

# Management Strategies for Apple Replant Disease

Michelle M. Leinfelder and Ian A. Merwin

Department of Horticulture, Cornell University, Ithaca, NY

**A**s spring approaches, growers begin to consider whether replanting is in their best interest. Perhaps it is time to plant new varieties or upgrade to a higher-density planting. Whatever the reason, when the decision to replant is made, growers should not forget a problem that could severely hinder their new orchard – apple replant disease. Research recently conducted at the Cornell Orchards in Ithaca has provided insight into this disease complex and shown that there are practical ways to combat it.

Apple replant disease (ARD) has plagued apple growers for more than 200 years and is now found in most fruit-growing regions world-wide (Mai and Abawi, 1981). Apple replant disease results from the degradation of soil conditions over time, as apple is planted successively into the same soil. Both living and non-living soil factors contribute to the severity of ARD. The living pathogens may include fungi, nematodes, and bacteria; the non-living factors can range from nutrient imbalances to herbicide residues to compaction. Though the causes can vary from region to region and even field to field, the symptoms commonly seen are decreased growth both above and below ground, delayed productivity, and even tree death. Many New York growers have seen their share of these symptoms.

Because of the limited lands where soil and climate conditions are best for fruit growing, many New York apple orchards have been in continuous production for more than a century, and in surveys, approximately half of New York fruit growers reported they had experienced replant problems (Pruyne et al., 1994). Therefore, in an industry as competitive and global as the apple industry, relief from replant disease would be extremely advantageous for New York growers.

Studies to relieve problems with ARD have investigated various methods of control. Chemical fumigation has sometimes been found effective and economically-feasible (Mai and Abawi, 1981), and ARD-tolerant rootstocks have emerged from the New York State Agricultural Experiment Station in Geneva (Isutsa and Merwin, 2000). “Alternative” methods of control – composting, cover-cropping, fertilizing, and row-repositioning, for example – have also shown positive results in some cases (Granatstein and Mazzola, 2001; Hoitink and Fahy, 1986; Savory, 1966).

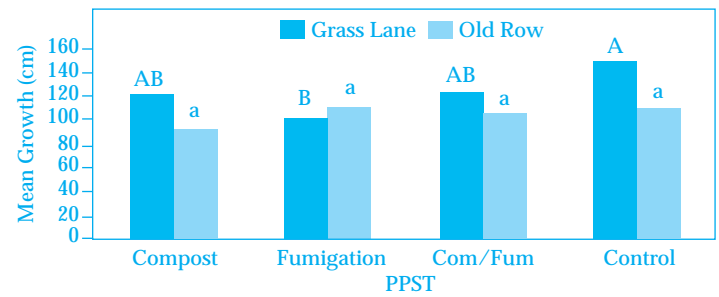
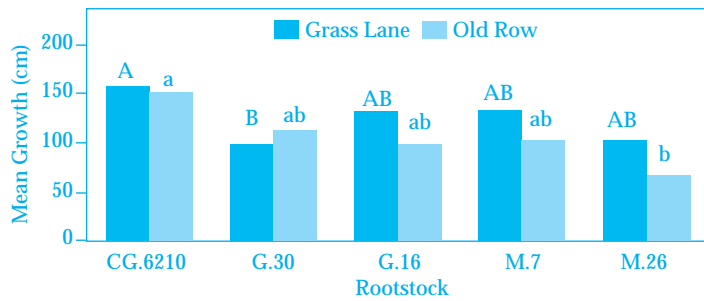
These three management categories – chemical control, rootstock selection, and alternative methods – have been tested together at Cornell Orchards since 2001. The site for this field trial had sustained apple trees for more than 90 years, and common ARD symptoms were evident after its first replanting in 1981 (Mai et al., 1994). Our trial had three variables of interest: four pre-plant soil treatments, two planting positions, and six dwarfing to semi-dwarfing rootstocks. We were interested in learning whether fumigant or compost treatments would affect tree growth, whether growth would differ between the old orchard rows and old grass lanes, and whether differences among rootstocks would be observed. Our objectives were to study these variables alone and in combinations, to provide practical solutions for New York growers faced with ARD in their fields.

## Materials and Methods

In this experiment, we investigated four pre-plant soil treatments – fumigation with Telone C-17 (40 gal/treated acre), composting (900 lbs/treated acre), fumigation and composting (same rates), and an untreated control; six rootstocks (‘M.9’, ‘G.16’, ‘M.26’, ‘CG.6210’, ‘M.7’, and ‘G.30’); and two

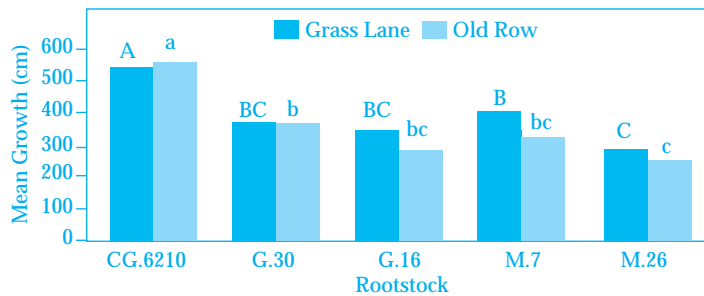
When the decision to replant is made, growers should not forget a problem that could severely hinder their new orchard – apple replant disease. Though pre-plant soil fumigants, have mitigated replant disease in the past, our results indicate that these efforts may not be necessary in some sites. Instead, selecting tolerant rootstocks, like ‘CG.6210’ and ‘G.30’ may be the best defense against replant disease.

planting positions (old tree row and old grass lane) as controls for apple replant disease. The compost consisted of 40% ground leaves and wood chips, 40% supermarket vegetable culls, and 20% pre-composted cattle and horse manure in wood shavings. Plots not receiving the compost treatment, received a mineral fertilizer (22N-4P-0K) at a rate of 280 lbs/treated acre. Soil preparation and treatment were completed between Sept. and Nov. 2001, when the trees were planted. Planting layout was perpendicular to the previous orchard rows in order to study the old tree row and old grass lane effect. Trees on ‘M.9’ rootstock were used only as buffer and filler trees around the other five rootstocks, and their growth was analyzed separately. This served as a parallel experiment where the pre-plant soil treatments could again be observed. The trees were grafted with ‘Royal Empire’, except for the ‘M.9’ trees, which were propagated with ‘NY-674’. The orchard was managed according to typical commercial orchard practices, and trees were measured annually for changes in growth and yield. Soil nematode and nutrient levels as well as leaf nutrient levels were also monitored.

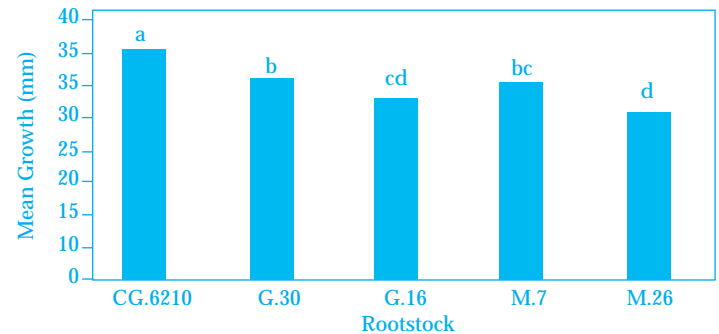


1A. Effect of rootstock on change in trunk cross-sectional area, 2002.

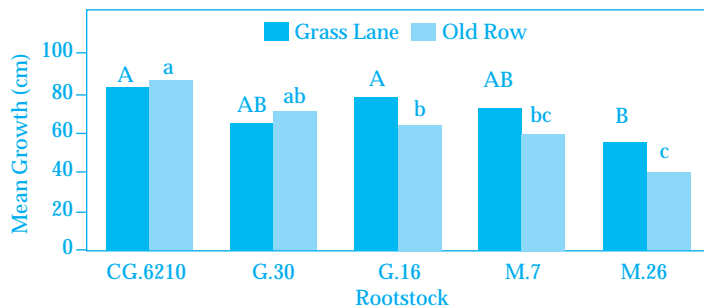
1B. Effect of preplant soil treatment on change in trunk cross-sectional area, 2002.



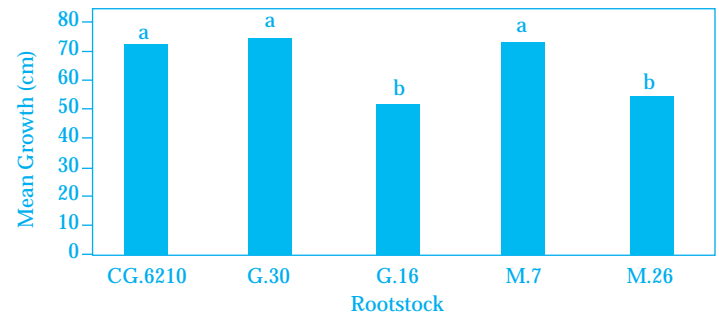
1C. Effect of rootstock on change in trunk cross-sectional area, 2003.



1D. Effect of rootstock on change in trunk cross-sectional area, 2004.



2A. Effect of rootstock on growth of Central Leader 2002.



2B. Effects of rootstock growth of Central Leader, 2003.

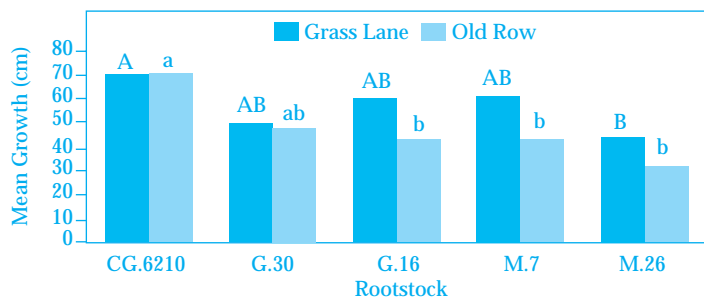
## Results and Discussion

**Tree Growth and Yield:** Over the first three years of this study, the rootstock and tree planting position affected tree growth most strongly and steadily. The rootstock ‘CG.6210’ consistently performed well, and trees on this rootstock were often the largest overall (Figs. 1A, 1C, 1D, 2A, and 3A). This rootstock also had the greatest root development, survival, and density at lower soil depths (Yao, 2005), and it substantially improved yield in the third leaf, in terms of average fruit weight per tree and crop density (Figs. 4A and 4B). The ‘G.30’ rootstock generally produced the second largest trees (Figs. 2B and 3B). Both ‘CG.6210’ and ‘G.30’ are semi-

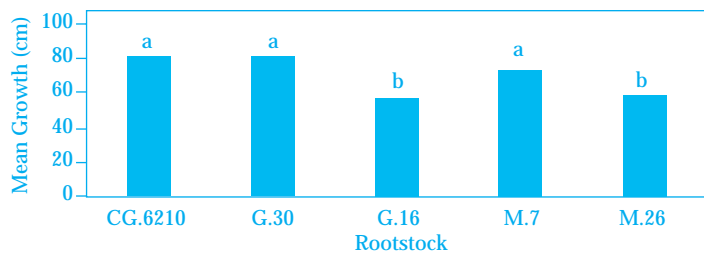
dwarfing rootstocks expected to be comparable in vigor to ‘M.7’. However, ‘M.7’ did not show the same impressive growth or yields as ‘CG.6210’ or ‘G.30’ in our study. The results in this experiment are consistent with those of previous New York studies, where ‘CG.6210’ and ‘G.30’ were reportedly tolerant to ARD (Isutsa and Merwin, 2001; Robinson, 2002). The Cornell-Geneva rootstocks also were found to harbor soil microbial populations different from the Malling series rootstocks (Rumberger et al., 2004), which could suggest a role for beneficial microbes in combating the replant problem.

The other factor we considered in relation to rootstock performance was tree

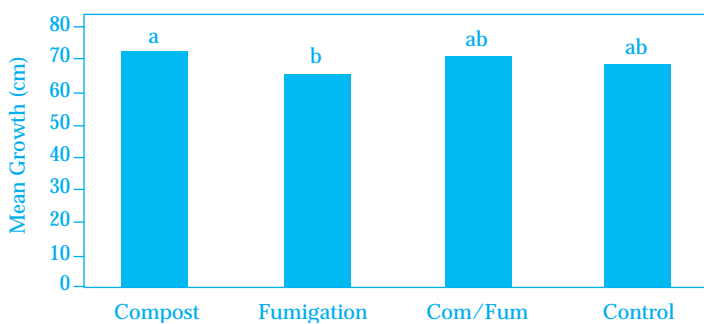
planting position – old tree row versus old grass lane positions. Trees on the ‘CG.6210’ and ‘G.30’ rootstocks essentially performed the same in both positions, but there was disparity among the other three rootstocks. In the cases of ‘G.16’, ‘M.26’, and ‘M.7’, tree growth was often influenced by planting position, and trees in the old grass lanes consistently grew more than those in the old tree rows (Figs. 1A, 1C, 2A, and 3A). Also, growth of ‘G.16’ and ‘M.7’ was generally improved in the old grass lanes, where it was more similar to that of ‘CG.6210’ and ‘G.30’ (Figs. 2A and 3A). This suggests that, though ‘CG.6210’ and ‘G.30’ may possess inherent tolerance to ARD, replanting outside of the old tree rows could improve the growth of rootstocks



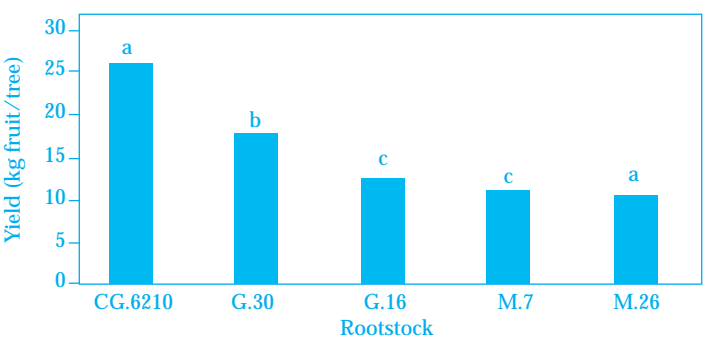
3A. Effect of rootstock on Lateral Extension growth, 2002.



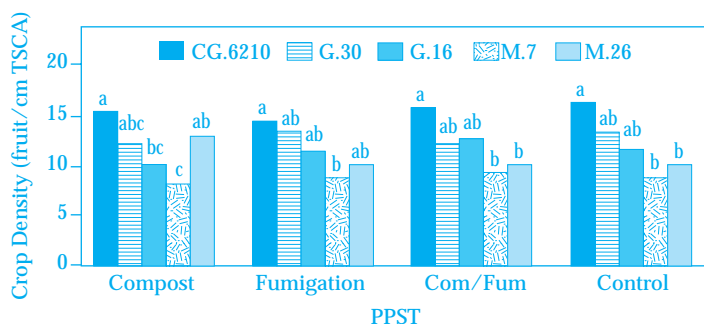
3B. Effect of rootstock on Lateral Extension growth, 2003.



3C. Effect of pre-plant soil treatment on Lateral Extension growth, 2003.



4A. Effect of rootstock growth on yield, 2004.



4B. Effect of pre-plant soil treatment on Crop Density, 2004.

that do not possess ARD tolerance. It has been suggested that this old row replant stunting occurs because pathogens reside on tree roots in those old rows (Savory, 1966) and/or because beneficial microbes develop preferentially in the “fresh” soil of the old grass lane (Rumberger et al., 2004).

The pre-plant soil treatments, unlike the rootstock and planting position factors, did not lead to growth or yield differences, as reported in some previous replant experiments (Hoitink and Fahy, 1986; Mai and Abawi, 1981). There was a trend toward improved tree growth in composted plots in the second year, but this difference was not significant compared with the growth of trees in the control plots receiving no pre-plant treatment (Fig. 3C). Compost quality or stability could explain this lack of change; nonetheless, we concluded that compost did not improve replant conditions or establishment at this site. Soil fumigation with Telone C-17 may actually have impeded growth, as trees in fumigated plots occasionally grew worse than those in the control plots (Figs. 1B and 3C). This may have resulted from inadequate time for dissipation between the application of the fumigant and the date of tree planting. Another explanation is that fumigation may have harmed beneficial microbe populations in the soil, thus reducing tree growth (Rumberger et al., 2004; Yao et al., 2006).

**Soil and Leaf Analyses:** Soil and leaf nutrient levels and soil nematode populations were also monitored at this site (data not shown). Compost treatments enhanced macronutrient and organic matter levels in the soil. Similar responses were also evident in the old grass lane positions. Nonetheless, nutrient levels were observed at satisfactory levels across all pre-plant soil treatments and planting positions (Stiles and Reid, 1991). The increased macronutrients and organic matter resulting from compost treatment and the old grass lane position did not translate into enhanced tree nutrition, as measured by leaf nutrient levels, or improved tree growth or yield.

Root lesion nematode populations varied across the pre-plant soil treatments and planting positions, though overall numbers were low according to published damage thresholds for replant sites (Jaffee et al., 1982). Compost treatments reduced populations of root lesion nematode, and the potential for compost as a suppressant of nematodes and pathogens has been noted in previous research (Hoitink and Fahy, 1986). Fumigation eliminated this nematode pest. Root lesion nematodes were found in greater number in the old grass lanes than in the old tree rows, which would suggest an affinity for grass roots over apple roots. Nonetheless, because of their low overall numbers and the improved tree growth in the old grass lanes, we concluded that root lesion nematode was not a major factor at this replant site.

**Parallel ‘M.9’ Experiment:** Because of the experimental design, ‘M.9’ performance was analyzed separately from the other five rootstocks, and it provided a separate case study of the four pre-plant soil treatments. Its performance across the four pre-plant soil treatments showed no differences, with growth and yield in the compost and fumigation plots similar to the control plots. These results provide further evidence against the time, effort, and expense of pre-plant soil treatments in mitigating the replant problem.

## Conclusion

As growers begin to think about orchard replanting this spring, it is important that they consider the impacts of apple replant disease on their new plantings. Though pre-plant soil treatments, specifically fumigants, have mitigated replant disease in the past, our results indicate that these efforts may not be necessary in some sites. Instead, observations from this experiment would first suggest selecting tolerant rootstocks, like 'CG.6210' and 'G.30' as the best defense against replant disease. Because of their vigor, however, these rootstocks may not be conducive to high-density plantings, in which case, altering the planting scheme into the old grass lanes could also mitigate the problem when less-vigorous, non-tolerant rootstocks are preferred.

## References

- Granatstein, D. and M. Mazzola. 2001. Alternatives to fumigation for control of apple replant disease in Washington state orchards. Nov. 2002. <<http://organic.tfrec.wsu.edu/OrganicIFP/AppleReplantDisease/IFPSpainProc.PDF>>.
- Hoitink, H. and P. Fahy. 1986. Basis for the control of soilborne plant pathogens with composts. *Annu. Rev. Phytopathol.* 24:93-114.
- Isutsa, D. and I. Merwin. 2000. *Malus* germplasm varies in resistance or tolerance to apple replant disease in a mixture of New York orchard soils. *HortScience.* 35:262-268.
- Jaffee, B., G. Abawi, and W. Mai. 1982. Role of soil microflora and *Pratylenchus penetrans* in an apple replant disease. *Phytopathology.* 72:247-251.
- Mai, W. and G. Abawi. 1981. Controlling replant diseases of pome and stone fruits in Northeastern United States by pre-plant fumigation. *Plant Dis.* 65:859-864.
- Mai, W., I. Merwin, and G. Abawi. 1994. Diagnosis, etiology and management of replant disorders in New York cherry and apple orchards. *Acta Hort.* 363:33-41.
- Pruyne, P., I. Merwin, P. Mullin, and D. Gibson. 1994. Diagnosis of apple replant problems in New York orchard soils and evaluation of nematode suppressive cover crops. *Acta Hort.* 363:121-128.
- Robinson, T., S. Hoying, M. Fargione, K. Lungerman. 2002. On-farm trials of the Cornell-Geneva apple rootstocks in New York. *New York Fruit Qrtly.* 10:22-26.
- Rumberger, A., S. Yao, I. Merwin, E. Nelson, and J. Thies. 2004. Rootstock genotype and orchard replant position rather than soil fumigation or compost amendment determine tree growth and rhizosphere bacterial community composition in an apple replant soil. *Plant and Soil.* 0:1-13.
- Savory, B. 1966. Specific replant diseases: Causing root necrosis and growth depression in perennial fruit and plantation crops. Cmwltth. Agricultural Bur., England.
- Stiles, W. and W. Reid. 1991. Orchard nutrition management. Cornell Coop. Ext. Bul 219.
- Yao, S. 2005. Soil microbial community analyses and root observations in apple replant and various groundcover management systems. Doctor of Philosophy dissertation, Department of Horticulture. Cornell University, Ithaca, NY.
- Yao, S., I. Merwin, G. Abawi, and J. Thies. 2006. Soil fumigation and compost amendment alter soil microbial community composition but do not improve tree growth or yield in an apple replant site. *Soil Biology and Biochemistry.* 38:587-599

---

*Michelle Leinfelder recently completed her Masters Degree at Cornell University with Dr. Ian Merwin who is a research and teaching professor at Cornell and who leads Cornell's research program in orchard ground cover management.*