FINAL PROJECT REPORT
WTFRC Project Number: PR-16-103

Project Title: Enhancement of postharvest decay management in pear

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Cooperators: Kelly Wallis (Oregon), multiple packers in WA and OR, Craig Christensen (Cashmere, WA).

Total Project Request: **Year 1:** $32,284 **Year 2:** $33,284 **Year 3:** $34,323

Other funding sources: None

WTFRC Collaborative Expenses: None

Budget 1
Organization name: WSU-TFREC **Contact Administrator:** Katy Roberts/Joni Cartwright
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Item	2016	2017	2018
Salaries[1]	17,550	18,252	18,982
Benefits[1]	7,434	7,732	8,041
Wages	0	0	0
Benefits	0	0	0
Equipment	0	0	0
Supplies[2]	4,100	4,100	4,100
Travel[3]	2,000	2,000	2,000
Miscellaneous	0	0	0
Plot Fees[4]	1,200	1,200	1,200
Total	32,284	33,284	34,323

Footnotes:
[1] Salaries for a research intern (Laxmi Pandit, 0.65 FTE) at 42.4% benefit rate.
[2] Supplies include Petri dishes, multi-well plates, microbiological media for fungi growth and fungicide sensitivity tests.
[3] Travel to multiple packinghouses in WA and OR for fruit collection.
[4] Plot fees for an experimental orchard to be used for field studies.

ORIGINAL OBJECTIVES

1- Conduct a general disease survey to identify and quantify major postharvest rots.

2- Conduct a general resistance monitoring program across multiple pear orchards and packinghouses in WA and OR to TBZ, pyraclostrobin, boscalid, fludioxonil and pyrimethanil.

3- Evaluate the efficacy of fungicides applied by thermofogging and investigate the possibility of reducing fungicide input.

4- Evaluate the impact of applying fungicide mixtures in orchards on postharvest decay and resistance development.

SIGNIFICANT FINDINGS

Objective 1: *Conduct a general disease survey to identify and quantify major postharvest rots*

- 243 grower lots including 124 and 119 lots in 2017 and 2018, respectively, from 9 packinghouses, including 4 packinghouses in WA and 5 packinghouses in Hood River OR, were surveyed from February to May of 2017 and 2018. Overall, 166 and 77 lots were surveyed from OR and WA, respectively in the two years.
- In 2018, gay mold followed by *Nectria* rot and Cladosporium rot were most predominant in Washington, whereas blue mold followed by gray mold and Mucor rot were most predominant in Oregon.
- The quarantine pathogen *Phacidiopycnis pyri* was found at about 8 and 4% of total decay in OR and WA, respectively. Its frequency was slightly higher in 2018 compared to the previous season.
- Gray and blue molds make for up to 50% of total decay in both regions.
- *Nectria* rot seems to be emerging as a potential problem. Geographical variabilities in its distribution have been observed. Further research is needed.

Objective 2: *Conduct a general resistance monitoring program across multiple pear orchards and packinghouses in WA and OR*

- A total of 1,140 isolates of *Penicillium expansum* (blue mold) and 2,000 isolates of *Botrytis spp.* (gray mold) were collected from the different packinghouses surveyed in 2017 and 2018 (Objective 1). These isolates were tested for sensitivity to 6 fungicides: thiabendazole (Mertect), pyrimethanil (Penbotec) and fludioxonil (Scholar) for both *P. expansum* and *Botrytis* and to pyraclostrobin + boscalid (Pristine) and fluxapyroxad (Merivon) for *Botrytis* only.
- Overall, resistance frequencies of *P. expansum* for TBZ and Penbotec decreased significantly in 2018 after most packers rotated with Scholar.
- Resistance in *Botrytis* stayed steady in 2018 compared to 2017 except to TBZ for which it decreased by almost 3 times in 2018.
- 243 decay and resistance profiles were created and sent to the participating packers and growers before the beginning of the new season to allow them change strategies and spray regimes based on decays and resistance found at their lots.

Objectives 3: Because it was not possible to identify a packer who drenches, fogs or aerosols at the same time, this objective was not conducted. The information collected from the 243 surveyed lots indicate that:

- About 64% of packers have been applying the fungicides through thermo-nebulization (Fog or aerosol), 21% on the packing line and 3% only through drench at harvest.
- Similar studies conducted on apple revealed an uneven distribution of fungicide residues when applied through fog or aerosol inside the storage room and also within bins.
- Trials on apples also revealed that decay on wounded fruit may show up earlier on fruit treated dry than those drenched at harvest.
- Dry application of fungicides will likely reduce incidence of blue mold and Mucor rot in storage but may have a lower efficacy against most field pathogens which initiate infections months or weeks before harvest.
- Rotation of Pristine and Merivon with Topsin-M seemed more effective than solo applications

Objective 4: *Evaluate the impact of applying fungicide mixtures in orchards on postharvest decay and resistance development.*

- Delaying harvest, a week to 10 days after commercial maturity increased decay significantly on fruit stored for 8 months. The grower at the commercial orchard where the trial was conducted harvest at the later date.
- Adding Ziram to Pristine or Merivon preharvest, reduced postharvest disease losses by 15 to 50% compared to Pristine or Merivon solo.

RESULTS AND DISCUSSION

Objective 1. *Prevalence of postharvest diseases*

As in 2017, gray mold (*Botrytis*) was predominant in both states with average frequencies of 43 and 24% in WA and OR, respectively (Figure 1). Incidence of blue mold (*Penicillium*) in OR decreased significantly from 25% in 2017 to 8% in 2018, whereas blue mold frequency in WA remained the same as in 2017 around 10%. We have noticed a sharp increase in the incidence of *Phacidiopycnis* rot in both states in 2018 but specially in OR where it jumped from 7% in 2017 to 22% in 2018. The incidence of *Nectria* rot increased in OR in 2018 compared to the previous season and remained steady in WA around 4% of total decay (Figure 1).

Besides the group of other diseases which is made of some minor diseases and few unknown pathogens, about 60% of the total decays is caused by pathogens infecting fruit in the orchards versus 25 to 28% of total decays caused by typical postharvest pathogens such as *Penicillium*, Mucor and *Cladosporium*. This strongly indicates that while postharvest disease management efforts are needed, preharvest management should be enhanced and started earlier than the 2 weeks to few days preceding the harvest.

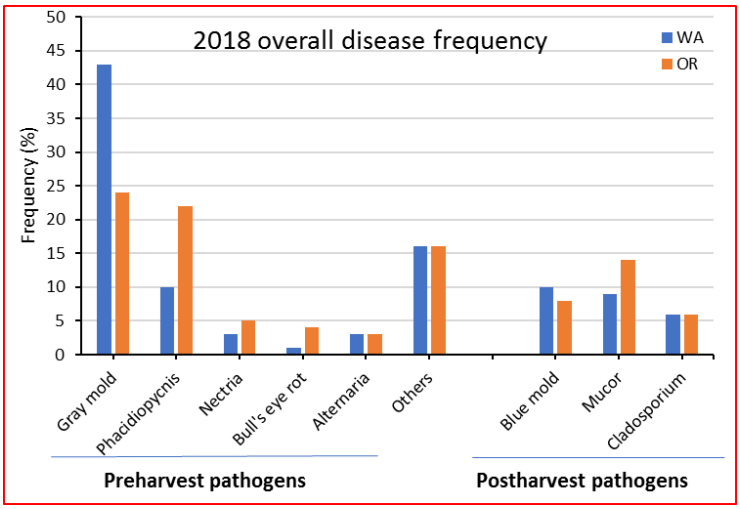

Figure 1. Overall incidence of major postharvest diseases found in in 2018 in Washington State (blue bars) and Hood River, OR (orange bars). Results are average from 119 growers lots.

Objective 2. *Fungicide resistance occurrence and frequencies*

A total of 480 isolates of *Penicillium expansum* (blue mold) and 1030 isolates of *Botrytis* (gray mold) were collected from the different packinghouses surveyed in 2018 (Objective 1). These isolates were tested for sensitivity to 6 fungicides: thiabendazole (Mertect), pyrimethanil (Penbotec) and fludioxonil (Scholar) for both *P. expansum* and *Botrytis* and to pyraclostrobin + boscalid (Pristine) and fluxapyroxad (Merivon) for *Botrytis* only. Overall, resistance frequencies of in *P. expansum* (blue mold) decreased sharply to TBZ and Penbotec compared to 2017 because most packers switched to Scholar application at harvest in 2017-18 season. The frequency of *P. expansum* isolates with reduced sensitivity to Scholar increased a bit in 2018 as a result of the switch to this fungicide but the resistance frequency remains relatively low around 10%.

On the other hand, resistance frequencies to *Botrytis* (gray mold) in 2018 decreased for TBZ by about 55% than in 2017 whereas frequencies remained steady for the other fungicides. The most worrisome finding is that resistance to Penbotec remained high around 60% of the total population in 2018 but variations were observed between lots. Overall, resistance frequencies were similar in WA and OR for *Penicillium* but were slightly higher in OR for *Botrytis*.

More details and specific numbers will be shared at the Pear Review meeting in February 2019.

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- ❖ Dry application of fungicides will likely reduce incidence of blue mold and Mucor rot in storage but may have a lower efficacy against most field pathogens which initiate infections months or weeks before harvest.

Objectives 4. *Evaluate the impact of fungicide rotations and mixtures in orchards on postharvest decay and resistance development*

In 2016, two new pre-harvest fungicides Pristine (new to pear but commonly used on apple) and Merivon were tested as solo or tank-mixed with the multi-site Ziram. Two harvest dates were tested, one at the end of August and the second one in early September.

Except for the untreated control, all treatments resulted in disease incidence lower than 10% on fruit harvested late August, whereas disease incidences ranged from 15 to 33% when fruit were harvested 10 days later in September (Figure 2).

Interestingly, Ziram' s efficacy was equal to that of Pristine or Merivon tank-mixed with Ziram. The inconveniency of irritation caused by Ziram to pickers should be avoided by wearing proper clothing during harvest. Moreover, economically it should be more beneficial to growers to include Ziram in their management programs. We have not tested for fungicide resistance in plots where Ziram was used, but previous studies on mixing single-sites with multi-sites fungicides such as Ziram, thiram or captan has delayed selection for resistance to single-sites such as TBZ and boscalid (Pristine).

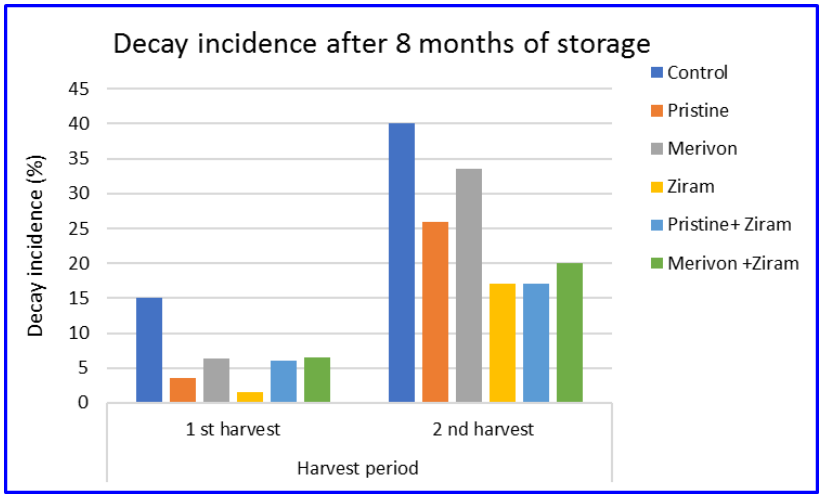

Figure 2. Overall decay incidence on d 'Anjou pear treated with Pristine, Merivon, or Ziram preharvest after 8 months of storage at 33F in a regular atmosphere. 1st harvest was done in 1st week of August 2016 followed by a 2nd harvest 10 days slater.

Additional trials were conducted in the 2017-18 season including Topsin-M, Merivon, Pristine and Ziram applied as solo products, rotated or tank-mixed. Results indicated that Pristine alone or rotated with Topsin-M was the most effective, whereas the rotation of Merivon with Topsin-M or tank-mixture of Merivon + Ziram improved the efficacy of Merivon. The full results will be presented and discussed at the Pear Review meeting in February 2019

EXECUTIVE SUMMARY

Summary of findings:

The traditionally-known disease threats such as blue and gray mold, in addition to the emerging new pathogens, mostly reported from Washington, have put a tremendous pressure on growers and packers in recent years in term of improving management and reducing losses. We first worked to accurately assess the real threats and their extent to develop sustainable solutions. We conducted two years of regional (WA and north OR) decay surveys combined with a regional fungicide resistance monitoring to assess any possible impact in recent shifts in cultural and management practices and climate change on emergence or exacerbation of pathogen populations or increased fungicide resistance frequencies. Such information was highly needed to improve fruit production sustainability. Fungicide resistance monitoring programs will be crucial to pinpoint location-specific problems, evaluate the potential impact of environmental conditions between regions and different spray regimes on resistance development. Moreover, the impact of target and no-target sprays in orchards as well as storage conditions on decay control efficacy and potential resistance development problems need to be assessed to improve disease management.

Summary of findings: We have a better understanding of the risks caused by pear pathogens in term of occurrence, distribution and importance. More specifically, we acquired new knowledge about the emerging quarantine pathogens (*Phacidiopycnis, Nectria*) in term of importance and distribution and control of *Phacidiopycnis*. One the major outcomes from the project is a better assessment of existing risks of fungicide resistance in pear fruit systems in Washington and North Oregon. Although, resistance has emerged to most fungicides, levels of resistance can be considered lower compared to other crop systems. However, caution is needed to avoid catastrophic scenarios due to control failure if resistance continues to increase because rationale solution and practices are not implemented. We have documented a positive effect on control level of adding multi-site fungicides such as Ziram to pre-harvest spray programs either solo, in rotation or tank-mixed with other single-site fungicides.

Project Outcomes:

- Peer reviewed publications: 2 (3 more pending)
- Extension publications: 5
- Professional presentations: 8
- Extension presentations: 25

Future directions:

- Develop specific management programs for major diseases: Gray mold and Blue mold
- Better understand the epidemiology of preharvest pathogens to enhance management in storage.
- Acquire more knowledge about the emerging (quarantine) pathogens such as *Phacidiopycnis* and *Nectria* in term of epidemiology and best management practices.
- Continue research efforts in assessing the effect of storage conditions on decay and fungicide resistance development and develop adequate solutions.