

2021 RESEARCH GRANT PROPOSAL

STATE HORTICULTURAL ASSOCIATION OF PENNSYLVANIA

Title: Investigating the role of viruses, soil fertility, nematodes and herbicides in rapid apple decline

Personnel:

PI: Dr. Kari Peter, Associate Research Professor of Tree Fruit Pathology, Department of Plant Pathology & Environmental Microbiology, The Pennsylvania State University Fruit Research and Extension Center, Biglerville, PA 17307 Phone: (717) 677-6116 Ext. 223 Email: kap22@psu.edu

Year 2 of 3 Funding period May 1, 2021 – April 30, 2022

Amount requested: \$8,576

Justification:

Over the last several years, there have been reports across the U.S. and Canada about an unusual rapid/sudden decline of young, dwarf apple trees (M9 rootstocks + a few others) typically when trees are in their prime, or about to be in their prime. When evaluating such cases, the usual culprits have been ruled out causing such rapid tree decline. The problem stems from damage and death of stem tissues around the graft union; the roots are always healthy. Hundreds, thousands of trees have been affected in orchards. There are many theories as to the origin; however, there is no one unifying theory or smoking gun solving the mystery, and it is most likely a yet-to-be-defined complex of issues. Regardless of theory, the problem keeps occurring and does not appear to be abating. In addition, there is considerable concern among those in the apple growing community: those who have been in the industry for a very long time have expressed they have never encountered a phenomenon like this with dwarf apple trees in all their years of growing fruit.

Considering these concerns, a Rapid Apple Decline Summit was held on December 4, 2019 in Winchester, VA. Around one hundred people (in person and via video conferencing) participated in the event: academia, federal, agrochemical companies, fruit industry and consultants. The purpose of the summit was to bring together folks of different backgrounds and expertise to try to determine a path forward in figuring out the mysterious decline and ultimately a management strategy. Presentations and formal perspectives were given by those from Penn State, North Carolina State University, Cornell, Washington State University, Michigan State University, USDA-ARS, Agri-Food Canada, and consultants. In addition, firsthand accounts from growers, nurseries, consultants and Extension personnel were shared. At the end of the meeting, a summary of the issues included the following:

- The apple decline phenomenon associated with dwarf apple trees in high density plantings has been observed predominantly in the last 10 years (suggesting something is different or has changed). Affected rootstocks were mostly M9; however, there reports of B9, G41 and G935.
- New viruses (ALV1, citrus concave gum-associated virus), viroids (apple hammerhead viroid) and typical latent viruses have been found in trees; however, still too early to determine the role of new viruses/viroids found in apple tree decline.
- The role of herbicides (especially contact) and herbicide injury is an important area to explore.

- Extreme weather events (large temperature swings during winter; drought) have been documented in several areas.
- Areas in some affected orchards may be influenced by topography influences (erosion, drought prone, etc.).
- Combination of factors contributing to the cause.

In 2020, the USDA-APHIS Plant Germplasm Quarantine Program (Beltsville, MD), Foundation Plant Services at UC Davis, and the Clean Plant Center Northwest at Washington State University teamed together to perform a national survey of viruses found apple trees from commercial orchards in the United States using high throughput sequencing. Known viruses and viroids were found in apple trees throughout the U.S.; however, there was a difference in what was/wasn't found by region. Data from the East Coast states surveyed to date (MD, VA, WV, NY, PA) have shown a high incidence of tomato ringspot virus (ToRSV; 18 – 88%) and tobacco ringspot virus (TRSV; 39 – 82%); little to no incidence (0-5%) of these viruses have been detected in the West Coast states surveyed (CA, WA). Both viruses are vectored by dagger nematodes and cause issues with graft union compatibility, which results in gradual tree decline. During the early years of studying apple decline, ToRSV was investigated initially and there was no incidence; however, TRSV was not tested. Taking into consideration the national apple virus survey results, as well as anecdotal reports of dagger nematodes being detected in orchards at high numbers throughout PA, we need to take a closer look at ToRSV, TRSV, and dagger nematodes in declining orchards in Pennsylvania.

We continue our quest to better understand the underlying causes to the mysterious apple decline. The goal of our 2021 SHAP grant is to continue the objectives from the 2020 SHAP grant by generating preliminary data in under-studied areas (herbicides, soil), as well as to compliment a funded PDA Specialty Crop Block Program grant, which is titled “Emerging Organisms and Tree Decline: Battling New Threats Facing the Pennsylvania Apple Industry.” This grant examines ALV1 and other organisms (previously undescribed microorganisms and Ambrosia beetles) and their potential association with apple decline in orchards and nurseries. This grant is supporting a full-time technician (located at PDA), supplies, sequencing services and some travel. Our 2021 SHAP funding proposal focuses on providing another year of support for a seasonal technician to assist PDA, as well as sampling soil of affected orchards for dagger nematodes. The research objectives we propose support the 2020 SHAP Research Priorities under Plant Pathology: **New and Emerging Disease Identification and Management – Rapid Apple Decline:**

2020 Objectives:

1. Continue to survey PA orchards and nurseries for the prevalence of apple luteovirus 1 and organisms potentially associated with rapid apple decline (for 2021: including tomato ringspot virus and tobacco ringspot virus).
2. Examine soil profiles in orchards with a mix of dead/declining and healthy apple trees (for 2021: finish sites not evaluated in 2020).
3. Evaluate influence of herbicides on young apple trees and on the potential role in rapid apple decline (for 2021: continue to monitor trees).

2021 Objective:

4. Survey affected and asymptomatic orchards in PA for the presence of dagger nematodes.

Procedures:

Objective 1: Continue to survey PA orchards and nurseries for the prevalence of apple luteovirus 1 and organisms potentially associated with rapid apple decline.

In 2020, we were able to collect samples from a only few locations (due to COVID travel restrictions): two sites at FREC (trees specifically grafted by ACN using FREC budwood and certain rootstocks with and without ALV-1, which were initially tested in 2018; a 2015 Ultima Gala/G.11 block that had about 10 suddenly declining trees); several blocks at Rock Springs (Rob Crassweller's orchard: a small nursery; young declining blocks; and M9 trees planted in the early 1980s); and we also tested a small apple nursery at ACN in Aspers. We will continue with samplings from orchards and nurseries, with the focus on healthy/asymptomatic orchards in 2021. For 2021, we are aiming to include specific analyses for tomato ringspot virus and tobacco ringspot virus in a subset of samples that have already been processed (2014 – 2020). This will predominantly be supported by the PDA grant; however, a seasonal technician will be assisting with this sample collection and processing.

Objective 2: Examine soil profiles in affected orchards.

During the 2020 season, we chose 6 locations with a known history of apple decline for soil mapping in Adams County. We worked with Helena Chemical in Biglerville to use soil electrical conductivity equipment to generate soil maps, while also taking physical soil samples. The drought impacted our ability to collect data from all locations since a certain level of moisture in the soil is necessary for effective evaluation and this prevented from sampling two locations, which will be completed in 2021 (supported by the 2020 SHAP funding).

Objective 3: Evaluate influence of herbicides on young apple trees.

Bark injury around the graft unions in young orchards resulting from herbicide damage has been a very popular theory as a contributor to rapid apple decline. Tree stress plays a role in RAD and herbicide injury is a tree stress, which could ultimately lead to premature decline due opportunistic pathogens, such as white rot, taking advantage of a compromised tree. Understanding if herbicide injury on young apple trees contributes to premature decline and/or death will take more than one year of study. In 2020, we chose three locations at PSU FREC where new trees were planted in May-June 2020 to test the herbicide theory. All trees were treated with the same herbicide; treatment difference was using a tree guard (no guards, Tyvek guards, trunk painting) (Table 1). Trees were be arranged in a randomized complete block with at least 10 – 15 trees per treatment, replicated 4-6 times within the block.

Table 1. Herbicide trial on young apple trees.

Trees (planted 2020)	Trunk/guard treatment	Herbicides applied
Crimson Crisp/G11 (~360 trees)	No guards, Tyvek	<ul style="list-style-type: none"> No herbicide treatment (mechanical weed removal) July: Gramoxone, Prowl, Surflan, Clethodim Fall: Prowl, Aim, Clethodim
Buckeye Gala/ G11, G41, G935, B9 (100 trees/25 each)	No guards, Tyvek, painted	<ul style="list-style-type: none"> June: Gramoxone Fall: Prowl, Aim, Clethodim
Golden Delicious/M9 (+ALV1) Aztec Fuji/M9 (+ALV1) (220 trees total)	No guards, Tyvek	<ul style="list-style-type: none"> June: Gramoxone Fall: Prowl, Aim, Clethodim

We evaluated the trees at the end of the 2020 season for overall health, with emphasis of any changes at the graft union. To date, there have been no obvious damage or issues at the graft union. In 2021, we will continue to monitor these trees (beginning, middle, and end of season).

Objective 4: Survey affected and asymptomatic orchards in PA for the presence of dagger nematodes.

Considering the national apple survey results found a high prevalence of the nematode vectored ToRSV and TRSV in Pennsylvania apple trees, as well as anecdotal evidence of high numbers of dagger nematodes in recently sampled PA orchards, we will perform a parasitic nematode survey in 2021 in approximately 18 locations throughout Pennsylvania. We will collect soil samples from known declining orchards (2 soil samples: declining trees and asymptomatic trees) and from orchards with no known history of decline, specifically analyzing for the presence of parasitic nematodes (dagger nematodes). Soil samples will be collected in September, when all suspected eggs have hatched. Nematode analyses will be outsourced to the Nematode Assay Lab at the North Carolina Department of Agriculture.

Budget:

Wages for 1 seasonal employee (\$14.25 hr, 37.5 hr/wk, 14 wk):	\$7,481
Wage fringe benefits (7.94%):	\$595
Services:	\$500
Total requested:	\$8,576

Budget Justification:

Salaries/Wages - \$7,481

Funds are requested to hire an hourly seasonal technician who will be working at the Pennsylvania Department of Agriculture on this project. They will be paid similar wages compared to seasonal technicians hired by PDA: \$14.25/hr for 37.5 hr/wk for 14 weeks. This individual will be assisting the lead lab technician (funded by a PDA grant), who will oversee the rapid apple decline project. The seasonal technician is considered Category III Salaries and Wages.

Fringe Benefits - \$595

Fringe benefits are computed using the fixed rates of 34.88% applicable to Category I Salaries, 12.35% applicable to Category II Graduate Assistants, 7.94% applicable to Category III Salaries and Wages, 0.31% applicable to Category IV Student Wages, and 23.88% for Category V, Postdoctoral Scholars and Fellows, for fiscal year 2020 (July 1, 2021, through June 30, 2022). If this proposal is funded, the rates quoted above shall, at the time of funding, be subject to adjustment for any period subsequent to June 30, 2021, if superseding Government approved rates have been established. Fringe benefit rates are negotiated and approved by the Office of Naval Research, Penn State's cognizant federal agency.

Services - \$500

Funds are requested to have soil samples analyzed for nematodes, specifically dagger nematodes. The Nematode Assay Lab at the North Carolina Department of Agriculture will be analyzing the soil samples and providing the report. Funds will cover the \$13/sample fee plus shipping (out-of-state cost). Approximately 18 locations throughout PA will be sampled: affected orchards, with 2 soil samples at each location (declining trees vs. asymptomatic trees) and healthy/asymptomatic orchards.

Sponsor doesn't allow for indirect costs.