Section II.
Bee Poisoning, Environmental Toxicology and Regulatory Issues

IMPACT OF PESTICIDE RESIDUES ON A NATIVE BUMBLE BEE POLLINATOR, *BOMBUS VOSNESENSKII* (HYMENOPTERA: APIDAE).

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Introduction

Pollination is critical for adequate fruit set and seed production in a great number of Oregon crops. Bees serve as the primary pollinating agents for many of these crop plants (Free, 1993). In addition to honey bees, wild bees such as bumble bees are also considered to be efficient pollinators playing a key role in agricultural production. Currently, there is a worldwide decline in the availability and abundance of both honey bee and native bee species. One of the principal causes of this decline has been attributed to the extensive use of pesticides in agricultural ecosystems (Goulson et al., 2008). Bees are affected by pesticides via drift, contaminated nectar and pollen sources and residues on plants (Johansen, 1966).

Historically, honey bees have received the majority of attention with regard to evaluating the toxicological effects of pesticides on bees (Devillers et al., 2003). Few studies have examined the effects of pesticides on feral bee populations. As such, the rate and application recommendations of pesticides have been established based on the response of honey bee

pollinators to pesticide exposure (Riedl et al., 2006). Given the differences in life history, ecology, and foraging behavior of bees, these data do not provide an accurate criterion for assessing toxicity of wild bee pollinators such as bumble bees (Thompson, 2001). The objective of this study was to assess the toxicity of several pesticides commonly applied during bloom on the mortality of a dominant feral bumble bee, *Bombus vosnesenskii*.

Materials and Methods

Two separate lab bioassays were conducted using the methods outlined below to determine the residual effects of treated blueberry and red clover plant material on the mortality of queen and worker bees.

Blueberry

Highbush blueberry (*Vaccinium corymbosum*) plant material was collected from an unsprayed planting at the North Willamette Research and Extension Center (NWREC) in Aurora, OR. Three pesticide compounds were tested on blueberry plant material: Admire 2, Success and Pristine. These products were selected given their usage to control the primary pests of blueberry production (aphids, leaf rollers and fruit rot) as well as their registration for foliar application during bloom. Pesticide treatments consisted of the minimum, maximum and 2X maximum recommended field rate listed for the insect pest. Each treatment was replicated six times. Queen bumble bees were utilized in these bioassays given their early season prevalence in blueberry during bloom. A total of 144 wild caught queen bees were used in the bioassays.

Red clover

Red clover (*Trifolium pratense*) plant material was taken from an unsprayed field located in Polk County, OR. Four pesticide compounds were tested on red clover: Admire 2, Metasystox-R (MSR), Lorsban Advanced and Brigade 2EC. These products are used to control the principal aphid pest of red clover production systems, being applied as a foliar application during bloom. The minimum, maximum and 2X maximum recommended field rate for aphid control were used in the experiment. Each treatment was replicated six times. Worker bumble bees were used given their late season abundance in red clover during bloom. A total of 384 wild caught worker bees were exposed in these bioassays.

Bioassay

Standard cylinder cages described by Johansen et al. (1983) consisting of a 15 cm plastic petri dish and 45.7 cm x 5.1 cm strip of metal screen (6.7 meshes per cm) were used for all bioassays. Prior to application, plant samples consisting of flowers, leaves and stems were condensed to 2.5-5 cm lengths and 15.5 g were placed inside cages (Johansen et al., 1983). Pesticides were applied to plant material within cages using a Potter precision laboratory spray tower (Potter and Way, 1958). After application, residues were allowed to dry for a period of 1-2 hours prior to the introduction of bees. Bees were anesthetized to facilitate handling and were randomly assigned to treatments. Each cage contained either 2 queen bees or 4 worker bees. Bees were fed 50% nectar solution by a cotton wick feeder attached to the bottom of each cage (Johansen et al., 1983). Cages were kept under controlled environmental conditions of humidity (50-60%), temperature ($28^{o}C \pm 2^{o}C$) and photoperiod (D7:L17). Mortality was assessed after 24, 48 and 72 hours by recording the number of dead bees within each cage.

Results and Discussion

Blueberry

The mortality of queens exposed to treated blueberry plant material indicated that Admire 2 (83.33%) had the highest mortality compared to the Success (37.50%) and Pristine (58.33%) treatments (Table 1). Queens exposed to Admire 2 experienced the highest mortality at 2X the maximum field rate of 0.08 lb/acre, while the minimum field rate of 0.03 lb/acre and maximum field rate of 0.04 lb/acre had similar queen mortality (75% at 72 hours). Similarly, queens exposed to Pristine experienced the highest mortality at the maximum field rate of 23 oz/acre and 2X maximum field rate of 46 oz/acre at 72 hours of exposure. In contrast to the other pesticides, the highest queen mortality among the treatments of Success occurred at the minimum field rate of 0.03 lb/acre after 72 hours of exposure. It is not known why bumble bees exhibited a reverse response to doses of Success used in the experiment.

Red clover

For worker bees exposed to pesticides applied on red clover plant material, the highest mortality occurred with Lorsban Advanced (100%) and Brigade 2EC (100%) when compared to Admire 2 (62.50%) and MSR (58.33%) (Table 2). Workers exposed to all treatments of Lorsban Advanced experienced 100% mortality at 72 hours. Across treatments of Brigade 2EC, worker mortality was highest with the 2X maximum field rate of 0.20 lb/acre. Similarly, the highest mortality rate of bees exposed to Admire 2 and MSR occurred at 72 hours in the 2X maximum field rate for each of the chemicals. For both of these chemicals, worker mortality only occurred after 48 hours of exposure for both the minimum and maximum field rates.

These data provide evidence of adverse effects caused by pesticide applications during bloom on populations of wild bumble bee pollinators. Given their economical importance in agricultural ecosystems, it is imperative to consider the timing of pesticide applications to avoid non-target effects on feral pollinators. As such, growers are encouraged to make pesticide applications when possible, during pre-bloom, to avoid potential impacts on native bumble bees.

Table 1. Mortality of queen bumble bees exposed to pesticides on blueberry plant material.

Treatment				% Mortality (avg)		
Trade Name	**Active ingredient (% ai)**	**Formulation**	**Rate/acre**	**24 hours**	**48 hours**	**72 hours**
Admire 2	imidacloprid (21.4%)	suspended concentrate (SC)	0.03 lb	8.33	66.67	75.00
			0.04 lb	16.67	66.67	75.00
			0.08 lb	16.67	16.67	83.33
Untreated check			----	0	25.00	25.00
Success	spinosad (22.8%)	emulsifiable concentrate (EC)	0.03 lb	4.17	25.00	37.50
			0.10 lb	4.17	12.50	20.83
			0.20 lb	4.17	8.33	8.33
Untreated check			----	0	4.17	8.33
Pristine	pyraclostrobin (12.8%)/ boscalid (25.2%)	granular (G)	18.50 oz	0	8.33	16.67
			23.00 oz	0	50.00	58.33
			46.00 oz	50.00	58.33	58.33
Untreated check			----	8.33	8.33	33.33

Table 2. Mortality of worker bumble bees exposed to pesticides on red clover plant material.

Treatment				% Mortality (avg)		
Trade Name	**Active ingredient (% ai)**	**Formulation**	**Rate/acre**	**24 hours**	**48 hours**	**72 hours**
Admire 2	imidacloprid (21.4%)	suspended concentrate (SC)	0.03 lb	0	33.33	41.67
			0.04 lb	0	33.33	54.17
			0.08 lb	12.50	33.33	62.50
Untreated check			----	8.33	20.83	20.83
Metasystox-R (MSR)	oxydemeton-methyl (25.5%)	emulsifiable concentrate (EC)	0.38 lb	0	37.50	41.67
			0.50 lb	0	25.00	45.83
			1.00 lb	16.67	33.33	58.33
Untreated check			----	16.67	25.00	37.50
Lorsban Advanced	chloropyrifos (40.18%)	emulsion in water (EW)	0.50 lb	83.33	95.83	100.00
			1.00 lb	100.00	100.00	100.00
			2.00 lb	100.00	100.00	100.00
Untreated check			----	20.83	20.83	29.17
Brigade 2EC	bifenthrin (25.1%)	emulsifiable concentrate (EC)	0.06 lb	87.50	95.83	95.83
			0.10 lb	91.67	91.67	91.67
			0.20 lb	95.83	100.00	100.00
Untreated check			----	0	8.33	33.33

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