Project Title: Improved timing for initial SWD sprays in blush and dark sweet cherry

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Total Project Request for Year 2 Funding: $18,249

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WTFRC Collaborative Costs: None (OSCC Project)

Budget 1
Organization Name: Oregon State University, Agricultural Research Foundation
Contract Administrator: Charlene Wilkinson
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Item	2021	2022	TOTAL
Salaries[1]	6,750	6,953	13,703
Benefits[2]	4,772	5,014	9,786
Wages (Hourly)[3]	3,360	3,360	6,720
Benefits	0	0	0
Equipment[4]	3,500	0	3,500
Supplies[5] **(Insect colonies, cups, cages)**	460	320	780
Travel[6]	580	580	1160
Miscellaneous	0	0	0
Plot Fees	0	0	0
Total	21,443	18,249	$39,692

Footnotes: [1]Faculty research assistant Heather Andrews, 0.15 FTE. [2] Benefits, Faculty Research Assistant (0.70). [3]Wages for student assistant at $14.00/hr and 30 hr/wk for 8 wk (no OPE associated or permitted). [4]Approximate cost for colorimeter and firmness tester unit. [5] Approximate cost for insect rearing, supplies such as cages, traps and lures. [6] Travel is based on OR mileage reimbursement rate ($0.58/mile) for 100 miles per week for 10 weeks (1k miles) to travel to and from field sites.

OBJECTIVES

This project was intended to help address the issue of SWD risk in blush and dark sweet cherry as a function of fruit maturation variables including fruit size, color, firmness, pH, brix, and heat unit accumulation as well as by examining potential for traps to predict risk. We worked at two Willamette Valley orchards where we have excellent cooperators and access to multiple cultivars with unsprayed fruit, so that we can examine risk factors in blush compared to dark cherries. Our goal is to improve understanding of SWD fruit infestation risk and to evaluate potential tools that can more effectively inform growers about risk.

Objective 1) Associate cherry ripening factors with attack by SWD. As fruit ripen, we are quantifying fruit ripening data including color, brix, pH, hardness, size along with SWD damage and infestation data to associate ripening factors with natural and induced damage and infestation by SWD.

Objective 2) Associate environmental and trapping data with fruit ripening and SWD attack. SWD will be monitored on-site with traps and data loggers will be used to capture environmental data to associate with ripening factors and SWD infestation data at each site. These data will help make the results more broadly applicable to other cherry production regions.

Objective 3) Analyze all variables to determine relative importance and distill results into digestible, easily implemented grower recommendations.

SIGNIFICANT FINDINGS

- We followed color development in 5 cherry cultivars, both blush and dark, to associate color with SWD fruit infestation data and trap captures.
  - Our goal is to use simple RGB color analysis that could be captured in the field with a cellphone.
  - We used photos of fruit and RGB analysis in the open-source image analysis software ImageJ to demonstrate color trends in fruit as it ripened.
  - For cv. 'Rainier', increasing red and blue and decreasing green occurred as fruit matured (Fig. 1 from 2021 report). More analysis is needed for the 2022 color data.
  - Color data for both years need to be aligned on a degree day scale to determine how color variables relate to environmental variables and probability of attack by SWD

- We examined the capture of SWD on dry and wet traps to evaluate the relationship between captures and SWD fruit infestation data. Two Trece lure formulations were evaluated along with one AlphaScents trap in 2021. In 2022 we dropped the AlphaScents trap because it was not catching SWD. In 2022 we added the Scentry liquid trap as a sensitive standard. We also had to change Trece traps because the specific lure was discontinued. Instead, we evaluated the dry vs. the liquid version of the Trece broad spectrum lure. Three reps of each trap were deployed at each site.
  - From 2021 we reported that SWD were caught in Trece dry traps starting in mid-June. We reported the highest numbers were found at the higher elevation site (potential heat evasion strategy), and some interesting trends were detected:
    - The broad-spectrum lure caught the most SWD
    - While the broad-spectrum lure did have more by-catch, on rare occasions the specific lure had huge by-catch
    - By-catch increases time required to count SWD on the sticky cards and could affect captures of SWD by occupying space on the card.

        - There was a very strong correlation between male and female SWD caught on the broad-spectrum trap, though the trap caught mostly females.
            - The strong correlation between male and female captures suggest that only males could be counted, and the number of females estimated with strong confidence.
            - Counting just males based on presence of wing spots could save time when checking traps.
    - From 2022 trapping data we see that the Scentry trap is far more sensitive than the two Trece trap types (**Fig. 1)**. However, increased sensitivity is only beneficial if it results in detections when other traps are not working and thereby informs about population trends that are difficult to detect. However, that was not the case, when the Scentry trap was catching SWD, so were the Trece traps, just at a lower rate (**Fig. 2)**. This suggests that much labor can be saved by counting flies on panel traps rather than dealing with liquids.
        - The earliest detections in mid-May preceded infestation of the crop (**Fig. 2)**
        - Very few flies were being captured at the time when the first infestions of fruit occurred in mid-June.
        - The Scentry trap and Trece liquid traps had the strongest linear relationship between male and female captures (**Fig 3)**. The dry red panel Trece trap appeared to be more attractive to males, as there were multiple occasions where males were caught but females were not.

- Firmness and size of fruit were captured by the FirmTech machine on a weekly basis for 5 cherry cultivars, both blush and dark.
    - These firmness data followed distinct trajectories that can be easily modeled (**Fig. 4**)
    - 2022 was a much cooler season than 2021, and this was evident by the delayed softening of fruit in 2022 (**Fig. 4**).
    - Individual varieties showed distinct trajectories in softening, indicating that risk of SWD attack differed by variety.

- We also examined pH and Brix trends to associate these variables with fruit infestation data and trap captures. There were major differences between the cultivars depending on the time of sample, we reported on this in 2021.

- First detections of infested fruit in both seasons were in early June (**Fig. 5**). There were far more detections of natural infestation in 2022 vs. 2021. Wild detections coincide with initial softening of fruit.

- Another tactic we used to evaluate fruit susceptibility was to artificially infest fruit harvested fruit with SWD reared in the lab (**Fig. 6**). Fruit first became susceptible in late May in 2021 and in early June 2022.

- Data loggers were deployed in the field sites and these data will ultimately be used to calculate heat units to associate with all of the other variables (not analyzed yet).

- Nonlinear multivariate analysis will ultimately be performed on all the variables to better understand their relative power to predict fruit infestation. This analysis can be used to produce a cherry risk model (not analyzed yet).

METHODS

Objective 1) We sampled untreated fruit from two blush (Rainier and Royal Anne) and four dark cherry varieties (Benton, Skeena, Sweetheart, and Van) every week. We originally planned to sample just two blush and two dark cherry varieties, and to sample every 2-3 days, but logistically we could not achieve this. We determined color of fruit from RGB (Red, Green, Blue) analysis using the open-source software ImageJ, not as determined by colorimeter as originally planned. Firmness of fruit was determined by FirmTech machine. Originally, we had planned to use penetrometer nfor the firmness data and the FirmTech was a big improvement. Dissolved soluble solids of the fruit was measured by refractometer, and pH of fruit as measured by digital pH meter. These fruits were assessed for signs of SWD damage. We then used the saltwater test on a subsample of fruit to evaluate infestation level. SWD emergence was monitored from a random collection of 100 fruit (representing more than 20 cultivar/rootstock combinations). These fruits were brought back to the laboratory and oviposition damage by SWD was estimated under magnification Fruit were placed in cups (we originally planned to use cages) to allow any SWD emerge. After two weeks, the number of adults that had emerged was determined. In addition to rearing wild SWD, a subset of collected fruit with no visible signs of damage were exposed to laboratory colonies of SWD to determine fruit susceptibility. For this experiment, we added a male and female SWD from our laboratory colony to individual fruit in cups and subsequently evaluated success of SWD to attack and reproduce on the fruit.

Objective 2) We evaluated commercial dry SWD traps which were monitored weekly to determine relationships of trap captures to other measured parameters of fruit ripeness and SWD infestation levels of fruit, and b) temperature data loggers will be placed in trees at research sites to calculate growing degree-days as the time scale for all data. Traps will be placed in untreated as well as treated areas of the orchard as well as natural borders at cooperator farms and will be checked at each orchard visit (Obj. 1). Data loggers will be placed in tree canopies as soon as Jan 1 to allow precise calculation of growing degree days at each site.

Objective 3) Ripening parameters will be associated fruit infestation rates by SWD for blush and dark cherry varieties and will be distilled down to make simple grower-oriented rules for initial treatments against SWD for commercially relevant cherry varieties. For example, simple rules for guiding management timing and fruit susceptibility to SWD attack based on the accumulation of growing degree days could be helpful metrics that would not require trapping or frequent monitoring of fruit. It will also be important to examine SWD susceptibility as a function of ripening asynchrony, i.e., SWD risk quantified as a percentage or proportion of all fruit. For example, what proportion or percentage of susceptible fruit should be considered a risk factor. Comparison of different varieties will provide an interesting basis for comparison of results. Results will be summarized in an Extension document targeting PNW commercial cherry growers (regional).

RESULTS

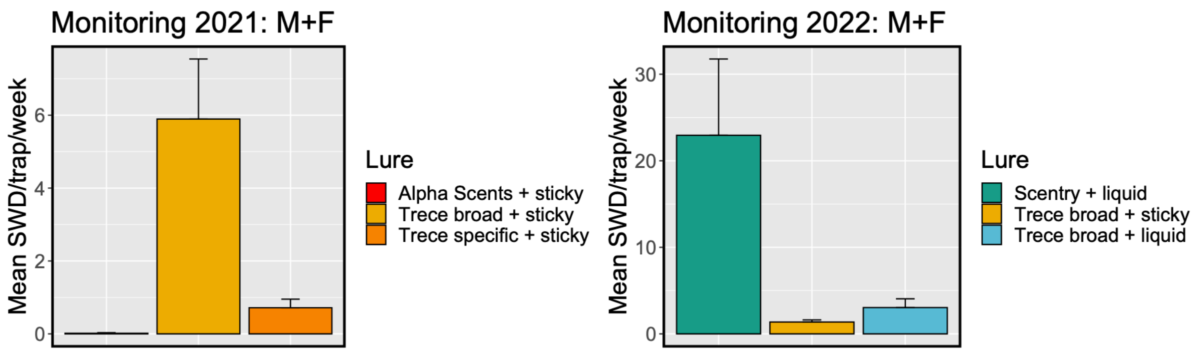

Figure 1. *Captures of SWD on' traps at the two cherry orchards. Alpha Scents was not used in 2022, Trece specific lure not available in 2022.*

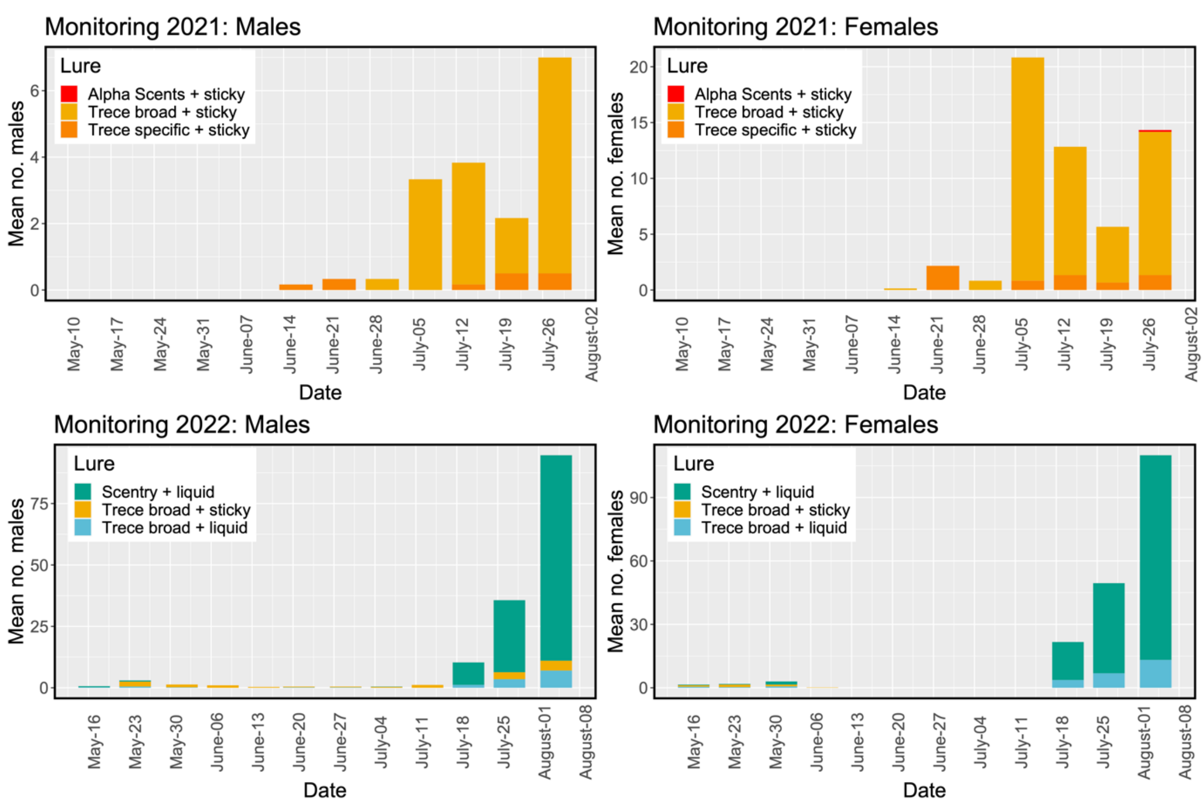

Figure 2. *The monitoring objective was modified in 2022. The AlphaScents trap was not used due to lack of captures in 2021, and the Trece narrow spectrum lure was no longer available. We instead compared the sensitive Scentry trap to the Trece broad lure in both a dry panel and liquid configuration. The Scentry trap was very attractive later in the season but caught comparable SWD numbers to the Trece traps early in the season. Trap captures were very low at the time of first fruit infestation.*

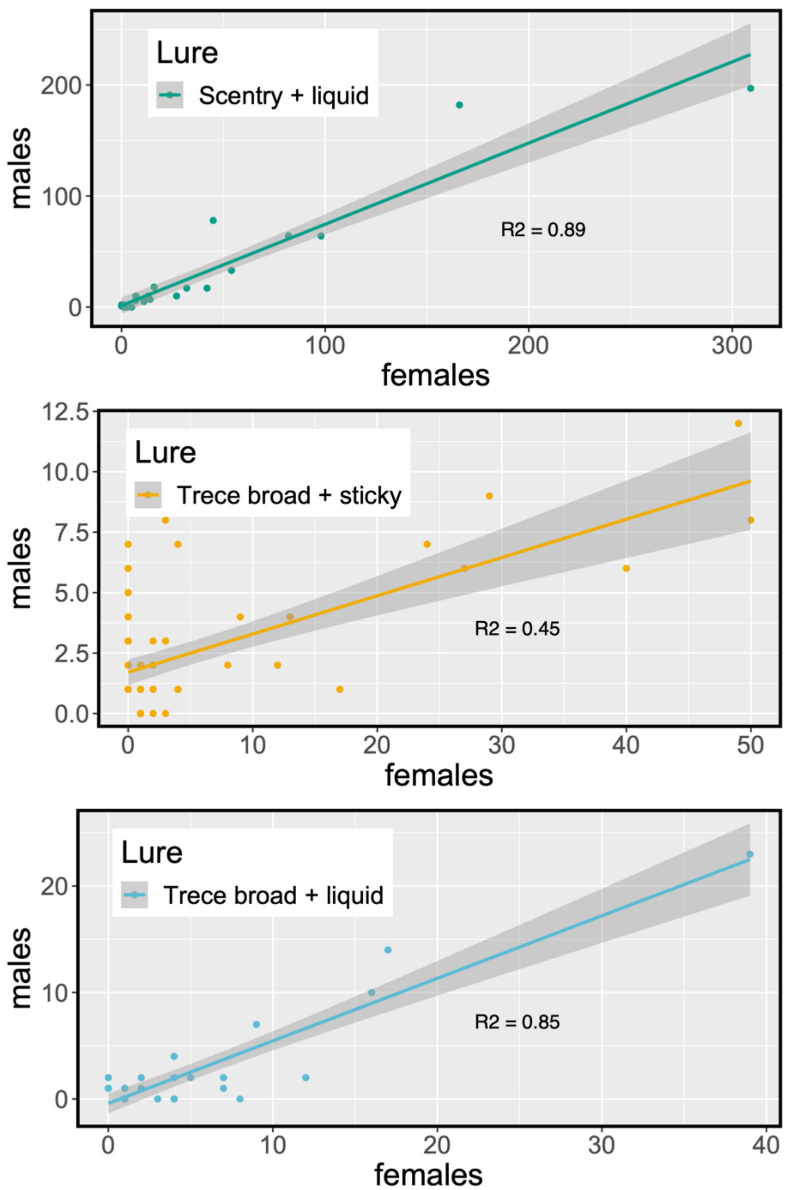

Figure 3. *The relationship between male and female captures was not the same for all traps. The Scentry trap and Trece liquid traps had the strongest linear relationship between male and female captures. The dry red panel Trece trap appeared to be more attractive to males, as there were multiple occasions where males were caught but females were not.*

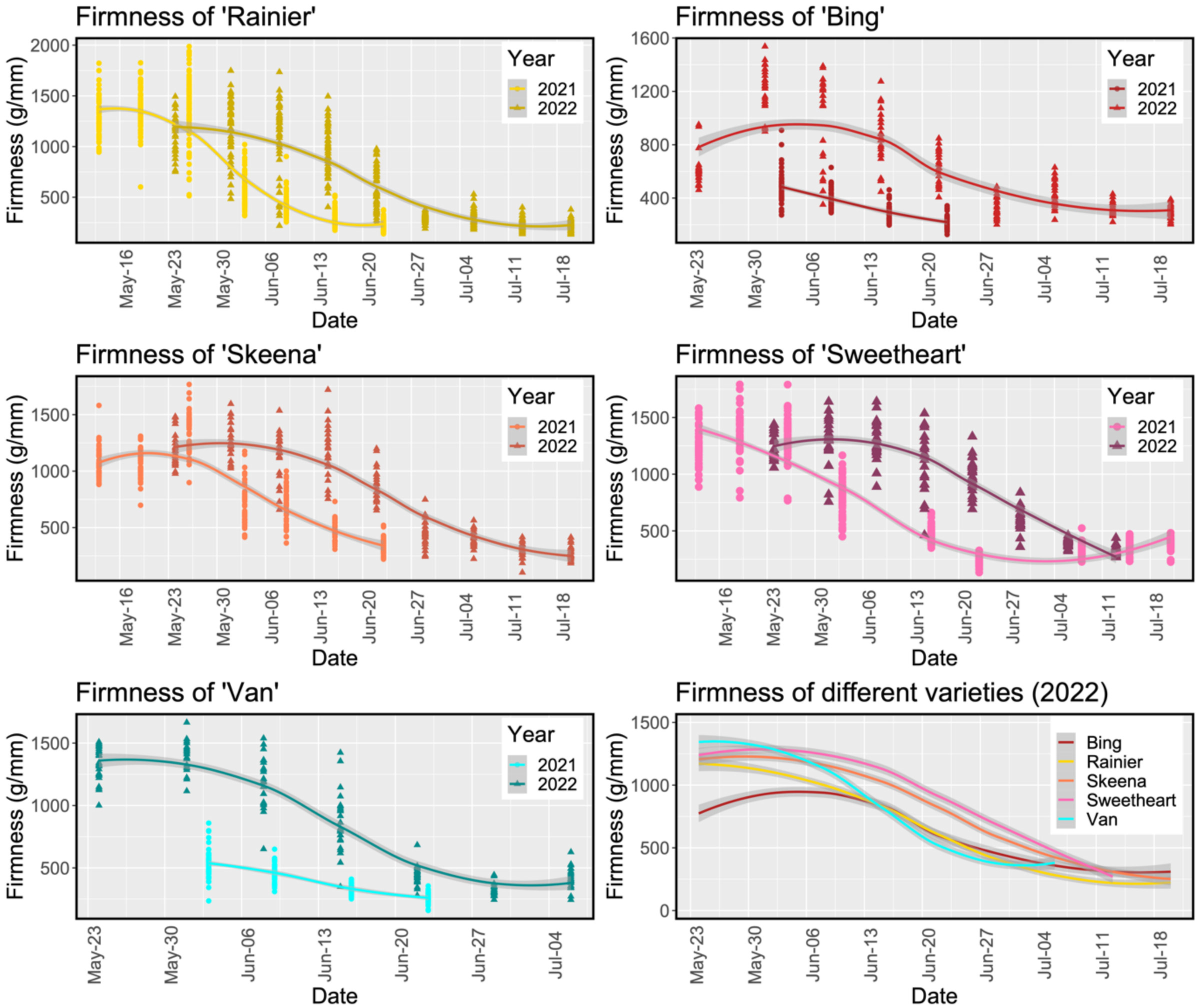

Figure 1. *Firmness of all varieties in 2021 and 2022 as determined by the FirmTech. Firmness followed a very well-defined pattern that can be modeled with high confidence. There was a clear difference in firmness from 2021-2022. The cooler 2022 season delayed fruit maturation by about 3 weeks at the beginning of the season. Environmental effects can have a strong influence on optimal spray timing. Differences in maturation between the varieties also indicates fruit susceptibility to attack by SWD varies by variety. 'Skeena' and 'Sweetheart' are predicted to have delayed susceptibility compared to the other varieties examined.*

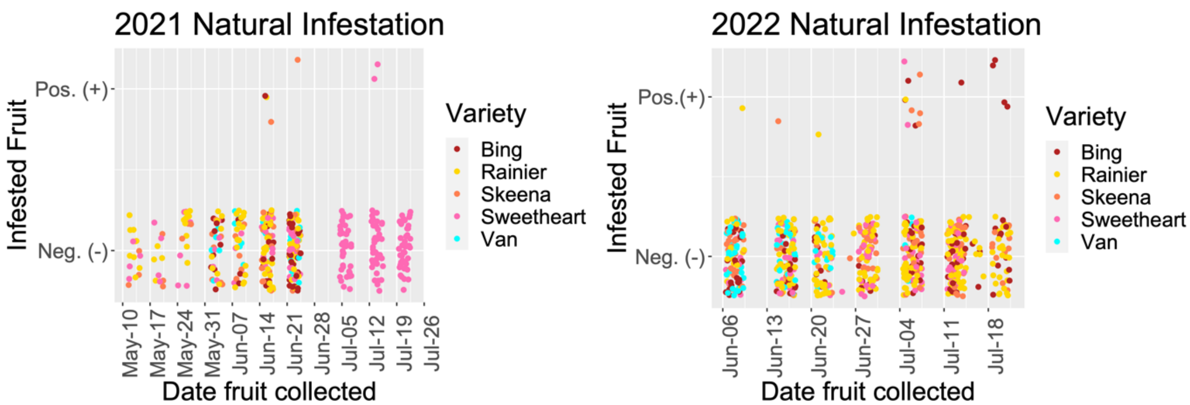

Figure 5. *Natural infestation of all varieties in 2021 and 2022. First detections of infested fruit in both seasons were in early June. There were far more detections of natural infestation in 2022 vs. 2021. Wild detections coincide with initial softening of fruit.*

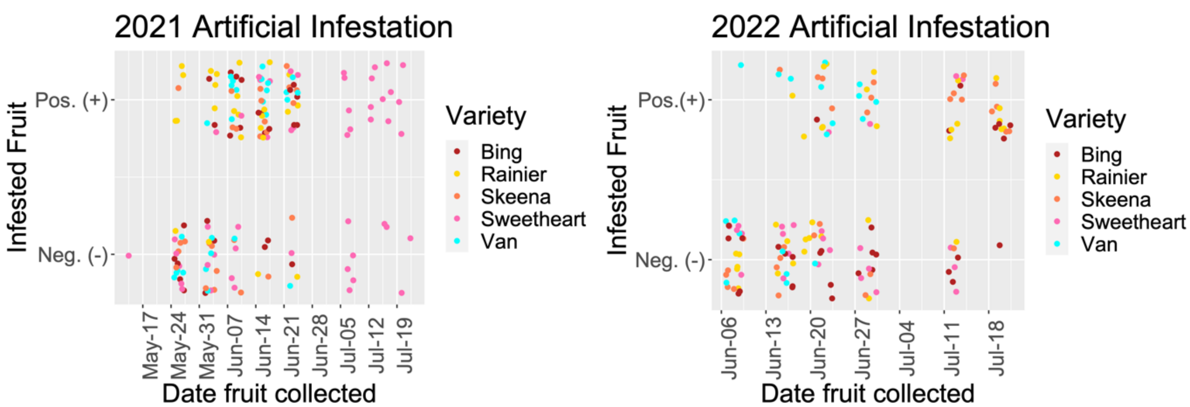

Figure 6. *Artificial infestation of all varieties in 2021 and 2022. These fruit were collected from the field and then SWD were added to determine if fruit were susceptible to attack. These data indicated more of the fruit were susceptible than suggested by the naturally infested data.*