FINAL REPORT TO MICHIGAN DEPARTMENT OF AGRICULTURE AND RURAL DEVELOPMENT HORT FUND PROJECT FY 2015

PROJECT TITLE:

Producing Nursery and Greenhouse Plans in Michigan that are Safer for Pollinators in the Yard and Garden

INVESTIGATOR:

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PROJECT SUMMARY:

Two experiments were designed to test the impact of imidacloprid drenches applied to greenhouse or nursery plants on bumble bees after plants are sold. A third experiment was conducted to determine how long before shipping should growers avoid using a foliar spray of a standard insecticide in order to avoid leaving harmful residues on flowers.

A more rapid decline in colonies of bumble bees caged for 3 weeks with annual flowers in pots drenched with imidacloprid, compared with colonies caged with flowers soil-drenched with water suggests that soil drenches of imidacloprid made in spring of the year that annuals or perennials are sold will be harmful to bees feeding on those flowers later in spring or summer. This conclusion is supported by the greater number of dead bees found in colonies held with imidacloprid-treated plants, and high levels of imidacloprid in the dead bees.

Excellent survival of bumble bees after being confined with *Tilia* trees which had been treated the previous year in early July with an imidacloprid drench suggests that treatments made a year before trees are sold will not be harmful to bees. Analysis of pure nectar from Tilia flowers indicate a mean concentration of 1.27 ppb of imidacloprid in the nectar, a concentration that is unlikely to be harmful to pollinators.

The results of an experiment with four types of annual flowers indicates that annual flowers can be sprayed 3 or more weeks before the shipping date without leaving harmful residues on flowers. Systemic movement of imidacloprid to flowers following a foliar spray did not appear to be a problem.

As research continues on how to produce greenhouse and nursery plants that will be safe for pollinators after they are sold and planted in the yard and garden, it is becoming increasingly clear that growers should focus their efforts on plants that are highly attractive to bees. Many of the most popular annual flowers and many trees and shrubs are not frequently visited by bees, and therefore production practices are not expected to impact bees. However many perennials, some trees and shrubs, and a few annual flowers are highly attractive to bees. For these plants it

is important to avoid soil applications of a systemic insecticide in spring of the same year that they are sold, and avoid spraying open flowers the least three weeks before shipping.

PROJECT PURPOSE

- Determine the impact of an imidacloprid soil drench made to annual flowers growing in pots or to container-grown trees on bumble bees visiting the same plants after they are sold at a garden center.
- Determine the impact of a foliar spray of imidacloprid to annual flowers on bumble bees when sprays are applied at 1, 2 or 4 weeks before the shipping date

PROJECT ACTIVITIES

1. Impact of an imidacloprid basal drench applied to annual flowers grown in 12" pots on bumble bees. One popular cultivar each of petunia, verbena, geranium, marigold, portulaca, salvia and begonia were grown in the greenhouse with standard production practices (Figure 1). At 5 weeks before the finish date, half of all the plants were drenched with imidacloprid at the labeled rate. The remaining plants were drenched with water. One week after the finish date, four plants of each type were put into 16 different screen tents (Figure 2). Half of the tents were filled with imidacloprid-treated plants and half with control plants. One bumble colony was placed in each screen tent for 3 weeks. After the exposure period, bumble bee colonies were moved to shelters and allowed to forage freely.

Results

Of the seven types of annuals grown in pots, four of them absorbed imidacloprid from the soil and transported it to flower tissues, as determined by analysis of whole flowers collected during the screen-tent exposure period. The concentration of imidacloprid found in whole

Figure 1. Marigold, geranium (below) and five other popular annual flowers were grown in 12" pots. Half of all pots received a soil drench treatment of imidacloprid at 5 weeks before shipping.

flowers varied from 0 for geranium and marigold, to 292 ppb in petunia (Table 1). Imidacloprid concentrations in whole flowers of petunia, verbena, portulaca and begonia were high enough (> 25 ppb) that undesirable levels of imidacloprid could appear in nectar or pollen,

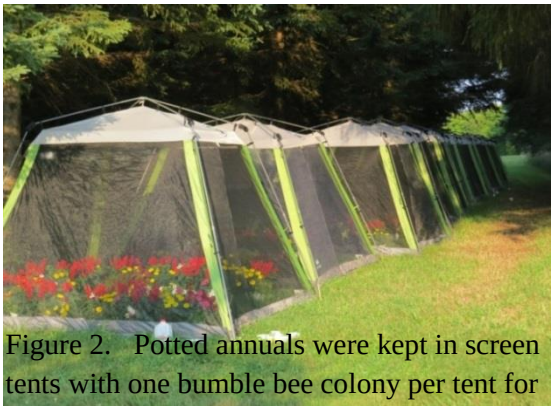

Figure 2. Potted annuals were kept in screen tents with one bumble bee colony per tent for an exposure period of 10 days.

although pollen and nectar samples were not collected and analyzed in this study. Because no imidacloprid was found in whole flowers of marigold or geranium, and only 5 ppb in whole flowers of salvia, it is possible that these types of plants could be treated with an imidacloprid soil drench in the greenhouse or nursery without posing any risk for pollinators after the plants are shipped and sold (Table 1). One of the active imidacloprid metabolites, imidacloprid-OH, was found in low concentrations in salvia and begonia. The olefin metabolite of imidacloprid was not detected in the same flower samples.

Table 1. Concentrations of imidacloprid and imidacloprid 5-OH found one week after shipping in the whole flowers of 7 types of annual flowers treated 5 weeks prior to the shipping date with an imidacloprid soil drench at the labeled rate. Data are means ± SE imidacloprid in ppb (parts per billion).

Plant type	**Imidacloprid (ppb)**	**Imidacloprid 5-OH (ppb)**
Petunia	292 ± 108	0
Verbena	51 ± 5.0	0
Geranium	0	0
Marigold	0	0
Portulaca	30 ± 11.1	0
Salvia	5 ± 2.0	1.0 ± 0.4
Begonia	34 ± 7.8	13 ± 5.6

The number of bees per colony declined in both treatments, but colonies in screen tents with imidacloprid-drenched plants declined more rapidly (Figure 3). In the first half of this experiment (until a Julian day of 170) bumble bees were held in a cold room (3°C) for 20 – 30 minutes for marking with a dot of paint and counting. However, because all colonies were declining in numbers we switched to using a CO_2 method, which was less harmful to the bees. After that time (day 170) the number of bees per colony in the control treatment remained fairly stable, while the number of bees continued to decline in the imidacloprid-drench treatment (Figure 3). Also, more dead bees were found in screen tents with treated plants, and the dead bees contained fairly high levels of imidacloprid and the 5-hydroxy metabolite of imidacloprid (Table 2).

Figure 3. Survival of bumble bee colonies confined in screen tents with annual flowers for three weeks in June, 2015, then moved to shelters and allowed to forage freely outdoors in a pasture area. Each screen tent contained twenty 12” pots of flowers previously drenched with imidacloprid or with water (Control). Data are mean number of bees per colony (n = 8). A star above a pair of data points indicates that the control mean was significantly different from the treatment mean on that date (P = 0.05).

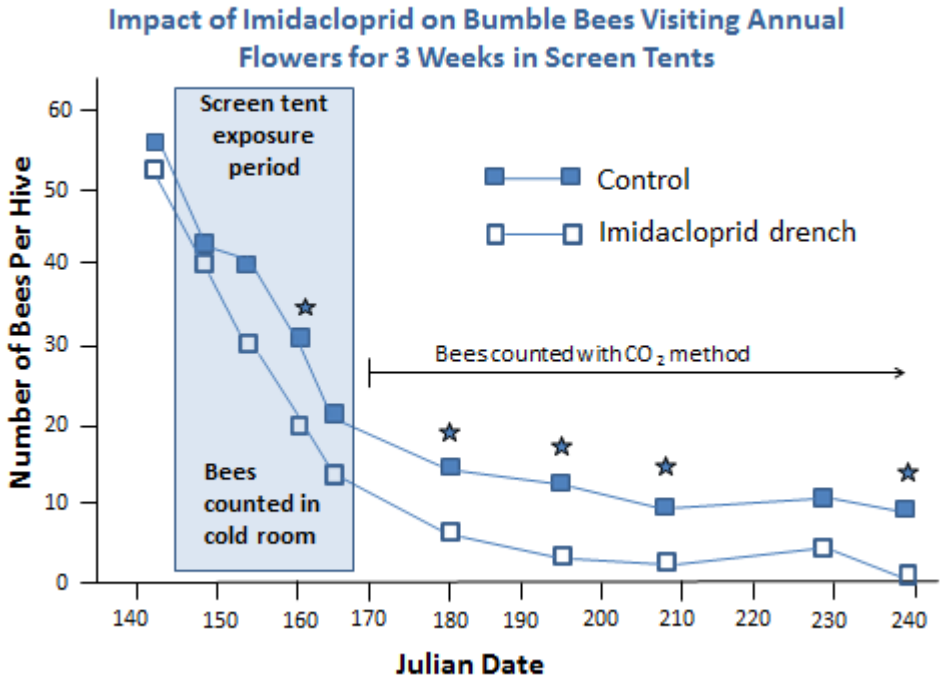

Table 2. Dead bees collected from screen tents at end of 10-day exposure period with imidacloprid-drenched plants or control plants. Data are means ± SE amount of imidacloprid, olefin metabolite or 5-hydroxy metabolite found in dead bees.

Treatment	Number of dead bees collected	Imidacloprid (ppb)	Imidacloprid olefin (ppb)	Imidacloprid 5-hydroxy (ppb)
Imidacloprid basal drench	3.86 ± 0.69	83.0 ± 63.5	16.5 ± 12.3	119.4 ± 61.5
Control	1.38 ± 0.25	0	0	0

2. Impact of an imidacloprid basal drench applied to base of container-grown *Tilia* trees in early July 2014, on bumble bees caged with the same trees in June 2015. *Tilia americana* and *Tilia cordata* trees were grown in pot-in-pot containers at the Horticulture Farm at Michigan State University. Half of the trees received a basal soil drench of imidacloprid, applied at the labeled rate, in early July, 2014, after the trees had finished blooming and most of the flowers had dropped. The *Tilia* trees were moved into screen tents on June 15, 2015, when they first started blooming. One bumble bee colony was placed into each screen tent at this time and remained in the tents for 10 days. Bumble bees were counted weekly or biweekly for the rest of the summer, until August 27th. Queen cells were counted at the end of the summer. *Tilia*

flowers from all trees in screen tents were collected on day 5 of the 10-day exposure period. A nectar wash method was used to determine the amount of imidacloprid in the nectar.

Figure 4. Screen tents used for enclosing bumble bee colonies with treated or control *Tilia* trees for a 10-day period. Clean marigold and portulaca were included as a source of pollen.

Results

Bumble bee survival was very good in both treatments. All counts were made using the CO_2 method, which suggests that using CO_2 is far better for the bees than counting them in a cold room, as we did in the beginning of the previous experiment. Imidacloprid drenches made a year earlier had no impact on the number of bumble bees per colony throughout the growing season, or on the number of queens produced per colony (Figure 4). Control colonies averaged 7.8 new queens produced per colony at the end of the summer, while colonies in the imidacloprid treatment averaged 5.8 queens per colony. No imidacloprid metabolites were found in nectar from flowers on control trees. The nectar from trees that had received a soil drench of imidacloprid one year earlier contained a mean of 1.27 ppb of imidacloprid (Table 3). Imidacloprid metabolites were not detected in the nectar. This concentration of imidacloprid is unlikely to be harmful to pollinators.

Figure 4. Survival of bumble bees after being caged with Tilia trees for 10 days in June, 2015, when the trees were blooming. Trees in the imidacloprid drench treatment were drenched in early July, 2014. Data are means of four colonies per treatment.

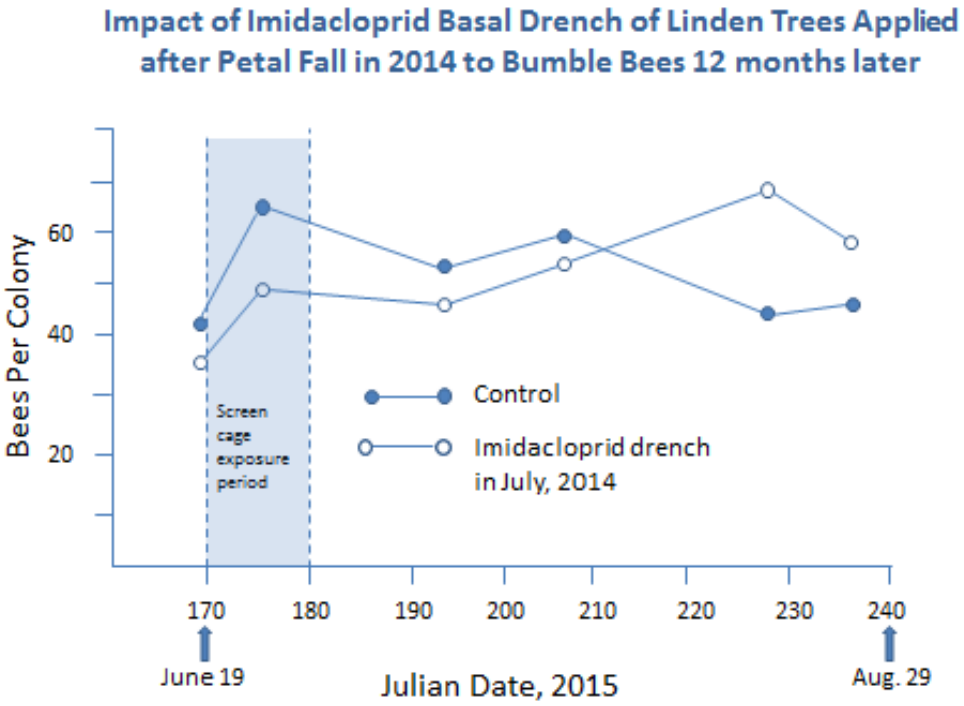

Table 3. Imidacloprid and active metabolites found in *Tilia cordata* nectar one year after a basal soil drench of imidacloprid was applied at the label rate. Flowers were collected from the container-grown grown trees in June of 2016. Data are ppb of imidacloprid in dry flower tissue (whole flowers), ppb imidacloprid in nectar wash based on dry weight of flower tissue (nectar wash), and ppb of imidacloprid found in pure nectar (pure nectar).

Sample	**Treatment**	**Imidacloprid (ppb)**	**Imidacloprid 5-OH (ppb)**	**Imidacloprid olefin (ppb)**
Whole flowers	drenched	ND	2.50	ND
	drenched	ND	0.97	ND
	drenched	ND	3.91	ND
	drenched	ND	3.12	ND
	drenched	ND	2.01	ND
	drenched	ND	5.58	ND
	drenched	ND	1.27	ND
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND

	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
Nectar Wash	drenched	1.45	ND	ND
	drenched	4.20	ND	ND
	drenched	6.88	ND	ND
	drenched	40.13	ND	ND
	drenched	3.07	ND	ND
	drenched	4.15	ND	ND
	drenched	6.75	ND	ND
	Drench mean	***9.52***		
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
Pure nectar	drenched	0.79	ND	ND
	drenched	0.09	ND	ND
	drenched	0.09	ND	ND
	drenched	1.98	ND	ND
	drenched	0.09	ND	ND
	drenched	0.11	ND	ND
	drenched	5.77	ND	ND
	drench mean	***1.27***		
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND
	control	ND	ND	ND

3. Dislodgable residue of imidacloprid on the flowers of annuals sprayed 1, 2 and 4 weeks before shipping. In a third experiment flowers were sprayed with imidacloprid at 1, 2 and 4 weeks prior to shipping. This experiment was conducted in spring of 2015, with four types of

annual flowers grown by Dr. Eric Runkle in the MSU horticulture greenhouses. Plants were grown with standard grower production practices. Whole flowers were collected on the shipping date, dried, weighed, covered with dichloromethane and agitated for 30 s. The solvent was decanted and reduced before HPLC analysis for imidacloprid residue.

Results of dislodgable residue experiment

Very little dislodgable residue was recovered from flowers sprayed 4 weeks or more before shipping (< 2 ppb), and it is unlikely that this would have any impact on bees (Table 4). Some dislodgable residue was recovered from flowers sprayed 1 or 2 weeks before shipping (< 6 ppb), but it is not known if this enough to affect bees. These results suggest that it would be safe for bees to land on flowers sprayed a week or more before shipping with imidacloprid, but more research is needed to determine the concentration of imidacloprid in pollen or nectar following foliar sprays applied at 1 – 4 weeks before shipping.

Table 4. Results from a 2015 experiment designed to determine how much dislodgable residue is present on flowers sprayed at 1, 2, or 4 weeks before shipping.

Weeks before shipping	Plant type	Olefin (ppb)	Imidacloprid (ppb)
1	Portulaca	0	5.4 ± 1.7
1	Verbena	0	4.0 ± 0.8
1	Salvia	0	0.7 ± 0.2
1	Marigold	0	1.8 ± 1.1
2	Portulaca	0	5.8 ± 0.8
2	Verbena	0	3.4 ± 0.4
2	Salvia	0	0.9 ± 0.3
2	Marigold	0	0.3 ± 0.2
4	Portulaca	0	1.8 ± 1.0
4	Verbena	0	1.1 ± 0.52
4	Salvia	0	1.9 ± 0.9
4	Marigold	0	0.8 ± 0.3

GOALS AND OUTCOMES ACHIEVED

Results of this research provides some practical guidelines for greenhouse and nursery growers that want to produce annual flowers, perennials, shrubs and trees that are safe for pollinators. These guidelines can be summarized by the following bullet points:

- Focus efforts on flowering plants that are highly attractive to pollinators. A list of highly attractive plants can be downloaded free at this website: http://msue.anr.msu.edu/resources/how_to_protect_and_increase_pollinators_in_your_landscape

  For highly attractive plants, consider the following best management practices:
- Avoid spraying flowers or flower buds the last three weeks before shipping
- Do not use a soil drench of a systemic insecticide in spring of the same year they are sold

- For perennials, trees and shrubs that are attractive to pollinators, do not use a soil drench of a systemic insecticide in the last 9 months before they are sold

BENEFICIARIES

Michigan greenhouse and nursery growers, extension agents and other farm advisors, retail stores with garden centers, independent garden centers, beekeepers, gardeners and homeowners.

LESSONS LEARNED

Greenhouse and nursery plants can be grown in a way that will minimize the impact on pollinators by using best management practices.

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