Notes from the Lab:
The Latest Bee Science Distilled

by Scott McArt

Pesticide residues are common in soils surrounding corn and soybean fields and are associated with fewer species of native bees.

Last month's "Notes from the Lab" focused on how landscapes dominated by corn and soybeans can be both good and bad for honey bees. Good because colonies grow quickly when soybeans (at least some varieties) are in bloom and the bees take advantage of abundant nectar or pollen from soybeans and weedy clover flowers. Bad because colonies lose weight more quickly compared to when they're surrounded by less corn and soybeans (and thus more wildflowers) for the remainder of the summer and fall. This means floral resources are a major limiting factor for honey bees in corn and soybean-dominated landscapes.

Anson collecting flowers

But what about other potential stresses on bees? The majority of corn and soybeans grown in the United States use pesticide seed treatments, most often comprised of neonicotinoid insecticides and fungicides. Do these pesticides ever contaminate things that honey bees or native bees interact with, such as wildflowers or soil? If so, are concentrations of the pesticides in soil or wildflowers sufficient to negatively impact bees? These are the topics for our twenty-eighth "Notes from the Lab," where we highlight **"Reduced species richness of native bees in field margins associated with neonicotinoid concentrations in non-target soils,"** written by Anson Main and colleagues and published in the journal **Agriculture, Ecosystems and Environment (2020).**

For their study, Main and colleagues surveyed 24 agricultural fields located in four Missouri Department of Conservation Areas in north-central Missouri. The Conservation Areas are managed public lands that include areas of agricultural production to provide food resources and habitat cover for wildlife. At each Conservation Area, six study fields were sampled, three or four of which contained seed-treated corn or soybeans and two or three of which contained untreated fields. The treated fields were planted with either clothianidin-treated corn or imidacloprid-treated soybeans, and had also been planted with seed treatments at least one additional time within the past five years. The untreated fields had not been planted with neonicotinoid-treated seed for >10 years and remained in their current state of use (e.g., hayfield). Thus, this study did not assess differences between corn and soybean fields with and without seed treatments. Instead, the study assessed differences between seed-treated corn and soybean fields compared to untreated fields in their current state of use.

The authors took four types of data at each of the fields. First, soil was sampled and tested for pesticide residues at four times during the growing season: pre-seeding (mid-April), two weeks post-seeding (mid-June), mid-season (July), and during harvest (September). Soil samples were taken from within each field and outside of each field (i.e., in the margins where wildflowers and/or shrubs were growing). Second, plants in the field margins were collected in June, July and September and tested for pesticide residues. All soil and plant samples were assessed for concentrations of six neonicotinoids (acetamiprid, clothianidin, dinotefuran, imidacloprid, thiacloprid, and thiamethoxam) using high-performance liquid chromatography and tandem mass spectrometry (HPLC-MS/MS). Field margin plants were also tested for fungicides (azoxystrobin, fluxapyroxad, metalaxyl, pyraclostrobin, trifloxystrobin). These fungicides were often included on the treated

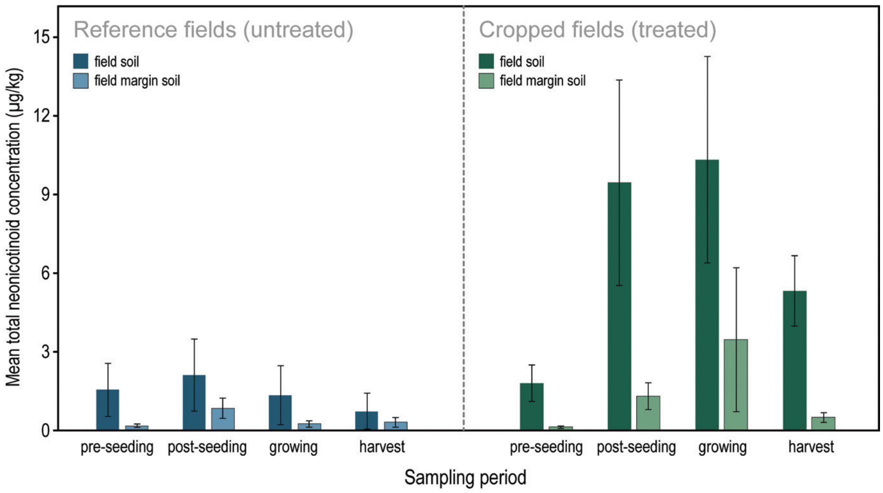

Fig. 1 *Mean total neonicotinoid concentrations in agricultural field and surrounding field margin soils (µg/kg) across four sampling periods of 2016. Concentrations are measured in study fields that were designated as reference fields (untreated) or cropped fields (treated) located on Missouri Conservation Areas. Error bars indicate the standard error.*

seeds and/or were widely used in the study region.

In addition to the samples collected to assess pesticide residues, the authors also characterized the plant and bee communities at each site. The plant community in field margins was assessed using quadrats and all species were identified via the authors' taxonomic knowledge. The bee community was assessed using a combination of blue vane traps and sweep netting at each site, then identifying each of the species using published keys.

So, what did they find? Did the fields and field margins next to seed-treated corn and soybean fields contain more pesticides than untreated fields? Yes. Neonicotinoids were detected in 53% (pre-seeding) to 93% (harvest) of field margin soils adjacent to seed-treated corn and soybean fields, while 22% (pre-seeding) to 56% (harvest) of field margin soils adjacent to untreated fields contained neonicotinoids. As can be seen in Fig. 1, there were also greater concentrations of neonicotinoids in the soils from fields and field margins that used seed treatments compared to untreated reference fields (compare the height of the bars on the left side of the dotted line to the bars on the right side of the dotted line). Conversely, neonicotinoids were rarely found in the wildflower plants located in the field margins of either seed-treated or untreated fields. Only 9% of wildflower samples next to treated corn and soybean fields contained neonicotinoids, while 7% of wildflowers next to untreated fields contained neonicotinoids. Fungicides were found in 40% and 15% of wildflower samples taken from the margins next to treated and untreated fields, respectively.

What about the concentrations of pesticides in soil and plants? Were they at levels that could harm bees? This is a trickier question. While concentrations of most pesticides were very low in the field margin plants and unlikely to lead to risk on their own, concentrations in soils were much higher. Honey bees don't interact extensively with soils, of course. But most native wild bees do. In fact, the majority of North America's ~4,000 bee species are ground-nesting bees. Thus, pesticides in soil could be a big deal for native wild bees as they dig through the soil to build their nests and then rear their young in that soil.

Main and colleagues found that soils in seed-treated fields contained clothianidin, imidacloprid and thiamethoxam at concentrations up to 55.7, 11.6, and 7.4 parts per billion (ppb), respectively. Concentrations in field margin soils surrounding the seed-treated fields were found at up to 41.7 and 3.0 ppb for clothianidin and imidacloprid, respectively (note that 1 ug/kg = 1 ppb, in case you're looking at the values in Fig. 1 while reading this). While few studies have attempted to quantify risk from neonicotinoid residues in soil to ground-nesting bees, one notable recent study suggests that all of the above neonicotinoid concentrations in soil could pose significant risk to the ground-nesting hoary squash bee, *Peponapis pruinosa* (Willis-Chan et al., 2019).

OK, my eyebrows are raised. Was this risk borne out in the study? In other words, was there any indication the bees may have been impacted by the neonicotinoids and/or fungicides? Unfortunately, yes. Main and colleagues' bee diversity data support the notion that pesticide risk to bees was biologically relevant. Specifically, the authors found a negative relationship between neonicotinoid concentrations in field margin soils and the diversity of wild bees collected in those field margins. Furthermore, the severity of this negative relationship depended upon the concentration of fungicides that were found in field margin wildflowers. In other words, when fungicide concentrations were greater in wildflowers, the negative association between

Panorama of Whetstone Creek field

neonicotinoid soil concentrations and bee diversity was steeper. These results support growing evidence that interactions with fungicides can increase the toxicity of neonicotinoids and other insecticides to bees.

Over the past few years, numerous studies have shown that neonicotinoid seed treatments in and near corn and soybean fields result in exposures to bees, sometimes at levels known to cause risk to those bees. This can add further stress to bees in an already poor floral resource landscape. So, what can we do if we want to ease stress on bees? We humans need to eat, of course, which means we need to grow corn and soybeans and lots of other foods. But perhaps we can grow corn and soybeans in ways that are better for bees and other wildlife. Last month we highlighted the STRIPS program, which helps integrate native habitat into corn and soybean fields (**https://www.nrem.iastate.edu/research/STRIPS/**). This doesn't just help bees; the strips can also dramatically limit sediment and nutrient loss, which can be a big deal if you're a farmer who wants to grow healthy and productive plants.

This month, we have two things to highlight. First, if you're a soybean farmer, did you know that a recent meta-analysis of 194 field studies conducted in the Eastern and Midwestern United States found that neonicotinoid seed treatments of soybeans provide negligible benefits to farmers (Mourtzinis et al., 2019)? Perhaps something to consider as you order seed this winter or spring. In addition, please continue to share our "Pesticide Decision-Making Guide to Protect Pollinators" (Van Dyke et al., 2018), which summarizes all known information regarding risk to bees from insecticides, fungicides, and insecticide-fungicide synergisms. When farmers choose to use a pesticide, they have a choice of which pesticide to use. Some pesticides (and some pesticide combinations) are much safer for bees than others, including the various pesticides that are used on corn and soybean seed treatments.

Until next time, bee well and do good work,

Scott McArt

Blue vane traps post collection

Melissodes

References:

Main, A. R., E. B. Webb, K. W. Goyne and D. Mengel. 2020. Reduced species richness of native bees in field margins associated with neonicotinoid concentrations in non-target soils. ***Agriculture, Ecosystems and Environment*** 287:106693. **https://doi.org/10.1016/j.agee.2019.106693**

Mourtzinis, S., C. H. Krupke, P. D. Esker, A. Varenhorst, N. J. Arneson, C. A. Bradley, A. M. Byrne, M. Chilvers, L. J. Giesler, A. Herbert, Y. R. Kandel, Maciej, J. Kazula, C. Hunt, L. E. Lindsey, S. Malone, D. S. Mueller, S. Naeve, E. Nafziger, D. D. Reisig, W. J. Ross, D. R. Rossman, S. Taylor and S. P. Conley. 2019. Neonicotinoid seed treatments of soybean provide negligible benefits to US farmers. ***Scientific Reports*** 9:11207. **https://doi.org/10.1038/s41598-019-47442-8**

Van Dyke, M., E. Mullen, D. Wixted and S. H. McArt. 2018. A Pesticide Decision-Making Guide to Protect Pollinators in Landscape, Ornamental and Turf Management. *Available for free download at:* **https://pollinator.cals.cornell.edu/resources/grower-resources/**

Willis-Chan, D. S., R. S. Prosser, J. L. Rodríguez-Gil and N. E. Raine. 2019. Assessment of risk to hoary squash bees (*Peponapis pruinosa*) and other ground-nesting bees from systemic insecticides in agricultural soil. ***Scientific Reports*** 9:11870. **https://doi.org/10.1038/s41598-019-47805-1**

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