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Short communication

Neonicotinoid insecticide removal by prairie strips in row-cropped watersheds with historical seed coating use

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ABSTRACT

Neonicotinoids are a widely used class of insecticides that are commonly applied as seed coatings for agricultural crops. Such neonicotinoid use may pose a risk to non-target insects, including pollinators and natural enemies of crop pests, and ecosystems. This study assessed neonicotinoid residues in groundwater, surface runoff water, soil, and native plants adjacent to corn and soybean crop fields with a history of being planted with neonicotinoid-treated seeds from 2008 to 2013. Data from six sites with the same crop management history, three with and three without in-field prairie strips, were collected in 2015–2016, 2–3 years after neonicotinoid (clothianidin and imidacloprid) seed treatments were last used. Three of the six neonicotinoids analyzed were detected in at least one environmental matrix: the two applied as seed coatings on the fields (clothianidin and imidacloprid) and another widely used neonicotinoid (thiamethoxam). Sites with prairie strips generally had lower concentrations of neonicotinoids: groundwater and footslope soil neonicotinoid concentrations were significantly lower in the sites with prairie strips than in those without; mean concentrations for groundwater were 11 and 20 ng/L ($p = 0.048$) and <1 and 6 ng/g ($p = 0.0004$) for soil, respectively. Surface runoff water concentrations were not significantly ($p = 0.38$) different for control sites (44 ng/L) or sites with prairie strips (140 ng/L). Consistent with the decreased inputs of neonicotinoids, concentrations tended to decrease over the sampling timeframe. Two sites recorded concentration increases, however, potentially due to disturbance of previous applications or influence from nearby fields where use of seed treatments continued. There were no detections (limit of detection: 1 ng/g) of neonicotinoids in the foliage or roots of plants comprising prairie strips, indicating a low likelihood of exposure to pollinators and other insects visiting these plants following the cessation of seed coating use. Offsite transport of neonicotinoids to aquatic systems through the groundwater and surface water were furthermore reduced with prairie strips. This study demonstrates the potential for prairie strips comprising 10% of an agricultural catchment to mitigate the non-target impacts of neonicotinoids.

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1. Introduction

Neonicotinoids are currently the most widely used class of insecticides in the world and are frequently applied as seed coatings for a variety of crops including corn and soybeans (Douglas and Tooker, 2015). Neonicotinoids may pose a risk to pollinators and non-target insects that use plants with neonicotinoid residues as food sources and to aquatic life due to water contamination through runoff (Bonmatin et al., 2015). Neonicotinoid insecticides are water-soluble; they can be transported offsite predominately via surface and groundwater, and less so with soil particulates (Bonmatin et al., 2015). The offsite transport of neonicotinoids has been documented by their frequent detections in streams across the Midwestern United States in areas of high corn and soybean production (Hladik et al., 2014) and also their detections in foliage and pollen adjacent to agricultural fields including corn (Krupke et al., 2012) and oilseed rape (Botías et al., 2016). Vegetated buffer and filter strips including prairie strips can limit offsite transport of water, sediment and pesticides from agricultural fields (Liu et al., 2008; Helmers et al., 2012;

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Hernandez-Santana et al., 2013), and thus have the potential to also limit transport of neonicotinoids, protecting downstream water quality.

This study presents the rare opportunity to compare concentrations of neonicotinoids in shallow groundwater, surface water runoff, soil, and plant tissues from crop fields with and without prairie strips that were planted with clothianidin and imidacloprid treated corn and soybean seeds from 2008 to 2013. Because the use of treated seeds ended at the study site in 2013 and initial measurements were not started until 2015, the results can provide insights on both the off field dissipation of neonicotinoid concentrations from their use as seed coatings and the potential effectiveness of prairie strips in limiting their offsite transport.

2. Materials and methods

2.1. Study area

The study site was located at the Neal Smith National Wildlife Refuge (NSNWR; 41°33′ N; 93°16′ W), a 3000-ha area managed by the U.S. National Fish and Wildlife Service, located in the Walnut Creek watershed in Jasper County, Iowa (Fig. 1). Created by an Act of Congress in 1990, the refuge's mission is to reconstruct Iowa's pre-settlement vegetation, particularly native tallgrass prairie. Portions of the refuge awaiting restoration are either leased to area farmers for crop production or maintained in perennial pasture (Zhou et al., 2010; Helmers et al., 2012). For this site, daily precipitation was obtained from the National Ocean and Atmospheric Administration station at the NSNWR.

Study sites spanned six of the 12 catchments comprising the Science-based Trials of Row crops Integrated with Prairie Strips (STRIPS) experiment at the refuge (Table 1; Zhou et al., 2010). The two treatments considered here—a 100% row crop (control) and a 90% row crop: 10% prairie strips treatment—were randomly allocated to study sites located across three blocks when the experiment was established. In September 2006, the row cropland was converted from cool-season perennial grasses, primarily *Bromus inermis*, and thereafter farmed on a soybean-corn rotation using no-till soil management techniques. In July 2007, reconstructed prairie vegetation was established within approximately 10% of the catchment area in the footslope position on three of sites. The prairie was established by broadcast seeding 32 native species; one additional species was hand sown the following spring (Hirsh et al., 2013). All sites had treated seeds planted through 2013; clothianidin-treated corn seeds planted starting in 2008 and imidacloprid-treated soybeans starting in 2011. One

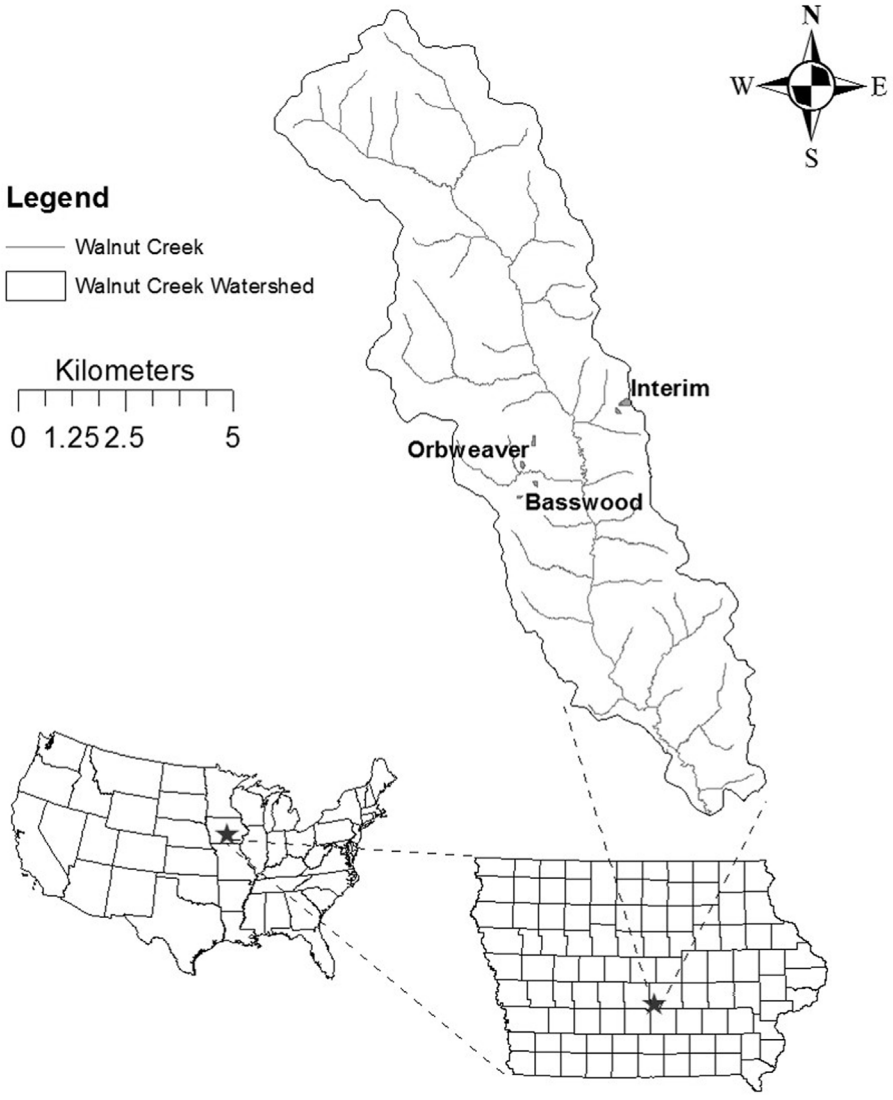

Fig. 1. Location of Walnut Creek Watershed and study watersheds.