Use Patterns of Neonicotinoid Insecticides on Cucurbit Crops and Their Potential Exposure to Honey Bees

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Introduction

Colony Collapse Disorder (CCD) is the sudden decline in adult honeybee populations without evidence of mortality. Pesticide use has been identified as a potential contributing factor to these declines among other factors such as new and re-emerging pathogens, habitat loss, pests, and nutritional stress. Researchers suspect that the declines result from a combination of factors representing environmental stressors that compromise the immune system of bees and make them more susceptible to disease.

In this experiment, use of neonicotinoid pesticides was examined as a potential source of environmental stress. Neonicotinoids containing the nitrogen mustard moiety such as imidacloprid, dinotefuran, thiamethoxam and clothianidin have very selective toxicity to insects. They, as well as the carbamate insecticide oxamyl, are widely used on cucurbits such as cantaloupe, cucumber, and watermelon crops and other crops pollinated by bees.

Neonicotinoids are systemic insecticides which metabolize into several different metabolites, all of which contain elements of the 6-chloropyridinyl group. Pollen and nectar are the main food sources for honey bees. A honey bee visits about 100 to 1500 flowers in order to fill its honey sac which holds almost 70 mg of nectar. Foraging bees consume their food needs from the nectar of the first flower they visit. The goal of this experiment was to determine whether residues of neonicotinoids are found in these food sources.

Experimental Design & Procedure

Residues of the following neonicotinoid insecticides: imidacloprid, dinotefuran and thiamethoxam and their metabolites as well as the N-methyl carbamate examyth were determined in foliage, pollen and nectar collected from pumpkin (Cucurbita pepo L.) fields treated at label-approved application rates using different application methods. The experiment was conducted over two growing seasons to address the risk management issue involving neonicotinoid insecticides and their potential exposure to honey bees and other pollinators.

Pumpkin (Cucurbita pepo L. var ‘Howden’) was chosen to represent the cucurbits crop grouping because of its large flowers.

Treatment

Imidacloprid (Admire Pro, four treatments)

Transplant treatments of a low rate of 7 oz/acre

Transplant treatment of a high rate of 10.5 oz/acre

Split applications: transplant water treatment followed 4 weeks later by chemigation through the drip when plants were flowering.

Dinitofuran (Venom, two treatments)

Split treatments: applied as a half rate (3 oz/acre) in the transplant water and the remaining half rate applied 3 weeks later by drip irrigation.

Foliar sprays applied as two foliar sprays, each 3 oz/acre at 3 and 6 weeks after transplanting.

Thiamethoxam (two treatments): split applications: Platinum applied as a half rate (5.5 oz/acre) in the transplant water and the remaining half rate applied 3 weeks later by drip irrigation.

Foliar applications: Actara 25WDG applied as two foliar sprays, each 5.5 oz/acre, at 3 and 6 weeks after transplanting.

Extraction & cleanup

2g pollen, nectar, or foliage were extracted with 2% TEA/ACN & partitioned with MgO/I4NO/AC, centrifuged. The supernatant was passed through C-18 SPE, dried, reconstituted in MeOH-H2O (1:1) filtered and analyzed using LC-MS/MS.

LC-MS/MS Method

Instrument: Waters Acquity ultrahigh performance liquid chromatography (UHPLC) tandem mass spectrometer (Waters Acquity UPLC-MS/MS)

Column: Acquity HSS T3 column (100 mm x 0.31 mm), 0.17 mm particle size

Mobile phase:

A: water-MeOH (95:5) + 10mM ammonium formate + 0.1% formic acid

B: MeOH:water (95:5) + 10mM ammonium formate + 0.1% formic acid

Gradient:

Initial conditions: 95% A in 3 min, then back to initial conditions

Source: ESI + at 230°C

Cone gas, flow: nitrogen at 50 L/H

Collision gas & flow: argon at 0.3 mL/min

Desolvation gas, flow and temperature: nitrogen at 1000 mL/min at 550°C

Results and Discussion

Results show evidence of potential exposure to bees at label rates. Residues of thiamethoxam + metabolites may reach up to 100 mg/g in pollen and 15 mg/g in nectar. An average bee collects about 70 mg nectar and about 150 mg pollen each trip.