Your management program MATTERS

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Pesticides are an important tool to protect crops from pest damage. While pesticides are aimed at killing pests, their chemistries and use must meet regulations and not pose harm to humans and nontarget organisms. For this reason, organophosphate insecticides like azinphos-methyl (Guthion) have been or are being phased out, and newer "reduced-risk" chemistries have been registered as replacements.

According to U.S. Environmental Protection Agency criteria, these reduced-risk pesticides are safer for humans, birds, and fish, but they can have negative impacts on natural enemies like lacewings and predatory mites, resulting in secondary pest outbreaks.

Our five-year Specialty Crop Research Initiative project "Enhancing Biological Control in Western Orchards" evaluated whether certain reduced-risk pesticides disrupt the biological control of secondary pests. In a series of laboratory experiments, we tested the effects of five insecticides and two fungicides on adult and immature stages of eight natural enemy species.

Just as pesticides kill pest insects or mites, they can also kill beneficial insects and mites. These natural enemies can be exposed to pesticides by direct contact, contact with residues, or ingestion. Direct contact occurs when the natural enemy is sprayed with the pesticide. Natural enemies are exposed to pesticide residues when they walk on treated leaves or fruit. They can also ingest a pesticide that has contaminated their prey or other food sources (e.g., pollen) or when they groom themselves.

Most assessments

Most assessments of pesticide effects on natural enemies consider only acute toxicity, meaning, how many organisms die within 48 hours of exposure. For example, our laboratory tests consistently showed that Warrior (lambda-cyhalothrin), a synthetic pyrethroid, has a high level of acute toxicity to many natural enemies.

But, we also found that if a pesticide does not immediately kill a natural enemy, it can disrupt its biology in other ways. These sublethal effects can result in chronic mortality, or death that occurs beyond 48 hours after exposure. We discovered that exposure of lacewings and ladybird beetles (adults and larvae) to Altacor (chlorantraniliprole) caused chronic mortality, while it had a low impact on the other natural enemies, for example the predatory mirid bug *Deraeocoris brevis* and spiders.

Sublethal effects can also cause a reduction in the number of eggs laid or the number that hatch. Although Rimon (novaluron), an insect growth regulator, did not kill lacewing adults, it prevented nearly 100% of the eggs from hatching. We also found that Exirel (cyantraniliprole) reduced both the survival of ladybird beetles and the number of eggs laid.

Pesticides sometimes prolong the development of the immature stages, or even change the sex ratio of the offspring. For example, Exirel was found to increase the developmental time of convergent ladybird beetle larvae by about 20% and shift the sex ratio of *Deraeocoris brevis* to 72% females compared with 42% for untreated insects.

Effects vary

Overall, we found that the effects of a pesticide cannot be generalized for all natural enemies. Lacewings can be affected differently than ladybird beetles or predatory mites. Moreover, immature stages can be more susceptible than adults, making timing of pesticide applications a key factor in minimizing impacts. And parasitic wasps that develop inside their hosts, and are therefore somewhat protected, can be impacted differently than general predators or predatory mites.

All the acute and sublethal effects of pesticides have consequences on the population of a natural enemy, and, ultimately, the natural enemy's ability to control secondary pests. To simplify matters, we summarize all effects into the overall impact on population growth. Imagine a natural enemy population that grows from 10 to 100 individuals in one generation when not exposed to any pesticides. If the same natural enemy were exposed to a pesticide, population growth might be suppressed and only increase to 20 individuals due to acute and/or sublethal pesticide effects. And, depending on the percent reduction in population growth, we can assign the risk of a pesticide to a natural enemy as low, moderate, or high.

Worse case

Our laboratory results represent a worst-case scenario where an individual natural enemy had no way to escape pesticide exposure. In orchards, natural enemies might escape pesticides, because sprays rarely cover 100% of the tree surface. Therefore, we do not claim that our laboratory results exactly predict what would happen in an orchard, but we do believe that they provide a reasonable estimation of a pesticide's relative risk to a natural enemy population. When our results indicate either low or high pesticide impacts, we are confident that the risk of disrupting biological control in the orchard will be either minimal or high. However, when a pesticide's effects fall into the "moderate impact" category, predictions of disruption are more difficult. We conducted field studies and were able to confirm some of our laboratory findings, but more often than not, results were inconclusive because of too many uncontrolled variables.

Besides spray coverage, other factors can further modify a pesticide's risk to natural enemies and influence whether biological control will be disrupted in an orchard. These include how many generations a natural enemy has each year,

PHOTOS BY ELIZABETH BEERS, WSU

Nymphs and eggs of the predatory bug *Deraecoris brevis* (inset), an important predator in pears, are more susceptible to some pesticides than the adults.

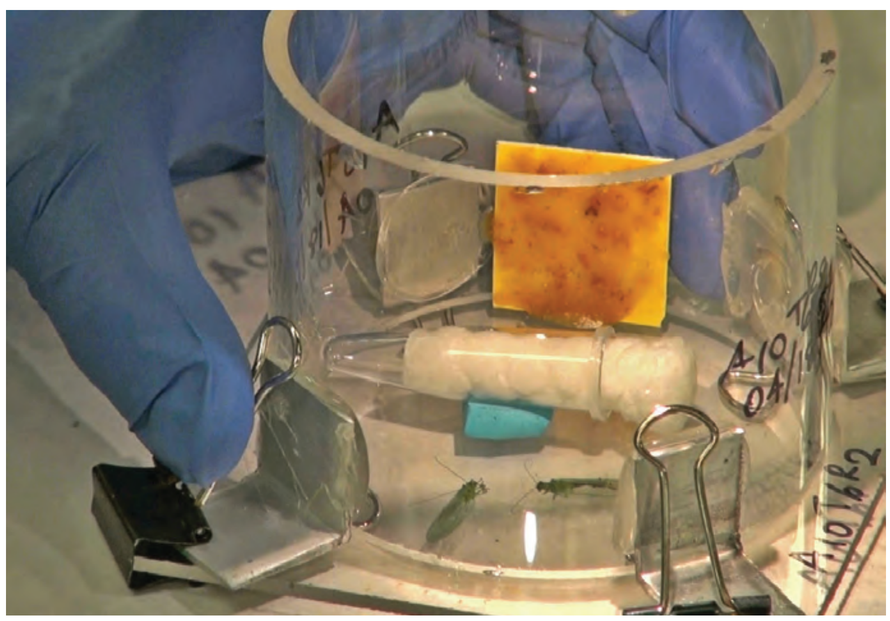

PHOTO BY ANGELINA GADINO, WSU

Pesticide effects on predatory mite populations were evaluated in the laboratory in mesocosm setups with isolated bean plants.

PHOTO BY HELMUT RIEDL, WSU

The parasitic wasp *Aphelinus mali* attacks woolly apple aphids and leaves black, swollen aphid mummies behind.

PHOTO BY ELIZABETH BEERS, WSU

Above left: Adult *A. mali* are affected by most of the tested reduced-risk pesticides.

how fast it can recolonize an orchard after treatments, how long a pesticide's residue affects the natural enemy, and how often and exactly when in the season the pesticide is applied. Some of these factors are the focus of current research projects.

Future research

Through this research, we realized that we are just scratching the surface in understanding how pesticides affect natural enemies. Future work will produce additional information to develop a more precise and dynamic disruptive index for each pesticide and natural enemy. With natural enemy models *(see "Use of natural enemy models is a new tool for IPM" in the March 1 issue of* Good Fruit Grower), we will soon be able to predict when susceptible stages are present in orchards and thus when to use low-risk pesticides. New monitoring tools that we have developed *(see "Natural enemy inventory" in the February 15 issue)* will reveal which natural enemies are present and when, and what impact management practices have on their populations.

Although we have already drawn some meaningful conclusions from our research, understanding the complete picture will take more time. All information we have available will be integrated as recommendations, databases, guides, videos and more on our project Web site *(enhancedbiocontrol.org)*, in the WSU Crop Protection Guide, and on the WSU Decision Aid System. To find out more about pesticide effects, visit our Web site, *http://enhancedbc.tfrec.wsu.edu/*, and look for more project information in the next two issues. ●

This is the sixth article in an eight-part series highlighting results of a five-year Specialty Crop Research Initiative project to enhance biological control of orchard pests. The project involves researchers from Washington State University, Oregon State University, University of California Berkeley, and the U.S. Department of Agriculture in Yakima, Washington.