Further investigation of hand-applied mating disruption for San Jose scale in sweet cherries

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Introduction. San José scale (SJS) was brought into California from China in the early 1870s and quickly became a serious pest of apples, peaches, and plums. SJS spread rapidly across the U.S. and became a pest of tree fruits in nearly all production regions. Since the mid-2000s, SJS has been increasingly problematic in sweet cherries in northwest Michigan, and more recently, this pest has continued to contribute to substantial tree health decline, death, and loss of production. Despite the use of recommended SJS control measures, growers have sustained economic losses due to the build-up of SJS populations in orchards.

In 2019, we investigated the efficacy of hand-applied mating disruption (MD) for SJS in commercial sweet cherry orchards. This project entailed the release of large amounts of synthetic sex attractant (pheromone) into participating orchards with the intent to interfere with SJS mating. Our preliminary results suggested that MD effectively disrupted SJS mating behavior. We repeated the trial in 2020 as well as started to investigate the potential to apply MD every other year as a cost-saving strategy. Our goal is to find an effective and economically viable alternative to insecticide-dependent SJS management programs, particularly as these insecticide-alone measures have not provided adequate control of this pest.

This project addressed the Michigan cherry committee research priority of insect protection via IPM efforts. The Japanese company, ShinEtsu, produced an experimental dispenser containing SJS pheromone that has shown a high level of season-long MD in their preliminary field trials. In the 2019 and 2020 seasons, we tested the efficacy of these dispensers in commercial sweet cherry orchards.

Objective 1. *Determine the field efficacy of a hand-applied MD formulation designed for SJS control.* We hypothesized that there will be differences in the number of male SJS and crawlers in plots treated with dispensers compared with untreated plots.

Objective 2. *Evaluate the efficacy of different SJS MD strategies.* We hypothesized that different MD strategies will impact SJS efficacy and populations in orchards. We predicted that plots that receive two years of MD will result in the best efficacy compared with growers' standard, non-disrupted plots.

Methods. To confirm 2019 results, we repeated our on-farm MD trials in 2020 at the same five commercial sweet cherry orchards where the 2019 research was conducted. Within each orchard, field plots consisted of half to one-acre plots separated by a buffer of similar size; the experiment was replicated by farm. In both years, growers managed the blocks using standard management programs. To address Objective 1, the effectiveness of Isomate SJS in the orchard was directly compared to an insecticide-only check, the growers' standard (GS). To address Objective 2, two additional treatments: MD every year, and MD alternate year were incorporated into the trial. There were four treatments in the 2020 trial (Table 1). Two dispensers per tree or

Table 1. 2020 SJS MD Experimental Treatments

Treatments	MD in 2019 (Yes or No)	MD in 2020 (Yes or No)
MD every year	Yes	Yes
MD 2019	Yes	No
MD 2020	No	Yes
Grower Standard (GS)	No	No

~200 per acre were deployed in late May in treated plots; the same rate was used in 2019.

We measured and compared the number of SJS males that we captured in the different treatments using Trécé Pherocon V San Jose Scale pheromone-baited traps. Four traps in a square-grid orientation were placed in each plot for a total of 16 traps per orchard site. Traps were replaced and counted weekly during the first and second SJS flights. We also monitored for crawlers, but unlike data from 2019, no crawlers were found in any of the plots in 2020.

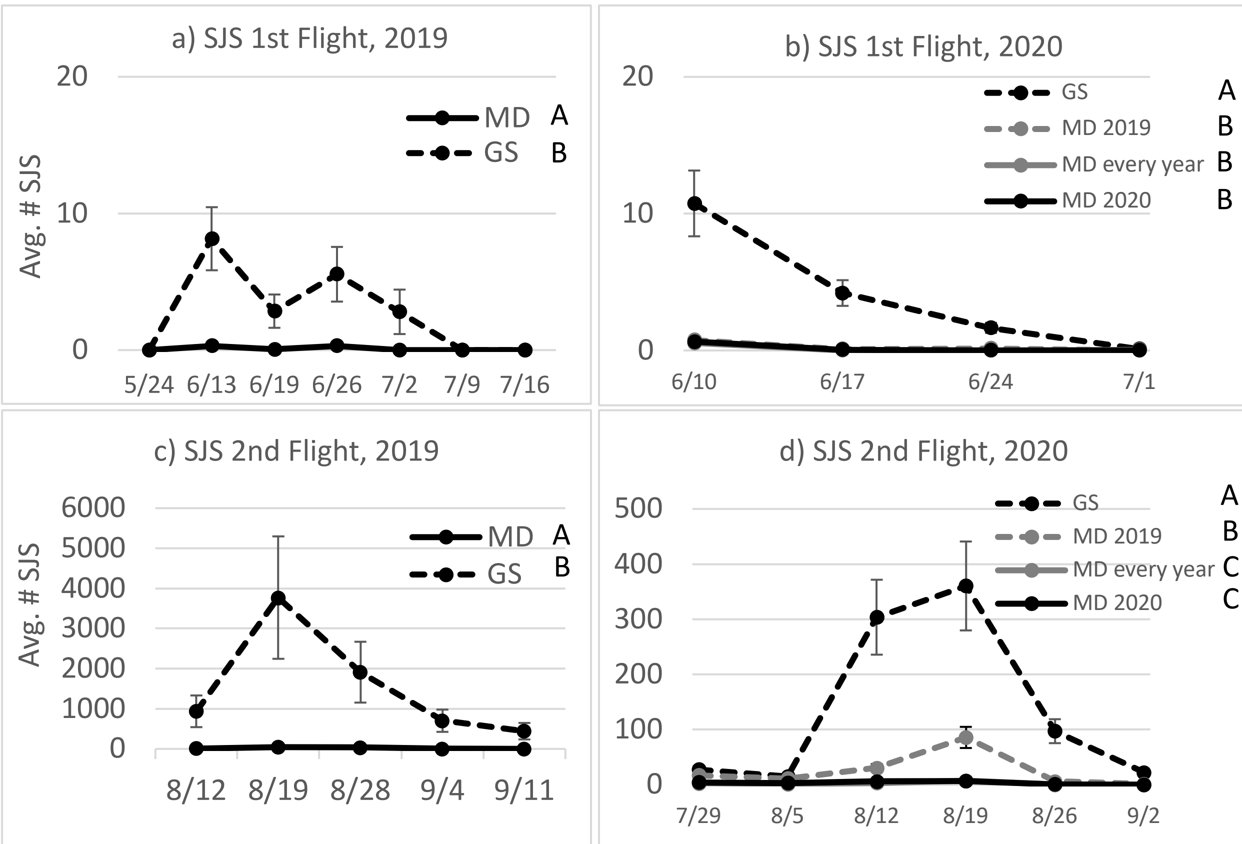

Fig. 1 (a-d). The average number of San Jose scale (SJS) on traps per treatment per week during the first flight in 2019 (top left) and 2020 (top right) and during the second flight in 2019 (bottom left) and 2020 (bottom right). Treatments followed by a different letter tested significantly different from each other (P<0.05) using non-parametric Wilcoxon signed rank test.

Results and Discussion. Our 2020 results corresponded with 2019 data when comparing plots treated with MD to plots that never received MD (i.e. GS, grower standard). There were significantly higher captures of SJS in the GS compared with plots that received MD in 2019 and 2020 (Fig.1a-d). Similar to 2019, the 2020 trend was especially strong during the second flight when trap captures were a hundred times higher in the GS (Fig 1d). In MD treated plots, we observed 'trap shutdown' where very few or no SJS were captured throughout the season (Fig.1a-d). These results suggest that MD at a rate of 200 dispensers per acre (i.e. ~two per tree in a standard planting of sweet cherries) is an effective SJS management strategy.

We also found interesting impacts on SJS trap numbers when MD was used in alternate years. During the first flight, there was no difference in captures among MD treatments (i.e. MD every year, MD 2019, and MD 2020) (Fig. 1b). We caught significantly fewer SJS in these three treatments compared with the GS (Fig. 1b). This finding was unexpected; we predicted that plots that received MD in 2019, but not in 2020 would have resulted in higher SJS compared with plots that received MD in 2020. This result suggests that MD worked so effectively in 2019 that the benefit of reducing the population extended into the spring of 2020.

During the second flight, we observed separation among treatments (Fig. 1d). First, we observed almost no SJS on traps in the MD every year and MD 2020 treatments; these two treatments were not significantly different from each other (Fig. 1d). While the SJS numbers remained the highest in the GS, SJS started to rebound in the MD 2019 treatment during the second flight (Fig. 1d). As a result, SJS numbers were significantly greater in the MD 2019 treatment than in the MD every year and MD 2020 treatments, but still substantially lower than the UTC (Fig. 1d). These results further demonstrate that MD is working and also suggest that using MD in alternate years could be an effective strategy for reducing the population of SJS in sweet cherry orchards. Unfortunately, because there is currently a gap in the scientific literature of the relationship between pest density and damage, it is still uncertain whether the reduction of SJS in the alternate year program would be considered acceptable control. Based on our findings, we can conclude that MD provided better SJS management than the growers' standard management practices.

Next Steps. Over the past two seasons, our novel SJS MD research has provided a foundation for developing alternative management solutions for this difficult pest. Nevertheless, we still have much to learn. For example, the economic threshold for SJS is unknown and future research is needed to gain a better understanding of the relationship of pest density and damage. We are working with MSU fruit entomologists and horticulturalists to try to address this challenge. Moving forward we would like to continue refining implementation strategies. The first logical step is to carry out the SJS MD alternate year disruption strategy for one more season to complete the alternate year cycle. This additional year of data would confirm our findings from the 2020 season to understand whether alternate year MD is a viable strategy.

Additionally, dispenser density research conducted by our project collaborators Gut et al. in the 2019 and 2020 field season in apples resulted in two key conclusions. Firstly, the mechanism for SJS disruption appears to be competitive, meaning that each dispenser is competing with actual female SJS in the field for the attention of the males. Hence, in this scenario, the appropriate dispense rate for effective disruption is related to the level of infestation in the orchard; the higher the infestation, the more dispensers needed for effective control, and vice versa. However, this research was conducted in an orchard with high SJS pressure, and the results suggested that there is a point of diminishing returns which led to the second key discovery. They found that a rate of 100 dispensers per acre provided comparable results to the higher dispenser rates (200 per acre) that we used in our 2019 and 2020 research. Therefore, in 2021, we would like to verify this finding in the field by evaluating the efficacy of a reduced rate of dispensers (100 per acre or ~one per tree in a standard MD an affordable IPM option for cherry growers.