growing season in Nelson.

Rootstock	Royal Gala	Sciros	Rootstock mean
CG.202	4000	2900	3500
CG.210	3700	3500	3600
M.26	3000	2400	2700
EMLA.26	2900	2600	2800
Cultivar mean	3400	2800	

Numbers sharing the same letter in rootstock mean column are not significantly different at 5% level, LSD=500.

FIGURE 1

Annual increases in tree trunk cross-sectional area of Royal Gala apple growing on a range of rootstocks in new or untreated replant soil over eight growing seasons.