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

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Progress Report of 2009 Study

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The 2009 study addressed the risk management issue involving neonicotinoid insecticides and their potential exposure to honey bees and other pollinators. The specific objectives were: 1) to determine the extent and application methods of neonicotinoid insecticides used on cucurbit crops in the Region III states; and 2) to assess the levels of residues in pollen and nectar of a cucurbit crop treated with label allowed rates of neonicotinoids using different application methods.

For objective 1, we conducted a telephone survey of Extension Entomologists in the Mid-Atlantic Region and also contacted major crop advisors who monitor the majority of watermelon grown in Maryland and Delaware. An open discussion of insecticide use patterns on cucurbit crops was also conducted at the Eastern Branch Annual Meeting of the Entomological Society of America, the Mid-Atlantic Fruit and Vegetable Convention, the Southern Maryland Vegetable Growers Meeting, and the Lower Eastern Shore Vegetable Growers Meeting. Survey results showed that the majority of cucurbit growers treat their transplants with a bedding tray rate of imidacloprid just prior to transplanting or apply the low labeled rate in transplant water. Only <10% of the cucurbit acreage is treated with neonicotinoid insecticides after planting, either as foliar sprays or chemigation through drip lines. The most widely-used post-plant treatment applied for cucurbit insect pest control is Vydate L (240 g/L oxamyl). This systemic carbamate insecticide/nematocide is applied as a split treatment on a significant portion of the watermelon acreage on the Delmarva Peninsula. Growers usually apply 2 pts of product by chemigation through the drip within the first week of plant growth, followed two weeks later by another 2 pts of product by chemigation. And many growers apply a third chemigation of 2 pts two weeks later if aphids and cucumber beetles are still present. Most of these treatments are preventative rather than applied on a need basis. Another application method of using neonicotinoid insecticides is the seed dressing application of thiamethoxam along with a suite of fungicides (FarMore Technology). Growers are beginning to use this approach for cucumber beetle control during the early season. This treatment is a very low rate of thiamethoxam compared to the soil and foliar treatments. We plan to include the 2- and 3-way split applications of Vydate and the seed treatment in the 2010 experiment.

The 2009 study involved a field experiment and residue analysis. The field experiment was conducted on a pumpkin crop treated with label allowed rates of three neonicotinoid insecticides using different application methods to measure levels of insecticide residues in pollen and nectar. The study was located at the Central Maryland Research and Education Center, Beltsville Facility, Beltsville, Maryland. We used pumpkin (*Cucurbita pepo* L. var 'Howden') to represent the cucurbit crop grouping because its large flowers made possible the

collection of the required quantities of pollen and nectar. Plots were transplanted on plastic mulch beds on 8 June. Eight treatments consisting of different neonicotinoid insecticide-application method combinations plus an untreated control were evaluated (see Tables for details of treatments). Each treatment was replicated four times for a total of 36 plots. Each plot consisted of a single row 50 feet long, containing 18 plants spaced 3 feet apart. The treatments represented the major ways that neonicotinoids are used on cucurbit crops based on a preliminary telephone survey of crop advisors and extension entomologists in Region III and from western production areas.

During peak flowering (beginning 13 July for two weeks), male flower buds were bagged just prior to anthesis to prevent loss of nectar and pollen due to bees and other foraging insects. The bags with flowers were removed from plants the following day and brought to the laboratory to extract nectar and pollen. Nectar was collected with a 1 ml syringe by drawing the liquid from the center hollow chamber of the receptacle. Extractions were made on multiple flowers (usually 30-40) until 1.5 ml had been collected from each treatment plot. After the nectar was extracted, pollen from the single anther stalk of each flower was dislodged to collect at least 3 g per sample required for residue testing. Nectar and pollen samples were stored at -80° C. until shipped for determination of neonicotinoid concentrations.

The residue analysis was performed by the EPA BEAD Analytical Chemistry Branch ACB), located in the Environmental Science Center at 701 Mapes Road, Ft. Meade, MD. The chemists at ACB extracted and cleaned up the samples, followed by analysis using liquid chromatography-tandem mass spectrometry. Method validation on pollen and nectar samples was also carried out by analyzing replicates of control samples fortified with target analytes. ACB provided a report (see attached) of the amounts of neonicotinoid residues (ng/g) and method validation data, including method description, instrumental parameters, estimated Limit of Detection (LOD) and Limit of Quantitation (LOQ), standard deviation of replicate recoveries, and other QA/QC information.

Residual Results

Tables 1-3 summarize the amounts of neonicotinoid insecticides detected in the pollen and nectar samples. For the imidacloprid treatments (Table 1), the bedding tray drench was applied to transplants at a rate 6X higher than the label allowed rate for planthouse application but 21X less than the low label rate per acre for field application. Pollen and nectar samples from this treatment contained the least amounts of imidacloprid and its metabolites, ranging from 3.3-6.7 ppb in pollen and 0.3-0.5 ppb in nectar. The transplant water and split treatments resulted in significantly higher imidacloprid amounts ranging from 30-101 ppb in pollen and 3.8-13.7 ppb in nectar. Though not statistically different, residue amounts from the low rate (7 oz/acre) were 23 to 40% less than residue levels from the high rate (10.5 oz/acre) of the transplant water treatment. The highest amounts of imidacloprid were found in samples from plots treated as a split application (transplant water treatment followed 4 weeks later by chemigation), which applied one-half the labeled rate through the drip when plants were flowering. Metabolites of imidacloprid were also detected in these treatments in proportional amounts to the parent compound but at lower amounts. The chloronicotinic acid metabolite (LOD = 3 ppb) was not detected in any of the samples. Imidacloprid residues in nectar were significantly less, ranging from 8 to 34% of the levels detected in pollen, and showed corresponding differences among the four treatment regimes.

Pollen samples from plots treated with dinotefuran contained amounts of both dinotefuran and its UF metabolite ranging from 36-147 ppb and 8.1-21.1 ppb, respectively (Table 2). The DN metabolite of dinotefuran is not reported. Amounts of dinotefuran and its UF metabolite in nectar ranged between 5.3 – 10.8 ppb and 1.8 – 10.8 ppb, respectively. The foliar treatments of dinotefuran resulted in higher residues of the parent and metabolite in both floral resources but only the difference in dinotefuran UF in pollen was statistically significant.

Amounts of thiamethoxam found in pollen samples ranged between 55 -127 ppb, excluding an outlier of 825 ppb recorded for the third replicate of the foliar treatment (Table 3). The thiamethoxam metabolite clothianindin was also detected in the same samples, ranging from 9.8-41.2 ppb. Amounts of thiamethoxam and clothianidin in nectar ranged between 6.7 – 12.2 ppb and 0.7 – 6.4 ppb, respectively. Residues of parent and metabolite were also higher in the foliar-treated plots but not significantly different from the split treatments. There were three outlier samples containing high amounts of clothianidin were: sample 3-1 (3629 ppb), sample 3-2 (1126 ppb) and sample 4-3 (90.6 ppb).

In summary, this study reports residue levels of neonicotinoid insecticides in pollen and nectar that are significantly higher that amounts published in the open literature from studies of seed-treatment agronomic crops. In general, residue levels in pollen and nectar were lower for treatments applied prior to or at planting and at lower rates. Foliar and drip treatments applied during flowering resulted in the highest residues of parent insecticide and metabolites.

Table 1. Residue levels (ng/g) of imidacloprid and its metabolites detected in pollen and nectar collected from flowers of a pumpkin crop treated with labeled rates of Admire Pro using different application methods. 2009.

Floral		Imidacloprid			Imidacloprid metabolites[2]		
resource	Treatments[1]	Mean[3]	Min	Max	Mean[3]	Min	Max
Pollen	Bedding tray drench	4.9 c	3.3	6.7	0.7 b	0.0	2.7
	Transplant (high rate)	60.9 ab	40.5	86.6	17.5 a	10.6	21.9
	Transplant (low rate)	36.7 b	30.1	40.1	11.4 a	8.3	16.6
	Split applications	80.2 a	52.3	101.0	19.1 a	13.2	27.5
	Untreated	0.2 c	0.0	0.4	0.1 b	0.0	0.2
Nectar	Bedding tray drench	0.4 c	0.3	0.5	0.1 c	0.0	0.2
	Transplant (high rate)	7.4 ab	4.7	11.9	3.4 ab	0.2	5.9
	Transplant (low rate)	5.7 b	3.8	7.3	1.8 bc	0.0	4.0
	Split applications	11.2 a	9.0	13.7	6.4 a	5.0	9.4
	Untreated	0.0 c	0.0	0.0	0.0 c	0.0	0.0

[1] Bedding tray drench - Admire Pro applied at reduced rate at 0.009 ml product per plant; transplant (high rate) - Admire Pro (10.5 oz/acre) applied in the transplant water during planting; transplant (low rate) - Admire Pro (7 oz/acre) applied in the transplant water during planting; Split - Admire Pro (10.5 oz/acre) applied as half rate (5.25 oz/acre) in transplant water and remaining half rate applied 4 weeks later by drip irrigation.

[2] Imidacloprid metabolites included imidacloprid olefin, 5-OH imidacloprid, imidacloprid urea, imidacloprid desnitro olefin, imidacloprid desnitro HCl, and 6-chloronicotinic acid.

[3] Means within chemical by floral resource group followed by the same letter are not statistically significant at the 5% probability level.

Table 2. Residue levels (ng/g) of dinotefuran and its main metabolite detected in pollen and nectar collected from flowers of a pumpkin crop treated with labeled rates of Venom using different application methods. 2009.

Floral resource	Treatments[1]	Dinotefuran Mean[2]	Min	Max	Dinotefuran UF Mean[2]	Min	Max
Pollen	Split applications	57.5 a	44.0	69.2	10.3 b	8.1	12.0
	Two foliar sprays	88.3 a	36.0	147.0	17.1 a	14.6	21.1
	Untreated	0.0 b	0.0	0.0	0.0 c	0.0	0.0
Nectar	Split applications	9.2 a	7.1	10.6	4.1 a	3.5	4.8
	Two foliar sprays	7.5 a	5.3	10.8	6.5 a	1.8	10.8
	Untreated	0.0 b	0.0	0.0	0.0 b	0.0	0.0

[1]Split applications - Venom (6 oz/acre) applied as a half rate (3 oz/acre) in the transplant water and the remaining half rate applied 3 weeks by drip irrigation; Foliar sprays - Venom (6 oz/acre) applied as two foliar sprays, each 3 oz/acre at 3 and 6 weeks after transplanting.
[2] Means within chemical by floral resource group followed by the same letter are not statistically significant at the 5% probability level.

Table 3. Residue levels (ng/g) of thiamethoxam and its main metabolite detected in pollen and nectar collected from flowers of a pumpkin crop treated with labeled rates of Platinum/Actara using different application methods. 2009.

Floral resource	Treatments[1]	Thiamethoxam Mean[2]	Min	Max	Clothianidin Mean[2]	Min	Max
Pollen	Split applications	68.0 a	54.8	90.4	21.0 a	13.8	41.2
	Two foliar sprays	95.2 a	60.7	127.0	26.8 a	9.8	35.1
	Untreated	0.6 b	0.0	2.5	2.2 b	0.0	4.2
Nectar	Split applications	9.5 a	7.8	12.2	4.0 a	2.4	6.4
	Two foliar sprays	8.2 a	6.7	9.1	1.9 ab	0.7	3.3
	Untreated	0.1 b	0.0	0.2	0.8 b	0.0	2.8

[1]Split applications - Platinum (11 oz/acre) applied as a half rate (5.5 oz/acre) in the transplant water and the remaining half rate applied 3 weeks by drip irrigation; Foliar sprays - Actara 25WDG applied as two foliar sprays, each 5.5 oz/acre, at 3 and 6 weeks after transplanting.
[2] Means within chemical by floral resource group followed by the same letter are not statistically significant at the 5% probability level.