



The Latest Bee Science Distilled

by Scott McArt

Pre-bloom pesticide sprays in apple orchards — safe for bees?

As I write this, it's peak apple bloom here in New York. All the big orchards in our Big Apple state are filled with pallets of hives and the bees are busily doing their thing. Since apples are worth ~\$320 million/year in New York, and apple is also ~90% reliant on insect pollination to produce fruit, those bees are currently delivering ~\$288 million in pollination services.

At the same time, apple growers are protecting their crop from potentially devastating insect pests such as the European apple sawfly and rosy apple aphid, or diseases such as apple scab and fire blight. Most growers apply a variety of insecticides, fungicides and bactericides to their trees

in the fall and prior to bloom to control pests and diseases. Since many of those pesticides are systemic (i.e., they're taken up into plant tissues), they can potentially accumulate in pollen and nectar during bloom and expose bees to harmful chemicals.

So, are fall and pre-bloom pesticide sprays safe for bees? Given the economic importance of apple pollination, any beekeeper, grower or consumer of apples or apple products should want to know. This is the topic for our thirty-first "Notes from the Lab," where we highlight "**Pollinator exposure to systemic insecticides and fungicides applied in the previous fall and pre-bloom period in apple orchards,**" written by Sarah Heller

and colleagues and published in *Environmental Pollution* [114589 (2020)].

For their study, Heller and colleagues actually conducted two different studies. First, the authors applied one of six systemic insecticide or fungicide products to groups of 20-year-old apple trees: Assail 30SG (active ingredient acetamiprid), Calypso 480SC (thiacloprid), Actara 25WP (thiamethoxam), Provado 1.6EC (imidacloprid), Closer 240SC (sulfoxaflor), or Nova 40W (myclobutanil). The pesticides were applied once (5-7 days before bloom) at commercially-recommended rates via a standard airblast sprayer. Provado 1.6EC (imidacloprid) is not labeled for pre-bloom application but was included as a positive control since it's a commonly-used systemic insecticide outside of the pre-bloom and bloom periods.

Second, the authors conducted a fall pesticide treatment on different trees. For this experiment, Heller and colleagues applied one of five systemic insecticide products: Endigo ZC (active ingredients thiamethoxam and lambda-cyhalothrin), Leverage (imidacloprid and beta-cyfluthrin), Scorpion 35SL (dinotefuran), Belay 2.13SC (clothianidin), and Closer 240SC (sulfoxaflor). Each pesticide product was applied 1-4 times via an airblast sprayer in August and/or September according to management guidelines for the brown marmorated stink bug.

For both studies, whole flowers, pollen and nectar were collected at peak bloom for each group of plants and analyzed for concentrations of



A typical apple orchard during peak bloom. Photo Scott McArt

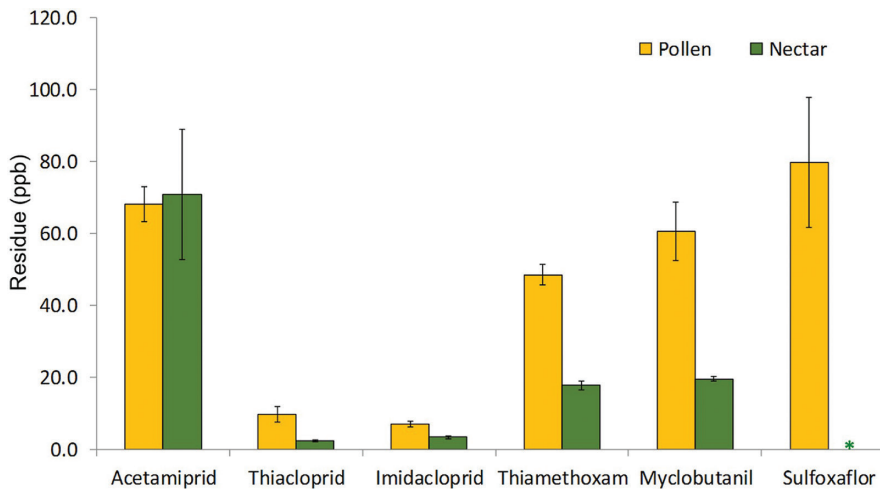


Fig. 1 Pesticide concentrations found in apple blossoms following pre-bloom application

each systemic insecticide or fungicide. Pesticide analyses occurred via liquid chromatography-mass spectrometry (LC-MS) and limits of quantification were 50 ppb for all pesticides in flower samples and 5-22 ppb for pesticides in nectar and pollen. Any detections below the limit of quantification were set to 0. In other words, the results summarized below (and shown in Figure 1) are conservative estimates of the true residue results since several low-level detections may have been set to 0 due to limitations of the LC-MS.

So, what did they find? Did pre-bloom sprays show up in the flowers, nectar or pollen during bloom? Yes. Every pesticide that was applied pre-bloom was found in the flowers, nectar and pollen during bloom with the exception of sulfoxaflor, which was not found in nectar (see Figure 1).

What about the levels of pesticides? Were they at concentrations that could harm bees? To address this question, it's best to evaluate the contaminated pollen and nectar, since those are the resources consumed by

bees. While the pesticides in nectar and pollen were not at concentrations that would acutely kill bees (i.e., death within 24-48 hours), some of the pesticides were at levels that could cause sublethal harm to bees.

For example, the average concentration of sulfoxaflor was ~80 ppb in pollen (Figure 1). That's 20x higher than the 5 ppb sulfoxaflor that Siviter et al. (2018) dosed bumble bee colonies with for 14 days and found that fewer reproductive offspring were produced over the colonies' lifetime. Unfortunately, very little is known about sublethal effects of sulfoxaflor beyond the study by Siviter et al. (2018). However, given their results, it seems reasonable to assume that exposure to 80 ppb during apple bloom is likely to result in detrimental effects to bees. Thankfully, to our knowledge, few apple growers are currently using sulfoxaflor as a pre-bloom spray.

Similarly, average thiamethoxam concentrations were ~50 ppb in pollen (Figure 1). That's about 10x higher than the 5.1 ppb thiamethoxam/clothianidin that Williams et al. (2015)

dosed honey bee colonies with during the queen-rearing period, observing that new queens were 34% less likely to survive four weeks after emergence and, of the queens that did survive, 38% less likely to lay eggs compared to queens reared in control colonies. Compared to sulfoxaflor, a lot more is known about sublethal effects of thiamethoxam on bees. In fact, a new paper from our lab (in review) shows there have been 19 published scientific studies that have observed sublethal effects on honey bee reproduction, behavior or physiology from exposure to less than 50 ppb thiamethoxam. Furthermore, from a recent survey of 30 New York apple orchards, we know that bee bread from honey bee colonies conducting apple pollination contains thiamethoxam at concentrations up to 48 ppb (McArt et al. 2017). This study found that apple pollen was not always the dominant pollen consumed by bees during apple bloom, though risk from pesticides was still over regulatory agency levels of concern at 22 of 30 orchards.

Finally, it's also worth noting that average myclobutanil concentrations were ~60 ppb (Figure 1). While myclobutanil is a fungicide and therefore much less toxic to bees compared to insecticides such as sulfoxaflor and thiamethoxam, myclobutanil can synergize with insecticides and increase their toxicity. For example, a recent study from our lab found that when bees are exposed to myclobutanil, thiamethoxam becomes 2.5 times more toxic to those bees (Iverson et al. 2019). Are bees simultaneously exposed to myclobutanil and thiamethoxam during apple bloom? Yes. Another recent study from our lab found that whenever thiamethoxam was found in pollen collected by honey bees during apple pollination, myclobutanil was also found in that pollen (McArt et al. 2017).

Well this doesn't seem good. What about the pesticides applied in the fall, did those result in exposures to bees? No. And this is an important result. None of the systemic insecticides applied via foliar sprays in the fall showed up in the flowers, pollen or nectar during bloom. This indicates that applying these insecticides in the fall is safe for bees the following spring (though the authors note that bark sprays, trunk injections and especially soil drenches are known to carry over from fall applications and be present at substantial levels during bloom the following spring).



Co-author Neelendra Joshi sampling nectar from apple flowers via a microcapillary tube. Photo Neelendra Joshi



Sampling pollen from apple flowers via a high-tech eyebrow brush from Walgreens. Photo Scott McArt

So what's the take-home here? Applying pre-bloom pesticide sprays is risky for bees but spraying in the fall isn't risky? A major result from Heller and colleagues' study is that systemic insecticides via foliar applications in the fall for invasive pests such as brown marmorated stink bug and spotted lanternfly are not risky to bees during apple pollination the following spring. When used according to label guidelines, these applications are also effective at controlling fall apple pests. But unfortunately, stating whether or not pre-bloom sprays are risky to bees isn't so simple.

For example, let's consider how the U.S. Environmental Protection Agency (EPA) considers risk to bees. While the EPA considers both the peer-reviewed literature and industry-funded studies, the EPA relies heavily on acute toxicity studies (i.e., studies that measure mortality of bees) when evaluating hazard. Since none of the residues from pre-bloom sprays in Heller and colleagues' study were at levels that would acutely kill bees, it makes sense why the EPA still allows pre-bloom sprays for these pesticides. For example, here's the EPA-approved label statement for Actara 25WP (thiamethoxam):

"Do not apply this product or allow it to drift to blooming crops/plants or weeds while bees are foraging in/or adjacent to the treatment area. This is especially critical if there are adjacent orchards that are blooming. After an Actara application, wait at least 5 days before placing beehives in the treated field."

Yet from Heller and colleagues' study, we've learned that applying Actara 5-7 days before bloom will result in

average thiamethoxam concentrations of ~50 ppb in pollen. Furthermore, we know from the peer-reviewed literature that, to date, 19 studies have observed significant sublethal effects on honey bee reproduction, behavior or physiology from exposure to less than 50 ppb thiamethoxam. One of these studies found significant impacts on queen reproduction at an exposure level of only 5.1 ppb, almost 10x less than the levels found in pollen by Heller and colleagues.

So, does this mean applying a pre-bloom spray of Actara is safe for bees? According to the EPA, the current answer is "yes." What do you think?

Until next time, bee well and do good work. And share our pesticide decision-making guide to protect pollinators in tree fruit orchards (Van Dyke et al. 2018)!

Scott McArt

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Scott McArt, an Assistant Professor of Pollinator Health, helps run the Dyce Lab for Honey Bee Studies at Cornell University in Ithaca, New York. He is particularly interested in scientific research that can inform management decisions by beekeepers, growers and the public.



Email: shm33@cornell.edu
 Lab website: blogs.cornell.edu/mcartlab
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