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Update on Entomology Research in Dried Fig

Navel Orangeworm & Driedfruit Beetle are Key Pests

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Dried fig is a traditional crop for the Fresno-Madera-Merced area. While this crop has a 100+ year-old history in the state, the industry has changed significantly over time. Fig growers still primarily produce dried fruit, although the California industry has shifted from a Calimyrna-dominant industry to one that is today primarily comprised of Black Mission, Tena,

Fig 1: NOW Larvae in a Late Season Mummified Fig Fruit (Credit: Phoebe Gordon)

and Conadria varieties. The two most significant insect pests in fig are navel orangeworm (NOW) (**Fig. 1**) (Amyelois transitella) and Nitidulid beetles, which are a complex of three Carpophylus species that infest ripe fruit. The predominant species in California is the driedfruit beetle (DFB) (**Fig. 2**) Carpophylus hemipterus. All of these insects cause direct damage to the fruit, as well as carry in organisms that cause spoilage. NOW and aflatoxin are correlated in nuts such as almond and pistachio, and while aflatoxin can be found in figs, its connection to NOW infestation remains unclear.

Survey work in the early 2000s (Burks and Brandl 2004) indicated that a little more than half of the insect damage to figs was due to DFB while approximately one third was due to NOW. Since that time, nut crop acreage has increased dramatically, and with that has come increased populations of NOW. Given the changes to the fig

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Fig. 2: Driedfruit beetle (DFB) larva and adult

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industry and the dominant crops in the Central Valley, we wanted to evaluate the use of mating disruption for control of NOW. An earlier study (Burks and Brandl 2004) examined the use of mating disruption in figs, which was shown to shut down traps baited with a virgin female NOW lure, but was ineffective at reducing NOW damage. Today, there are now four commercially available mating disruption products with improved technology, all of which have been shown to be effective in almonds. Can mating disruption control NOW in figs?

NOW Mating Disruption Trial

With support from the California Fig Institute, we conducted a two-year study in fig orchards in 2018-2019 to evaluate the efficacy of Cidetrak meso emitter (Trece Inc.) mating disruption for control of NOW. Field sites consisted of paired 30-acre blocks, one with mating disruption and the other without. There were three sites in 2018 and five sites in 2019. Sites consisted of Tena and Conadria in 2018 and Black Mission figs were added in 2019. The Cidetrak meso emitters were hung from the tree canopy at a density of 20 emitters/acre starting in mid-April. Meso emitter degradation was monitored every two weeks in order to quantify how quickly pheromone was dispensed over the course of the season.

Activity of NOW was monitored at the edge and interior of orchard blocks using three types of traps: a) wing-traps baited with synthetic pheromone lure (Suterra BioLure) to trap males, b) a pistachio/almond meal bait bag (Peterson Trap Co.) in 2019 to trap females, and c) a phenyl-proprionate (PPO) lure (Alpha Scents in 2018, Trece in 2019) to trap males and females. Each lure went into its own trap and all traps were spaced far enough apart so as to not interfere with neighboring traps.

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While pheromone and Peterson traps were placed at the center and edge of plots, PPO traps were only placed at the center of the plot. Trap liners were replaced weekly April – November and trap baits were replaced every month.

In 2019, crop damage in plots with and without mating disruption was evaluated by the CDFA Safe Food Alliance (Kingsburg, CA). Their damage assessment measured the level of insect infest (percentage as well as DFB vs. NOW) and spoilage.

In 2019 we also examined the source of NOW trapped in fig orchards by examining adult moth fatty acid profiles. NOW larvae typically develop on a singular host (e.g. almond, pistachio, fig) and this leaves a distinct signature in the composition of fatty acids found in the adult moth. There are many types of fatty acids and plant species produce unique types or ratios. Here, Dr. Burks was able to use these signatures to determine the origin of adult NOW trapped in these fig orchards.

Mating Disruption Shut Down Pheromone Traps, But No Differences in Crop Damage

Mating disruption generally shut down pheromone traps, although as the season progressed in both years, we caught males in pheromone traps even in plots under mating disruption (**Fig. 3 on page 36**). Pheromone emission from the meso emitters was steady over the course of the year and continued emitting pheromone through October (data not shown here). In contrast, female abundance in the Peterson traps was unchanged by the addition of mating disruption, indicating that gravid females were equally active between the two plots. A similar trend was observed in the PPO traps (data not shown). Population trends were found to be similar at the plot edge and interior. Finally, data from the 2019 crop damage assessment showed that mating disruption did not appear to reduce NOW infest (**Fig. 4**).

NOW Movement & Adapting Mating Disruption for Fig Orchards

These trends are not entirely surprising, and the lack of a crop damage reduction is certainly not a reason to rule out the use of mating disruption in figs – at least not yet. Rather, these trends highlight the need to better understand key aspects of NOW behavior in figs, such as the timing of crop susceptibility and the extent to which moths move into fig blocks, and use that information to refine the use of mating disruption in this unique cropping environment. Figs are also unique among tree fruit in that some produce two crops during the year: the breba (first crop) matures in June from fruit that were initiated the previous season and overwinter, and the main crop, which is harvested beginning in August. This study did not examine the role of the breba crop in NOW behavior, which may be an important source of NOW in fig orchards early in the season.

In this study we selected orchards based on whether they were acceptable for our mating disruption trial and did not take into account what the surrounding crop types were. As such, some of the fig orchards in this study were in landscapes dominated by almonds and pistachios, while some were in areas more dominated by figs. It is possible that NOW population dynamics differ between these areas, where almond and pistachio harvest may serve as a catalyst that drives moth movement into fig orchards as tree nuts are removed from the surrounding landscape, and that is something we hope to examine in future work. Fig harvest starts in mid to late August and can continue through October, providing ample time for NOW to move into this crop during tree nut harvest.

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Here, data from the fatty acid profile analysis is critical, as it indicated that in most months of the year about 50% of NOW adults trapped in fig orchards originated on a non-fig host (**Fig. 5 on page 36**). The proportion of moths that developed on figs slowly increased over the course of the season, ultimately reaching 100% in October, at which point most almonds and pistachios had been harvested. It is important to note that this fatty acid data is from a single year of study across five orchard sites, and additional data are needed to more fully understand the timing, extent and drivers of NOW movement into fig orchards from non-fig hosts. We are also missing critical information to fully interpret these results. We do not know when fig fruit become susceptible to NOW infest; while the fruit is not protected by a hard shell like nut crops, immature fruit produces copious amounts of latex, which likely deters insect infestation. We do not know whether NOW moths prefer to lay their eggs in certain crops, or if they only prefer fresh fruit/nuts over mummified fruit. We do not know how important the breba is in NOW population dynamics in figs. We do not know how long it takes for NOW larvae to complete development in fig fruit. It is possible that the proportion of

NOW adults from larvae raised on fig fruit increases in trap catches over the season because there is no significant fig crop for the larvae to infest until August. An alternative explanation is that the moths that developed on nut crops have already mated and laid the last eggs of the season, and the moths caught in fig orchards emerge relatively late.

In addition to moth movement into blocks, it may also be that the use of mating disruption requires some fine-tuning to effectively work in fig orchards. Fig trees present a unique canopy structure that may require a higher density of meso emitters to promote greater diffusion of synthetic pheromone in order to fully disrupt NOW mating. While samples from the meso emitters indicated that pheromone was being released over the entirety of the study period, the arrangement and density of meso emitters used was originally developed for use in tree nuts, and this may not be entirely applicable in the context of a fig orchard.

Crop Damage Assessment Reveals NOW as Dominant Pest

The crop damage assessment also demonstrated that NOW infest now accounts for a little more than 50% of the total insect damage in figs (**Fig. 6 on page 36**). This is an increase from what was observed about 15 years ago, when Brandl and Burks (2004) reported about 30% NOW infest. This is not unexpected given the rapid expansion of nut crops in

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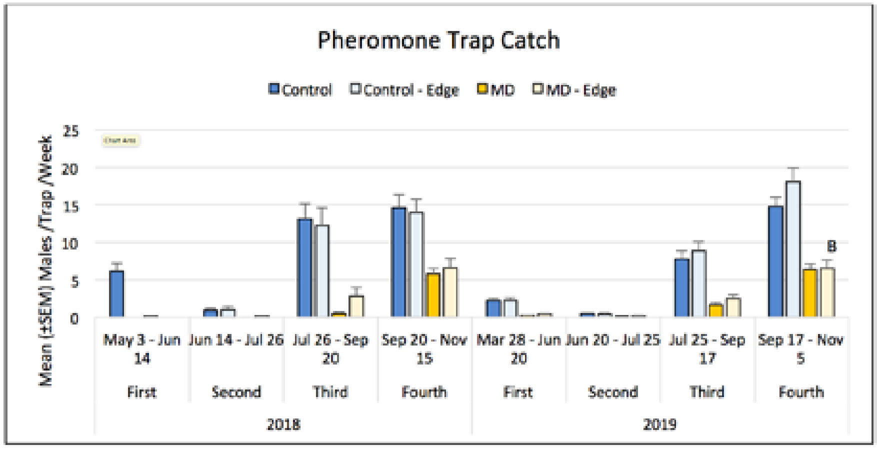

Figure 3. NOW catch was reduced in pheromone traps in mating disruption plots.

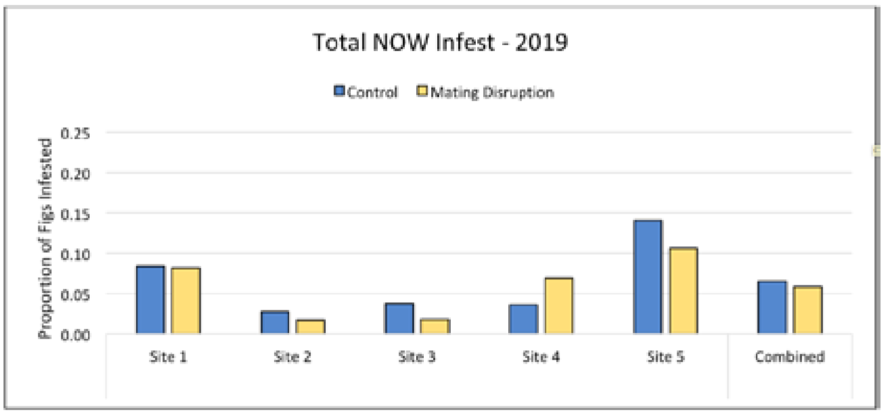

Figure 4. Fig infest from NOW was not consistently influenced by mating disruption.

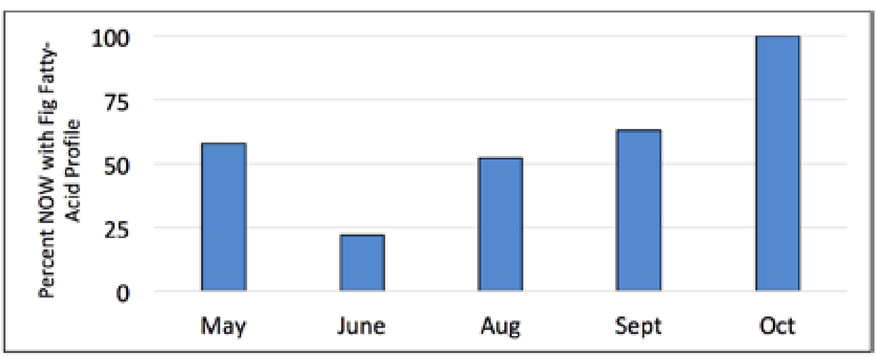

Figure 5. In most months, only about 50% of NOW captured in fig orchards actually originated on figs, indicating that many adults move into fig orchards from non-fig hosts (Data is preliminary as not all moths have been analyzed).

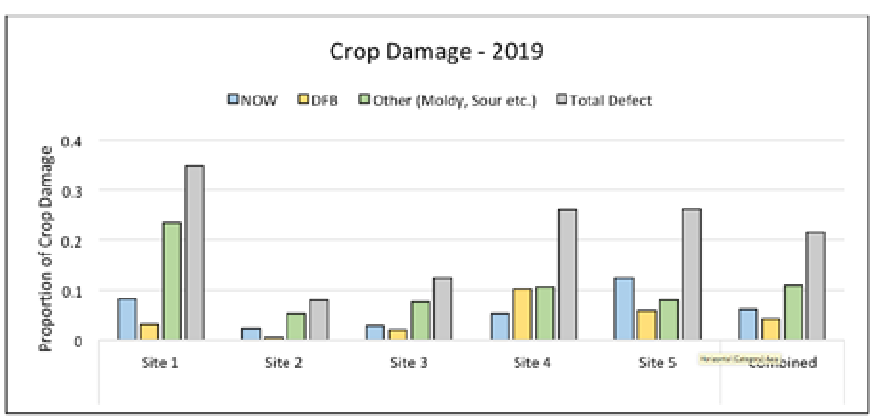

Figure 6. Most insect infest was due to NOW and DFB.

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fig producing areas over this period. It is notable here that the dominant insect pest (NOW or DFB) often varied across orchards, which may indicate varietal differences or an effect related to the amount of tree nuts surrounding an orchard, as described above. While we looked at different fig varieties, this trial was not set up to determine the relative susceptibility of different varieties to insect pests.

Conclusions & Future Directions

This was our first attempt to evaluate the use of a novel mating disruption product in fig orchards. While results found no effect of mating disruption on crop damage, this may be due to a large movement of NOW into fig orchards and/or the need to reconfigure the density or arrangement of meso emitters. Data from the fatty acid profile analysis show that many NOW trapped in fig orchards actually originate on non-fig hosts, indicating some degree of movement between orchards. While mating disruption can reduce NOW populations locally, colonization of orchard blocks by gravid females can occur at orchard edges. For this reason, mating disruption is thought to be most effective when applied over large, contiguous acreage. Finally, density and arrangement of meso emitters may need to be modified to better account for the unique structure of fig orchards. These and other related questions will be the focus of follow-up studies to better understand the behavior of NOW in figs orchards, as well as refine the use of mating disruption in this crop.

Acknowledgements

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