Rootstock Blight in Apple

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Rootstock blight has become increasingly prevalent in recent years due to the increasing use of both highly susceptible apple cultivars and susceptible dwarfing rootstocks. Losses from rootstock blight can be devastating. It is not unusual in young plantings on M.9 to witness losses of 50% in a heavy fire blight year. Resistant apple rootstocks could significantly reduce tree mortality rates primarily when highly susceptible cultivars are planted. New disease resistant rootstocks are now available providing growers with better options for new orchard blocks.

Originally discovered in the Hudson Valley in the late 1700's, fire blight is a bacterial disease of rosaceous plants caused by *Erwinia amylovora*. In recent years, due to changes in climate and horticultural techniques, fire blight epidemics have become more frequent, gaining serious attention from the agricultural and scientific communities. Fire blight is a recurring problem in Western New York and the Hudson Valley where epidemics can be devastating, costing growers significant amounts of time and money for intensive management practices, loss of productivity, and tree replacement. Climatic changes, including elevated temperatures early in the growing season, have expanded the optimal geographic range for fire blight infection.

Over the past 60 years, beginning with the adoption of streptomycin by agriculture, great strides have been made in predicting and managing disease outbreaks. Utilizing modern technology and new materials growers have greatly reduced losses due to shoot and blossom blight. Forecasting systems, such as *MARYBLYT™* and *Cougarblight*, adequately predict the proper timing for bloom application of antibiotics, limiting the incidence of blossom blight. Shoot blight, although unpredictable and sporadic, can be reduced by pruning infected shoots and through the use of the plant growth regulator prohexadione-calcium (Apogee from BASF company), which reduces excessive shoot growth during the growing season. Only rootstock blight, the most fatal form of fire blight, remains without an effective control strategy.

Rootstock blight is a fire blight infection persisting in the rootstock of the tree. The initial infection is often overlooked since above ground symptoms do not appear until late in the season, after the rootstock has died and the tree begins to decline. The most prominent symptom of rootstock blight infection is the secretion of glossy, dark colored ooze (Figure 1). The production of ooze is most common after a rain event or heavy dew, but only occurs for a short time. As the disease progresses, the rootstock blackens and the bark may begin to peel. Rootstock blackening and peeling however are not diagnostic symptoms, since some rootstocks display similar symptoms when healthy. Later in the season, infected trees undergo a premature leaf color change and leaves will turn a deep purple and remain fixed on the tree. Without visible ooze, an outbreak of rootstock blight is easily mistaken for other root diseases. Fungal-like organisms, called Phytophthora *sp.*, which cause root and collar rot, may also bring about a premature color change in foliage. One factor differentiating these diseases is the conditions favorable to development. Phytophthora occurs more often in wet soil whereas rootstock blight is more frequent during periods of hot dry weather, normally in combination with severe blossom or shoot blight. Rootstock blight symptoms will generally persist only in the main trunk of the rootstock and usually do not progress into the outlying root system or into the scion. There is no evidence that fire blight bacteria can survive in the soil or on root residue in the orchard. Soil residue poses little threat to replacement trees, although research on this topic has been limited. To avoid any risk of recurrent rootstock blight use of a fire blight resistant rootstock is recommended.

Bacteria may gain entry into the rootstock through open wounds such as mechanical damage or insect feeding sites. Rootstock suckers may also serve as a source of infection, though the risk of rootstock blight associated with suckers

Figure 1. Symptoms of rootstock blight in apples.

is limited. Excessive suckers should be removed to eliminate risk of infection. The most significant method of infection is the migration of bacteria from infected blossoms and shoots, down the trunk, into the rootstock. Bacteria move within the vascular system of the tree without causing visible necrosis. Migration occurs rapidly into the rootstock and bacteria reach detectable levels only a few weeks after infection. Once bacteria gain entry into the rootstock no treatment is available to prevent the development of rootstock blight.

Rootstock blight has become increasingly prevalent in recent years. The advent of new apple cultivars, most of which are highly susceptible to fire blight, coupled with the increasing acceptance of susceptible dwarfing rootstocks, has provided conditions favorable to rootstock blight. In an effort to remain competitive many growers have converted to high-density planting systems, which require less land, generate higher yields, and produce better quality fruit. High-density systems use dwarfing rootstocks that accelerate cropping of young trees by promoting early flowering. This enables orchards to reach bearing potential much sooner than low-density systems. Unfortunately rapid shoot growth and early flowering promote fire blight infections in young trees, which are more susceptible to rootstock blight. Young trees are more likely to develop rootstock blight when they reach bearing age and will remain vulnerable until their fifth or sixth leaf. The most vulnerable aspect of high-density systems is the reliance on traditional highly susceptible dwarfing rootstocks, specifically M.9 and M.26. Losses from rootstock blight can be devastating. It is not unusual in young plantings on M.9 to witness losses of 50% in a heavy fire blight year. When planting densities require 1,000 trees per acre, losses of 50% can be immense. With pressure to plant more marketable cultivars and the escalating premiums associated with club varieties, growers cannot afford to lose trees that have yet to make a profit. Even moderately resistant rootstocks such as M.7 are not immune to heavy disease pressure. The only guaranteed method of control is the use of resistant rootstocks. It is important to clarify that resistant rootstocks are only effective against rootstock blight and do not significantly affect levels of shoot blight or blossom blight.

When it became obvious that rootstock blight was a threat to the apple growing industry several rootstock-breeding programs made fire blight resistance a priority. Due to high demand a significant number of new rootstock varieties have been released from various programs around the world. The Cornell Geneva Rootstock Breeding Program originally founded by Drs. James Cummins and Herb Aldwinckle, and now a joint venture between the USDA (Gennaro Fazio) and Cornell University (Herb Aldwinckle, Terence Robinson), was the first rootstock-breeding program to focus on fire blight resistance. To date seven Geneva® rootstock varieties covering a wide range of dwarfing ability have been released. Additional rootstocks, from various breeding programs, are also being evaluated for fire blight resistance some with promising results. Rootstocks worthy of mention include, several Pillnitz (PiAu) selections from Dresden, Germany, the Vineland Series from Ontario, Canada, and several Japanese varieties including the JM series (See Table 1 for more information).

Rootstock Breeding Programs

Program (Country of Origin)	Rootstock	Size Chart	Fire Blight Resistance
Budagovsky (Russia)	B.9 Europe	M.9	Resistant
	B.9 US	M.9	Resistant
	B.62-396	M.26	-
Cornell Geneva (USA)	G.11	M.9	Tolerant
	G.16	M.9	Resistant
	G.30	M.7	Resistant
	G.65	M.27	Resistant
	G.41	M.9	Resistant
	G.202	M.26	Resistant
	G.935	M.26	Resistant
Morioka (Japan)	JM1	M.9	-
	JM2	M.7	Susceptible
	JM4	M.26	-
	JM5	M.7	-
	JM7	M.26	-
	JM8	M.26	-
	JM10	M.9	-
Pillnitz (Germany)	Supporter 1	M.9	-
	Supporter 2	M.9	-
	Supporter 3	M.26	-
	Supporter 4	M.7	Tolerant
	PiAu-51-4	M.7	Resistant
	PiAu-56-83	M.7	Resistant
	PiAu-51-11	M.9	-
Poland	P.16	M.9	-
	P.14	M.7	Resistant
	P.60	M.9	-
Vineland (Canada)	V1	M.26	-
	V2	M.26	-
	V3	M.9	-
	V4	M.9	-
	V7	M.9	-

Resistance Not Determined (-)

Limited selection of resistant rootstocks, many of which lacked practical information on orchard performance, made growers hesitant to plant new rootstocks. In an effort to alter grower perception, researchers have made a concerted effort to evaluate orchard performance of new rootstocks, in varying soil and climactic conditions. This was undertaken as part of the national NC-140 rootstock evaluation initiative, established to promote economic and environmentally sound horticultural improvements by focusing on rootstock development. Through this project rootstocks are consistently screened at the New York State Agricultural Experiment Station and at many other sites for productivity and orchard performance in an effort to better recommend planting material suitable for NY growing regions. In addition rootstocks are screened at the New York State Agricultural Experiment Station for fire blight susceptibility.

In our evaluation of rootstock resistance, blossoms of grafted trees are artificially inoculated with fire blight bacteria.

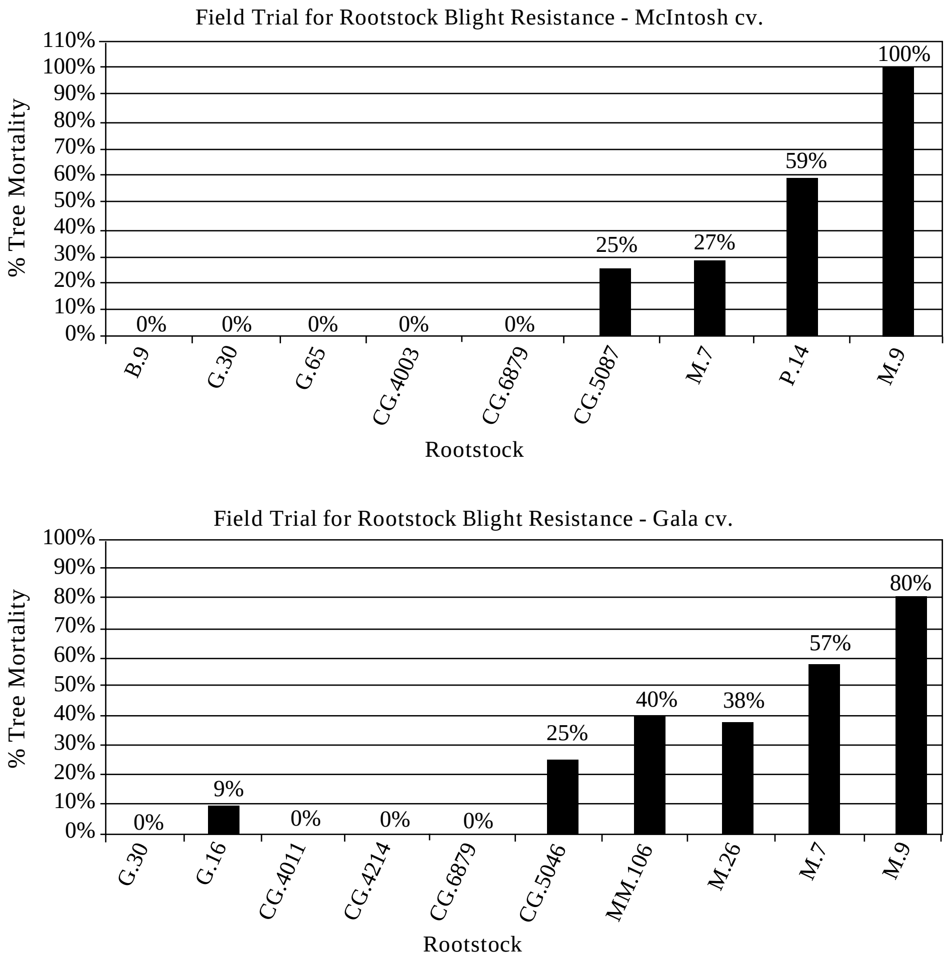

Figure. 2 Field Trial for Rootstock Blight Resistance.

Rootstocks are compared based on the resulting number of trees that die from rootstock infection, described as percent tree mortality. Severe blossom blight infection ensures the highest possible disease pressure. If a rootstock can resist disease pressure of this magnitude, it is likely to remain healthy in a typical orchard.

The East Malling rootstocks were not bred to withstand fire blight infection, and typically suffer heavy losses in our field trials evaluating rootstock blight resistance. In a trial consisting of Gala and McIntosh cultivars, M.9 suffered a total of 80% tree mortality with Gala and 100% mortality with McIntosh. M.7, which is generally listed as fire blight tolerant, had 57 and 27% tree mortality on Gala and McIntosh respectively (Figure 2). In this particular trial, M.26 had atypically low levels of infection; nevertheless 35% tree mortality would still be crippling in a high-density planting. This field test also demonstrated how well rootstocks withstand infection pressure when fire blight resistance is included in the breeding program. In this same field experiment, Geneva® rootstocks had no significant level of rootstock blight infections. Unreleased CG rootstocks that showed less than acceptable resistance were eliminated.

Another rootstock that has been gaining considerable attention in recent years is B.9, which has consistently shown resistance to rootstock blight in orchards. Budagovsky 9 (B.9 or Bud.9) is a dwarfing rootstock developed in the early 20th century at the Michurinsk College of Agriculture in Russia. B.9, a cross between M.8 and 'Red Standard,' a *Malus niedzwetzkyana* Diek red leaved variety, was originally bred for winter-hardiness, layering capacity, and graft compatibility. Similar in size and productivity to M.9, B.9 has a good reputation with growers and is readily available from many nurseries. Historically when inoculated as liners in the greenhouse, B.9 had appeared to be highly susceptible to fire blight. This classification prevented its widespread acceptance.

A number of anecdotal reports indicated B.9 might have some fire blight resistance, however, conflicting reports made it impossible to confidently recommend B.9 to growers as a fire blight resistant rootstock. Rootstocks are usually screened for fire blight resistance by inoculating non-grafted rootstock liners with *E. amylovora* and measuring the resulting lesion. Sensitivity of the non-grafted rootstock liners corresponds to a great extent to the level of susceptibility to rootstock blight of grafted trees in the field, making this an accurate and easy screen for breeders. In our recent experiments, using this type of screening procedure B.9 has been repeatedly categorized as susceptible to fire blight infection. Yet several growers have reported that side-by-side plantings of trees grafted to M.9 and B.9 have experienced heavy tree losses from rootstock blight with M.9, while trees on B.9 failed to develop symptoms. Conflicting reports are also found in the research community where multiple experiments show a wide range of rootstock blight sensitivity from highly sensitive, to tolerant, to completely resistant. Nurserymen were also concerned that material from two stool bed sources of B.9, located in Oregon (B.9 United States) and the

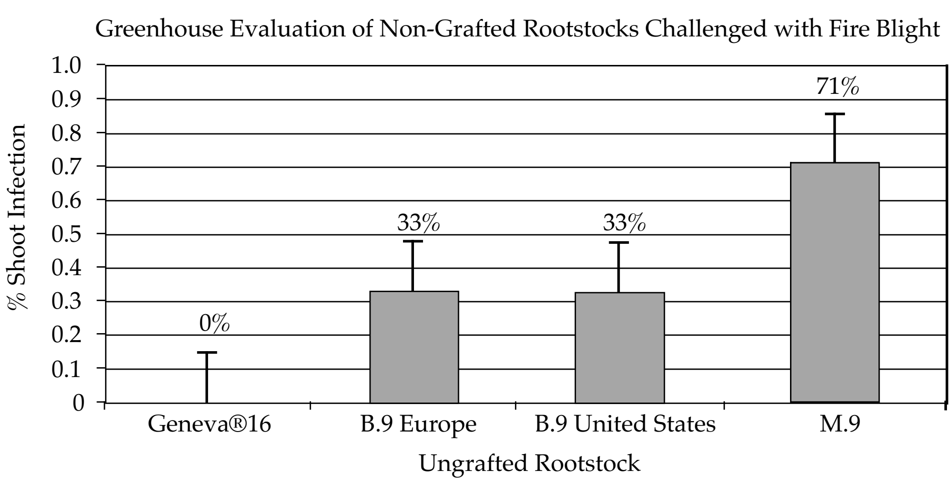

Figure 3. Comparison of shoot infection with non-grafted rootstock liners.

Netherlands (B.9 Europe), seem to have visible differences in growth habit, indicating a difference in genetic background which may play a role in resistance.

Verification of B.9 resistance and genetic identity has been a focus of our research. To date, no evidence of genetic irregularity in B.9 source material has been identified. Apparent differences in growth habit are likely due to propagation method and juvenility of plant material. If minute genetic differences do exist they are most likely too minor to be detectable by current methods, and it is doubtful they have any effect on fire blight resistance. Clones of popular rootstocks, such as M.9, are well known but these 'clonal' differences have never been shown to affect disease resistance.

Susceptibility tests of non-grafted B.9 liners were performed on rootstock material from European and US sources, and compared with resistant Geneva®16 (G.16) and susceptible M.9 (Figure 3). B.9 has an intermediate but still highly susceptible reaction, supporting the early classification of B.9 liners as susceptible. This test also concluded that B.9 liners, from both sources, had similar levels of susceptibility when challenged directly with fire blight. Research plantings at the NYSAES of grafted B.9 (US and European) however, continue to show high levels of rootstock blight resistance even when grafted to highly susceptible scion varieties.

Absence of rootstock blight in the field is so consistent that we now recommend B.9 to growers as a good disease resistant rootstock to replace M.9. The cause of the B.9 resistance is not clear and is unlike any other resistance previously described. The phenomenon seen with B.9 is the only known instance in which a rootstock displays different levels of resistance to rootstock blight; susceptible to infection as liners in the greenhouse while somehow resistant in grafted field plantings. Our preliminary study suggests B.9 develops resistance either due to the influence of grafting or through a developmental change in tissue related to aging. Further understanding of the mechanisms involved in B.9 resistance will aid in the selection of new rootstock varieties in the future.

Excessive use of streptomycin has led to the development of resistant fire blight bacterial strains on the West Coast and Michigan. If resistance becomes widespread the ability to control blossom blight would be greatly reduced and would lead to significant rise in the occurrence of all three forms of fire blight. Without a viable control option rootstock blight could become a more serious threat to NY orchards. Rootstock blight is preventable with the adoption of resistant planting material. Resistant apple rootstocks could significantly reduce tree mortality rates primarily when highly susceptible cultivars are planted. New disease resistant rootstocks are now available providing growers with better options for new orchard blocks.

Nicole Russo is a Ph.D. student doing research on rootstock blight and the mechanisms of rootstock resistance. Terence Robinson is a research and extension professor of pomology who specializes in rootstock performance in high density systems. Gennario Fazio is an ARS geneticist and adjunct Cornell professor who leads the joint UDSA-ARS/Cornell apple rootstock breeding program. Herb Aldwinckle is a professor of plant pathology who leads in fire blight research effort at Geneva, emphasizing epidemiology and genetic, biological and chemical control.