Evaluating Pesticide Effects On Pollinators And Disease Efficacy In Cucurbits

***James Jasinski**, Ohio State University Extension, Urbana, OH; **Reed Johnson**, Department of Entomology, Ohio State University, Wooster, OH, **Thomas Janini**, Ohio State University ATI*

Abstract

Pollinator protection from pesticide use in cucurbit crops is currently an important topic to resolve. Honey bees and squash bees were subjected to LD_{50} bioassays with insecticides and fungicides to determine adult mortality. Bifenthrin caused equal mortality among the species, but squash bees were significantly more tolerant of carbaryl than honey bees. Fungicides did not appear to increase mortality of either bee. In field trials, fungicide treatments were selected based on their reported neutral or detrimental effects on bees and evaluated for their crop protection value. Specific fungicide treatments with both lower pollinator impact and acceptable disease control were identified in this trial.

Introduction

The toxicity of insecticides and fungicides commonly used on cucurbits in Ohio were tested on squash bees, *Peponapis pruinosa*, a key wild pollinator of these crops in the Midwest, and honey bees, *Apis mellifera*. These bees and other pollinators are subject to the adverse effects of pesticides commonly reported in the literature on cucurbits.

In step with the toxicological findings, we sought to evaluate combinations of pesticides that limit detrimental impacts on bees yet confer acceptable crop protection and production. To that end, field trials were set up to evaluate the efficacy of "bee friendly" and "conventional" fungicide programs on pumpkin and butternut squash crops at the Western Ag Research Station in South Charleston, OH. Bee friendly fungicides are defined as products that currently have no research indicating detrimental effects on bees or their larvae; conventional fungicides have been associated with detrimental effects on bees or their larvae, applied either individually or in combination with other pesticides.

Methods

Approximately 550 male squash bees were caught in pumpkin for individual bioassays between July 7 and August 22 at sites in Clark and Wayne County. Bees were caught inside pumpkin flowers and transported back to the laboratory and chilled at 4°C for 30 min. to immobilize bees in preparation for a specially developed LD_{50} bioassay (Johnson et al 2013). Mortality was scored 24 hours after treatment and any bee exhibiting immobility or appearing moribund was scored as dead. A similar bioassay was conducted on 1,860 3-day old honey bees except these bees were anaesthetized with carbon dioxide prior to handling.

Technical-grade (>99% purity, non-formulated) bifenthrin and carbaryl, myclobutanil, and boscalid and pyraclostrobin combined were diluted in acetone at ratios reflecting the maximum labeled use rates for each product. One microliter of pesticides dissolved in acetone were applied to anaesthetized squash bees or honey bees on the thoracic notum using a 50µl syringe (Hamilton PB-905) fitted in a micro-applicator (Figure 1). For bifenthrin and carbaryl doses applied alone, groups of bees were treated with a geometric dose series so as to allow the determination of a dose –response curve and calculation of LD_{50}s. For pesticide combinations, a single diagnostic dose was chosen based on dose-response curves fitted for honey bee responses.

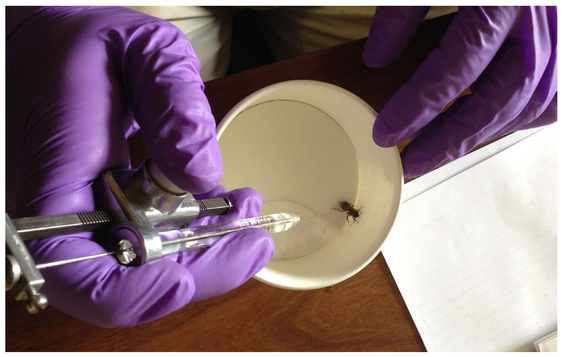

Figure 1. Micro application of pesticide to squash bee thorax.

Table 1. Fungicide treatments on pumpkin and winter squash.

Treatment	Sprayed 7/25, 8/7, 8/25	Sprayed 7/31, 8/14
Bee1	Quintec + Manzate Pro Stick	Regalia + Manzate Pro Stick + Sulfur
Bee2	Regalia + Manzate Pro Stick	Regalia + Manzate Pro Stick + Sulfur
Conv1	Pristine + Bravo	Procure + Bravo
Conv2[a b]	Torino + Activator 90 + Bravo	Rally + Bravo

[a] 5th spray of Conv2 treatment was Merivon (4 oz/A) + Bravo (1Pt/A)
[b] Torino has not been shown to cause detrimental effects against bees.

Betternut winter squash and Gold Standard pumpkin were planted in the fungicide efficacy trial. Four plots (15' x 90') of each hybrid were sprayed with each fungicide treatment on 7-10 day intervals initiated upon powdery mildew detection (Table 1). All treatments were applied at 35 gallons per acre using hollow cone nozzles at 65 PSI. Percent powdery evaluations were collected on the upper and lower leaf surfaces. Yield data is not reported here.

Results

Both squash bees and honey bees are similarly susceptible to the insecticide bifenthrin (Table 2). Neither squash bees nor honey bees become more susceptible to the insecticide bifenthrin when exposed to field-relevant concentrations of thiamethoxam (FarMore). However, squash bees do demonstrate remarkable tolerance for carbaryl (the active ingredient in Sevin) when compared to honey bees. Even at the top dose tested, 10 µg per bee, *no* mortality was observed in squash bees over the following 24 h. This is in marked contrast to the great susceptibility shown by the honey bees used in this study to carbaryl, which were at least 125-times more susceptible than squash bees.

Squash bees are of similar sensitivity to the insecticides bifenthrin and carbaryl regardless of whether fungicides are also present or not. The insecticide bifenthrin, when applied at 0.05 µg per bee and mixed at field-relevant ratios with the fungicides myclobutanil (Rally) or pyraclostrobin+ boscalid (Pristine), will kill between 40 and 50% of squash bees – similar to what would be expected by bifenthrin alone at this dose.

Table 2. Statistics for dose-response lines fit to 24 h. mortality data for squash bees (*Peponapis pruinosa*) and honey bees (*Apis mellifera*).

Treatment	Species	n	LD_{50} (95% CI) µg per bee
Bifenthrin	*A. mellifera*	784	0.08 (0.05-0.15)
	P. pruinosa	147	0.15 (0.06-1.57)
Bifenthrin + Thiamethoxam	*A. mellifera*	580	0.08 (0.04-0.99)
	P. pruinosa	9	0.15
Carbaryl	*A. mellifera*	493	0.08 (0.05-0.17)
	P. pruinosa	58	>10

Comparing disease development on the lower leaf surface of pumpkin, there was no consistent season long trend, however treatments Bee1 and Conv2 had numerically lower powdery mildew colonization than the other treatments for most of the season (Figure 2). Comparing disease development on the lower leaf surface of squash through August 12th, the highest disease rating is only 10% regardless of treatment, which is very low. The Bee1 and Conv2 treatments had under 40% powdery mildew on their lower leaf surfaces and would be rated as excellent to good in overall efficacy.

Figure 2. Aerial view of treatment efficacy (canopy) August 29th, 2014.

Conclusions

The difference in susceptibility to insecticides between these two important pollinators of cucurbit crops, honey bees and squash bees, is striking. Bifenthrin appears to be uniformly harmful to all bees. Carbaryl, however, appears to be of much lower toxicity (>125X) to squash bees than honey bees. While squash bees may tolerate some pesticides better than honey bees, the susceptibility of other bees visiting cucurbit flowers – bumble bees, mason bees, leafcutter bees and the like – is still unknown and careless application of insecticides, alone or in combination with fungicides, may cause grave damage to these pollinators.

The Bee1 treatment showed good control of powdery mildew on both crops over the season while the Conv2 treatment performed at a similar level only on the squash crop. The other two treatments Bee2 and Conv1 did not perform well over the season on pumpkin and had only fair efficacy on the squash crop. There appears to be combinations of fungicides that give acceptable powdery mildew control in cucurbits and have low impact on bee populations.

Johnson RM, Dahlgren L, Siegfried BD, Ellis MD: **Acaricide, fungicide and drug interactions in honey bees (Apis mellifera)**. PLoS One 2013, **8**:e54092.

Acknowledgements
This project was supported by the OSU EIPM, USDA NIFA, and the Ohio Vegetable Small Fruit Research and Development Programs. Special thanks to Nolan Harmotto and Randy Howell for their assistance.