**Sudden Apple Decline: Trunk-Related Problems in Apples**

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Apple growers and extension specialists in many states are seeing an alarming increase in the numbers of orchards, mostly young orchards, where trees are declining or dying due to dysfunctional trunks. The phenomenon has been named sudden apple decline (SAD) because affected trees seem to decline very rapidly. The visibly affected areas of the trunks exhibit cankers, cracks, or dead phloem and cambium. The damaged tissue usually becomes visible in the lower trunk within two feet of the soil line, although in some cases damage may also appear higher on the trunk. In some orchards the damage is prevalent on a single cultivar or cultivar-rootstock combination, but in other orchards the damage seems somewhat independent of cultivar. What causes these trunk decline problems is often difficult to determine, the more so because many of these decline problems probably result from interactions among multiple factors.

In this presentation, we will look at the seven contributing factors that I believe account for most of the SAD problems, along with methods for identifying situations where these factors may be playing a role in apple tree decline. My list of the seven leading causes of apple tree decline is as follows:

1. Fire blight in the rootstock
2. Herbicide injury
3. Boring insects
4. Winter injury
5. Drought stress
6. Fungal canker and wood-rot pathogens
7. Latent apple viruses

**Fire blight in the rootstock** is known as rootstock blight and has been described in numerous extension publications. Rootstock blight should be the first suspect as a cause of tree decline if the orchard had ANY visible fire blight either during the current or previous season AND if the rootstock is either M.26 or M.9 (including all M.9 clones). Rootstock blight is unlikely to occur on trees propagated on M.7, MM.111, Bud.9, or any of the Geneva series of rootstocks. Fire blight may get into rootstocks either by traveling down through symptomless trunk tissue from infections in the scion cultivar, via direct invasion from infection of shoot tips on root suckers, or perhaps via burr knots or borer damage (although I suspect these are low probability entry points).

**Herbicide injury:** Initially I believed that glyphosate was the cause of most trunk damage on apple trees (see http://www.scaffolds.entomology.cornell.edu/2004/040615.html from 14 June 2004). Some of the other symptoms associated with herbicide damage were described in a 2016 article in *Scaffolds* (see http://www.scaffolds.entomology.cornell.edu/2016/SCAFFOLDS-9-6-16.pdf).

Glyphosate uptake through trunks is still contributing to trunk injury throughout the state, but it is becoming apparent that other herbicides, while not translocated throughout the tree as is the case for glyphosate, may still be causing localized damage to trunks. Gramoxone, glufosinate (Rely), and perhaps other products can be nearly as injurious as glyphosate, especially if trees receive multiple applications each year. I suspect that many herbicides cause a slight desiccation of young bark that is hit by the sprays. Repeated desiccation over several years reduces growth of the lower trunk and encourages infection by *Botryosphaeria dothidea*, the white rot pathogen. Cultivars and rootstocks seem to differ significantly in their susceptibility to damage from herbicides. Painting trunks with a white latex paint may help to protect the trunks to some degree, but research to support this contention is lacking. Furthermore, it is very difficult to get good paint coverage on the exposed portions of the rootstocks that are often roughened by burr knots and flaky bark, so herbicides may still impact rootstock health even where trunks have been painted.

We have long suspected that adjuvants that have been added to glyphosate formulations (and perhaps to other contact herbicides) to speed weed kill may also serve to enhance uptake of the herbicide through tree bark. Thus, it seems logical that contact herbicides should be applied with the least amount of adjuvant that is compatible with decent weed control. More recently, George Hamilton, tree fruit extension specialist in New Hampshire, questioned whether applications of spray oil in early spring might leave oil residues on trunks that might enhance uptake of herbicides applied several days later. This interesting question can only be answered by conducting the appropriate research, but in the meantime it may be wise to avoid applying contact herbicides within 7 to 10 days after oil sprays have been applied in spring, especially on trees less than 8 to 10 years old that still have relatively thin bark.

In the absence of definitive studies on herbicide injury to trunks, the best suggestions for minimizing trunk damage include (i) keeping graft unions as low as is feasible without risking scion rooting; (ii) minimizing exposure of trunks to ANY and ALL herbicides, especially on trees less than 6 or 8 years old; (iii) minimizing the use of adjuvants or "fully loaded" glyphosate products that are formulated with adjuvants; (iv) when possible, making herbicide applications on young trees only during fast-drying conditions; (v) using white latex paint on trunks to minimize herbicide absorption; and (vi) perhaps using trunk guards (such as milk carton sleeves) around young trees to minimize herbicide contact with the trunks. However, if trunk guards are left in place throughout the year they may eventually serve to attract and protect borers.

**Boring insects** of most concern are dogwood borers and black stem borers. Occasionally we have also seen tree decline from *Prionus* beetles that can turn lower trunks into something that looks like Swiss cheese and from leopard moth larvae that can remove most of the center wood from young trunks. My entomologist colleagues have covered these insect problems in considerable detail in *Scaffolds* articles and other extension publications. Nevertheless, I am continually surprised how prevalent dogwood borers are in orchards that are 4 to 8 years old. Dogwood borers may become even more problematic as we continue to lose registrations for some of the most effective insecticides.

**Winter injury** that damages trunks can appear on the southwest sides of trees if the injury occurs from heating-cooling cycles that occur when the sun, sometimes aided by reflection from snow cover, heats trunks on the southwest sides of trees during the day and that tissue then cools rapidly to sub-freezing temperatures at night. Southwest injury can be minimized by painting trunks white so that they reflect sunlight in winter.

Winter injury of the lower trunk can also occur if trees grow late into the season and then encounter extreme temperature drops in late November or December before the tree has become fully acclimated to cold temperatures. The last part of the tree to harden off is the lower trunk from the lower scaffolds limbs to the soil line. Young trees that are "pushed" with too much nitrogen fertilizer may continue growing late into the season, thereby making trees more susceptible to winter damage. Even recommended levels of fertilization can cause problems if drought conditions during spring and early summer prevent nitrogen uptake and the applied fertilizer then becomes available to trees following rains in late summer or fall.

Symptoms of winter injury include browning of the bark and cambium layer that (i) stops abruptly at the soil line, (ii) usually extends, at least in a patchy pattern, from the soil line up to at least the lower scaffolds, and (iii) that occurs on all sides of the trunk (unless the damage is attributable to southwest injury). Glyphosate exposure is known to reduce by several degrees the winter hardiness of trees exposed to glyphosate drift, so trees exposed to drift may experience more extensive winter damage than would occur in the absence of glyphosate (see "Effects of Glyphosate on Apple Tree Health", *N.Y. Fruit Quarterly* 21(4):23-27 at http://www.nyshs.org/fq.php).

**Drought stress:** Apple trees subjected to drought stress during summer will eventually be attacked by *B. dothidea,* an opportunistic fungus that is resident in older bark and that can damage and even kill the bark and cambium on trees that are water stressed. When periods of water stress are limited, *B. dothidea* may kill only the outer bark, which then peels off in large flakes to reveal healthy, relatively green bark beneath the flakes. The solution for avoiding drought stress is to ensure that new plantings can be irrigated. I am increasingly convinced that trees on M.9 rootstocks should not be planted on any ground that cannot be irrigated because this rootstock will not survive the drought stresses that will likely become more prevalent throughout the northeastern United States as a result of climate change over the next 20 or 30 years. For those without access to (enough) irrigation water, the million-dollar question is which of the new rootstocks is best suited to surviving drought stress and at what spacing should they be used on non-irrigated sites?

**Fungal canker and wood-rot pathogens** usually cause a slow decline rather than a sudden decline in apple trees, and declines caused by these pathogens are more common in trees more than five years old rather than in younger trees. Most of the canker and wood-rot pathogens that occur in New York become problematic only after trees have been compromised by other injuries or environmental factors. (See "Canker Problems in Apple Orchards, *N.Y. Fruit Quarterly* 15(4):9-12 at http://www.nyshs.org/fq.php). However, cankers may appear in young trees if trees have been subjected to severe herbicide injury or to sustained periods of drought stress or waterlogged soils. Thus, while canker and wood-rot pathogens may contribute to apple decline problems, they are generally secondary rather than primary contributing factors.

**Latent apple viruses** are transmitted only via propagation or by root grafting from adjacent trees. Root grafting is more common in stone fruits than in apples, but a recent report indicated that root grafting is also quite common in apples. The common latent viruses are stem pitting, stem grooving, apple chlorotic leaf spot, and apple mosaic. These latent virus generally do not cause any visible symptoms or direct tree decline, although they can reduce yield in some cultivars. Clean nursery stock programs initiated during the 1950s and 1960s pretty much eliminated these virus problems, but those programs gradually were abandoned due to lack of interest and funding. Now tree decline from latent viruses is re-emerging as a commercial problem, especially if virus contaminated budwood is used to propagate trees on G.935. Although more research is needed, it seems likely that if healthy trees on G.935 (i.e., trees propagated with virus-free budwood) are later top-worked using grafting wood that carries latent viruses, then those trees will decline following topworking. It behooves growers to request and insist upon trees that are propagated using virus-free scion material so as to avoid tree losses several years after planting or after trees are topworked.

**Several less common causes of tree decline** and/or trunk problems are worth mentioning. Crown rot caused by *Phytophthora* species is often suggested as a cause for necrosis in the below ground sections of the crown. However, with the exception of M.26, the rootstocks commonly used today are relatively resistant to *Phytophthora* infections. Even when isolations or PCR tests show that *Phytophthora* species are present in declining trees, there is reason to question whether these fungi are primary invaders or only opportunistic pathogens of trees dying from other causes. The one situation where *Phytophthora* species may be killing trees involves the cultivar "Topaz" and its associated sports where the cultivar, not the rootstock, may die if *Phytophthora* spores are splashed onto the trunk. In these cases, the rootstocks usually remain alive but the trunks die starting at the graft union with necrosis extending upward. For more information on this phenomenon that is unique to Topaz, see http://blogs.cornell.edu/plantpathhvl/2015/01/05/trunk-disease-problems-on-crimson-topaz/.

"Wet feet" may be a factor if declining trees occur in areas that are known to have poor drainage, but most orchards today are planted on good sites where one would not expect saturated soils to persist long enough to cause tree declines.

Other root pathogens such as *Armillaria* and *Xylaria* species can occasionally be found in older trees, especially in locations that many years ago might have been forested with oak trees, but I have never seen these pathogens as primary causes of apple decline in the Northeastern United States.

Voles can girdle young trees or, in the case of pine voles, make the root system of young trees look like a carrot. However, damage from voles is easy to identify, is usually limited to a few trees on orchard perimeters, and often occurs only where growers failed to exercise the normal precautions essential for managing vole populations.

Occasionally trees will collapse rapidly after a lightening strike, but these instances can usually be identified by the rapid decline in a limited number of trees within days of a severe thunderstorm. In some cases where trees are supported using multi-wire trellises without individual tree stakes, all of the trees between two trellis posts may be killed at the same time because the electrical charge may not dissipate until it reaches a larger diameter post. For a longer description of lightening damage, see http://www.mail-archive.com/apple-crop@virtualorchard.net/msg02803.html.

Finally, there is always the possibility that some as-yet unknown pathogen may be contributing to tree declines. The common cherry bacterial pathogen, *Pseudomonas syringae*, has been reported as an apple pathogen in South Africa, and several phytoplasmas (phloem-limited, insect-transmitted bacterial pathogens that lack cell walls) have been identified in other parts of the world but have not yet been reported in the U.S. However, unless and until there is documented evidence to the contrary, I suspect that the vast majority of tree decline problems in Northeastern North America will continue to be caused by one or more of the seven common problems listed earlier in this publication.

Ultimately, good tree health is dependent on having healthy tree trunks. Growers who are investing up to $30,000 per acre in new plantings should be asking tough questions about rootstocks, virus contamination of budwood, recommended planting depths, herbicide programs, irrigation systems, and how to avoid fertility problems in dry years. Perhaps no one has all of the answers at this point, but we can't expect much progress if no one is thinking about how to improve the key structures (apple trunks) that support all apple production systems.