Reducing non-target effects of neonicotinoid insecticide applications in turfgrass: Evaluating use around landscape beds

Danielle Craig

Introduction

A series of recent studies implicating neonicotinoid insecticides in the declining health of pollinators and other wildlife across North America has placed these compounds at the center of an ongoing public debate about their environmental impacts (Mineau Palmer 2013). Although, there has been no smoking gun directly tying this class of chemistries to declines in pollinator populations, they are extremely toxic to bees (table 2). Despite the fact that the green industry only represents about 4% of total neonicotinoid usage, concerns about their wide-spread use in urban environments has emphasized the need for research that examines their potential as environmental pollutants in these environments.

Currently, 94% of all corn seed is treated with neonicotinoids and it is also the most commonly used insecticide for turfgrass, ornamentals and greenhouses. In turfgrass systems, neonicotinoids such as imidacloprid, clothianidin and thiamethoxam are commonly used to manage white grubs and other insects (Richmond and Patton 2014). Such widespread usage of neonicotinoids enhances the risk of pollinator exposure to these compounds. With approximately 1/3 of our food supply dependent on pollinators, limiting their exposure to neonicotinoids in urban environments could help provide refuge for these insects. The risk of pollinator exposure associated with current urban usage patterns is not fully understood.

Most golf course and home lawn systems are comprised of large expanses of turfgrass containing patches of flowering ornamentals imbedded within. The degree to which applications targeting turfgrass insects have to capacity to contaminate flowering plants that are attractive to pollinators has not been examined The objective of this capstone project was to examine the potential of neonicotinoid applications targeting turfgrass insects to be taken up by flowering plants located in adjacent landscape beds and evaluate the use of untreated buffer strips as a means to reduce such uptake.

Materials and Methods

I created a set of landscape plantings imbedded within a stand of turfgrass in order to simulate the vegetation matrix typical of most urban landscapes. The setup consisted of twelve individual planting beds each containing two species of flowering perennial plants (*Monarda dydima* and *Aster dumosis*) and two species of flowering annual plants (*Zinnia elegans* and *Pelargonium hortorum*) commonly planted as ornamentals in Indiana. One of four different treatment regimens was imposed on each bed:

1) Application of imidacloprid (Merit 75 WP) directly over the top of the flowering plants at the rate of 0.4 lb/acre.

2) Application of imidacloprid (Merit 75 WP) along the edge of the bed.

3) Application of imidacloprid (Merit 75 WP) applied to grass with a two foot buffer between the bed and application.

4) No application (control)

I hypothesized that the concentration of imidacloprid in the plant tissues would vary among treatments and over time. I expected that the flowers in the bed with the buffer zone would contain less residual imidacloprid than the flowers in the beds with the other two treatments. Leaf and flower samples were taken from every plant 5 and 8 w after treatments were applied. Samples were stored in a freezer until processed. Materials were lyophilized and ground to pass through a 1 mm mesh using a Udy cylcone mill (UDY corporation, Fort Collins, CO). Concentrations of imidacloprid in plant tissues were determined using quantitative ELISA (SmartAssay Series Imidacloprid Test Kit, Horiba, Kyoto, Japan).

Results

Five weeks after treatment, imidacloprid was detected only in one instance, In this case the concentration of imidacloprid in Zinnia leaf tissue taken from the plants where the application was made up to the edge of the bed was 283 ppb. After 8 w, no imidacloprid was detected in any treatment.

Discussion

Although neonicotinoid insecticides are extremely toxic to honey bees, little is known about the potential risk to these important insect posed by applications targeting turfgrass insects. Aside from direct applications to turfgrass, which does not serve as a source of pollen or nectar for honey bees, the potential of these applications to contaminate nearby flower beds has not been previously examined. In the case of this experiment, imidacloprid was detected at very high levels in the zinnia leaf in just one instance and was not detected in the flowers.

One of the major implications of my findings is that the levels of neonicotinoids seemed to be far outside of the parameters of the ELISA kit. The standards for the kit ranged from 2 ppb to 100 ppb. In the one instance that neonicotinoids were found, the level was well above two hundred parts per billion (see table 1). This could indicate that it is possible find very high levels of neonicotinoids in the plants when pesticide has been applied right up to the edge of the bed, but more testing would be required provide confidence in these results. Neonicotinoids are a systemic pesticide which means they are highly water soluble and could explain the absence of pesticide in direct applications

to the foliage. The lack of pesticide detected in the instances where the application was made directly to the bed could indicate that the pesticide was washed off of the plant during rain. The results may also have been affected by the fact that the plants had very underdeveloped root systems due to rodent feeding and being newly transplanted which would limit the uptake of the chemical.

Although imidacloprid was detected in the leaves of plants experiencing applications up to the edge of the bed, the risk to pollinators posed by these applications is still unclear and should be further examined. Bees feed on pollen and nectar and generally only come in contact with the flower of the plant. Imidacloprid was not detected in any of the flower samples so there is a possibility that even if the plant takes up the midacloprid it may not pose as a threat to bees.

Nonetheless, the current experiment provides useful information for designing future experiments to address the risk to pollinators posed by applications of neoicotinoid insecticides in turfgrass. HPLC could provide more accurate assessment of neonicotinoid levels using much less plant material. This would allow us to take more samples over time to better track where the imidacloprid shows up in the plant and how long it takes to get there. It may also prove interesting to test different parts of the flower such as the stamen, pistil and petals to determine where the highest concentrations of pesticide are found.

Table 1: Treatments and detection of imidacloprid in two species of ornamentalDetection of imidacloprid in two plant species four weeks after imidacloprid applications directly over top of the plants (in bed), up to the edge of the planting bed (edge), or up to within 2 ft of the planting bed (buffer) at e rate of 0.3 lb ai/A. Controls were untreated.

Species	Treatment	Detected
Zinnia elegans	Control	No
Zinnia elegans	Buffer	No
Zinnia elegans	Edge	One instance (283ppb)
Zinnia elegans	In Bed	No
Monarda dydima	Control	No
Monarda dydima	Buffer	No
Monarda dydima	Edge	No
Monarda dydima	In Bed	No

Figure 1: Map of plots showing arrangement of four treatments of imidacloprid made to ornamentals. Treatments included: 1. No application (control). 2. Application of imidacloprid (Merit 75 WP) directly over the top of the flowering plants at 0.3 lb/acre. 3. Application along the edge of the bed. 4. Application to grass with a two foot buffer between the bed and application.

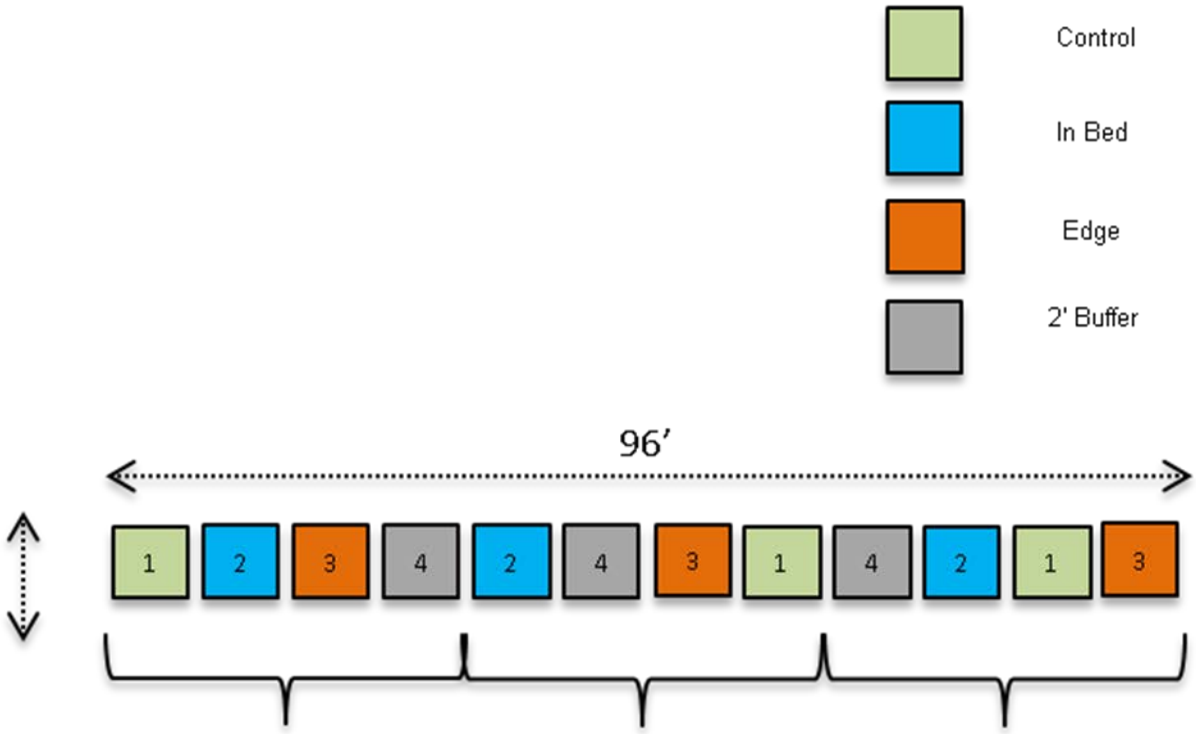

Table 2. Ecotoxicology of several common turfgrass insecticides in different animal systems. LD50 represents amount of material per unit body mass (mg/kg) or individual (g/bee) required to kill 50% of a test population. LC50 is the concentration of material in water required to kill 50% of a test population.

Insecticide (trade name/company)	Insecticide Class	Toxicity*			
		Mammal LD_{50} (mg/kg)[c]	**Bird** LD_{50} (mg/kg)[a]	**Fish** LC_{50} (mg/liter)[b]	**Honey Bee** LD_{50} (µg/bee)[c]
Clothianidin (Arena/Nufarm; others)	Neonicotinyl	>500	430	104	0.004
Dinotefuran (Zylam/PBI-Gordon)	Neonicotinyl	>2,000	>2,000	>100	>0.023
Imidacloprid (Merit/Bayer; others)	Neonicotinyl	424	152	211	0.0037
Thiamethoxam (Meridian/Syngenta)	Neonicotinyl	>1,563	576	>125	0.005

Resources

1. Richmond, Doug, Ph.D., and Aaron Patton, Ph.D. "Neonicotinoid Insecticides and Pollinators: What's the Buzz All About?" (2014): n. pag. http://extension.entm.purdue.edu/neonicotinoids/PDF/Neonicotinoidinsecticidesandbeeswhatsallthebuzzabout.pdf .
2. Krupke, Christian H., Greg J. Hunt, Brian D. Eitzer, Gladys Andino, and Krispn Given. "Multiple Routes of Pesticide Exposure for Honey Bees Living Near Agricultural Fields." Ed. Guy Smagghe. *PLoS ONE* 7.1 (2012): E29268. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0029268 .
3. Mineau, Pierre, Dr., and Cynthia Palmer. *The Impact of the Nation's Most Widely Used Insecticides on Birds*. American Bird Conservancy, n.d. http://extension.entm.purdue.edu/neonicotinoids/PDF/TheImpactoftheNationsMostWidelyUsedInsecticidesonBirds.pdf.
4. Larson, Jonathan L., Carl T. Redmond, and Daniel A. Potter. "Assessing Insecticide Hazard to Bumble Bees Foraging on Flowering Weeds in Treated Lawns." *PLOS ONE:*. N.p., n.d. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0066375 . 12 June 2013.