Sudden Apple Decline (SAD): The Pennsylvania Experience

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Introduction

The story of 'Rapid Apple Decline' or 'Sudden Apple Decline' began when I joined Penn State in 2013. During my first season in 2013, I was faced with an unusual problem in a three-acre plant pathology research apple block at the PSU Fruit Research and Extension Center in Biglerville, PA that was planted in 2011. This apple block, which was comprised of multiple varieties on M9.337, was to replace a much older semi-dwarf plant pathology block; however, hopes were dashed in 2013 when a massive die-off of trees in the new block occurred. Many chemicals were used (Aliette, Rampart, Ridomil) to try to save this apple block, but none of our remedies worked. In 2014, the problem continued and we discovered Penn State wasn't the only site in Pennsylvania with a problem orchard afflicted with a mysterious issue causing sudden collapse of trees.

Since 2014, my lab has been working closely with Pennsylvania Department of Agriculture (PDA) to expand resources for getting to the bottom of the problem, as well as figuring out a solution. In late 2016, we began to collaborate with the National Germplasm Resources Laboratory at the USDA-ARS in Beltsville, MD to look more closely at previously undescribed pathogens in the affected trees. At this point, we still have more questions than answers to the root cause of the problem, but we have gathered a lot of information to date to begin to help unraveling the mystery of RAD/SAD:

What is 'Rapid Apple Decline' or 'Sudden Apple Decline'?

RAD was named by PDA due to the rapid or sudden collapse of apple trees from the time the first symptoms appear to tree death. The diagnostic characteristics commonly associated with trees in Pennsylvania orchards are as follows:

- A block can have a mix of dead, declining and healthy trees dispersed fairly evenly throughout a block.
- Young (2 – 8 yr), dwarf trees are most susceptible (to date, semi-dwarf rootstocks have not been associated with this issue); multiple varieties and rootstocks (M9 most affected).
- The graft union is affected: severe shedding of bark around graft union and cankers are present.
- Necrosis begins at the graft union and it proceeds up the trunk of the tree.
- Affected wood is usually solid and not spongy.
- The rootstock is healthy, as indicated by many rootstock suckers present, as well as a healthy root system.
- The leaves on the trees begin to look pale yellow, then reddish (indicating tree girdling), and within two weeks the tree can be dead.
- Trees can collapse with a full load of large fruit.
- Total collapse of the trees has been observed from late July through September.

What tree varieties are affected by RAD/SAD and where has this been observed?

In Pennsylvania, we have observed the issue on young trees with dwarfing rootstocks; M.9 (including 337 and Nic29) appears especially susceptible, as well as the cultivars Fuji, Gala, and

Golden Delicious. The issue may be a cultivar – rootstock combination; however, this question needs further study. Another item to note is these trees came from multiple nursery sources.

Is RAD/SAD due to the harsh winters of 2014 and 2015, or drought?
If you talk to many folks, winter injury is the ultimate cause for RAD: the trees became weakened due to the stress (severe temperature fluctuations) of winter and ultimately became susceptible to weaker diseases that caused the tree to decline and die. This is a very plausible hypothesis since our 2014 and 2015 winters were exceptionally challenging. However, in several orchards, we observed the issue arise prior to 2014. Those in New York suspect the drought conditions this year may have been the tipping point that pushed the trees over the edge with regard to tree stress and susceptibility.

Is RAD/SAD due to fire blight?
This has been a prevailing hypothesis that many want to anchor onto; however, the bacteria have not been detected using molecular techniques in affected trees. We are tentatively ruling out fire blight as a cause of RAD.

Is RAD/SAD due to Phytophthora infection?
Although the symptoms of the graft union are suspect of a Phytophthora infection, we have ruled out Phytophthora in PA since we have not been able to isolate Phytophthora from the samples we have collected to date. In addition, the affected sites have had excellent drainage.

Is RAD/SAD due to another fungal pathogen?
In many of the samples that have been tested, we have found *Botrysphaeria* species present (causal organisms of white rot and black rot). However, these fungi are weak pathogens that only cause problems when the tree is already in a weakened condition. The presence of these fungi tells us: the trees are stressed or weak. We have to find out why were these trees are stressed and weak to become susceptible to these pathogens.

Is RAD/SAD due to insects?
We (and others) have observed borer issues in the graft union; however, this wasn't a common denominator among affected trees. We suspect these insects came in after the fact when the tree was already in decline.

Is RAD/SAD due to nematodes?
Nematodes were found in some locations, but not others. When nematodes were identified in soil samples, the numbers and types of nematodes detected would not cause significant damage. To further support this hypothesis, the root systems of all affected trees we have encountered to date are incredibly healthy, so much so they are producing rootstock suckers.

Is RAD/SAD due to virus infection?
Tomato ringspot virus, which is the most problematic virus to affect our region since it is vectored by dagger nematodes, has been ruled out more than once. The apple trees tested negative, as well as the weeds (horse nettle) in the orchard. As far as other viruses: in Pennsylvania, we have been detecting latent viruses (apple stem pitting virus and apple stem grooving virus) that are graft transmissible only; however, not all samples possessed a latent

virus. In December 2016, the USDA-ARS used sophisticated molecular tools and discovered a previously undescribed luteovirus infecting many of the tree samples collected from 2014 – 2017 (as well as samples from NY). As we have been studying this virus, we have observed the virus is not evenly distributed within the tree, making accurate detection of positive trees challenging. In addition, it is very difficult to prove if the virus is the ultimate cause of the problem because of the challenges of recreating the symptoms in a healthy, uninfected tree (especially if other factors, such as an abiotic tree stress, may also be involved). At this point, we do not know how or if this virus is playing a role in tree decline; however, we are continuing our efforts to learn as much as possible.

Is RAD/SAD due to herbicide injury?

There has been concern about the use of herbicides and the sub-lethal effect on trees. In 2017, we surveyed growers in PA who were experiencing significant tree decline and asked the history of herbicide use. To date, we have not found one particular herbicide that could tie all of the tree decline sites together. This topic still needs further investigation, especially if burr knots are present on affected trees as these may be more sensitive to injury and uptake of herbicides.

What can a grower do to attempt to prevent RAD/SAD?

There is a very good possibility that RAD/SAD is the result of not just one agent, but several agents (pathogen, environment, stress, etc.) working together to cause massive tree die-offs. As a result, this may make it more difficult to prove why RAD/SAD occurs to certain trees. Right now, the best action growers can do is to minimize tree stress. Although we do not ultimately know why trees are prone to stress to begin with, there are a few things growers can do to mitigate certain stressors, such as potential herbicide injury, drought or severe winter conditions. If you already do not irrigate, consider irrigation for your apple block, especially if you have trees on M9 rootstocks. To limit winter injury and herbicide injury, consider painting the trunks white or using white tree guards to prevent injury.