ALFALFA WEEVIL MANAGEMENT & RESISTANCE ISSUES

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ABSTRACT

The alfalfa weevil is a key insect pest of alfalfa in the western US. For decades, inexpensive and effective pyrethroid active ingredients have been used to maintain weevil populations below economically damaging levels. During the last few years, producer reports of the failure of pyrethroid insecticides (mode of action group 3A, MoA3A) to control alfalfa weevil, even after multiple spray applications, have increased. Research to quantify the level of pyrethroid resistance, and its distribution in the western region, has identified populations in six states that are highly resistant to lambda cyhalothrin, the most commonly used pyrethroid. Several different pyrethroid active ingredients are registered as a variety of commercial formulations for use in forage alfalfa crops. Data collected to date indicates cross-resistance between these different pyrethroid active ingredients, rendering the entire MoA3A class of active ingredients ineffective against populations that have developed resistance.

INTRODUCTION AND RESULTS

Alfalfa weevil (*Hypera postica*) is one of the most damaging pests of alfalfa in the US, and approaches to prevent damage have remained largely unchanged for several decades. During the last few years however, alfalfa producers in the western region have reported increasing problems managing this pest. The alfalfa weevil is native to Eurasia and North Africa where it feeds on alfalfa and related native plants and was introduced into the US at least three separate times. The three introductions are called the western (Salt Lake City UT in 1904), Egyptian (Yuma AZ in 1939), and eastern (Maryland in 1952) races. This introduced pest has now spread throughout the continental US and parts of Mexico and Canada.

Adult female alfalfa weevils lay their eggs within alfalfa stems. After eggs hatch, the tiny new larvae feed inside the developing leaf buds. As the larvae grow larger, they begin feeding on open leaves, at which point they cause the most damage. High populations can consume most of the leaves, giving the field a white, frosted appearance and reducing yield and forage quality. Alfalfa weevil management recommendations are rooted in integrated pest management (IPM) principles: scout and identify the pest; monitor pest numbers; if pest numbers exceed the economic threshold, employ available management tools (chemical, cultural, physical and biological tactics) in a coordinated way to reduce pest numbers below the threshold. Larvae can

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be monitored using a sweep net or by shaking alfalfa stems in a bucket. An average of 20 larvae per sweep or 1.5 – 2.0 larvae per alfalfa stem are commonly used thresholds. Once the economic threshold has been met, insecticide sprays can be used to reduce pest numbers and preserve yield, or, if the field is within 7-10 days of being harvested, it can be cut early to prevent yield loss.

Inexpensive and effective sprays of pyrethroid active ingredients (mode of action group 3A, MoA3A) have been used extensively for several decades to manage larval populations in alfalfa fields. This repeated use of pyrethroid insecticides has brought with it the threat of insecticide resistance, which could render these materials ineffective. Synthetic pyrethroids are a large class of insecticide with active ingredient names like permethrin, cyfluthrin, cyhalothrin and cypermethrin and trade names such as Baythroid®, Mustang Maxx® and Warrior®, among many others. Failure of insecticide application and suspicion of resistance have been reported by growers and agriculturalists in seven western states as well as the province of Alberta in Western Canada (Rethwisch et al. 2019).

A collaborative project to quantify the level of pyrethroid resistance and characterize its distribution in Western US states was initiated in 2019 with support from the USDA NIFA Alfalfa Forage Research Program. Determining the current scope of resistance, as well as identifying if populations are still susceptible, is a crucial initial step in developing a response to pyrethroid resistance in alfalfa weevil.

A field trial in southern Big Horn County Montana using an ATV ground application confirmed producer reports of pyrethroid insecticide failure in this area (Fig. 1). Lambda cyhalothrin (MoA 3A) applied at the high label rate failed to reduce larval populations two weeks after treatment relative to untreated check plots. An insecticide with a different mode of action, Steward® (MoA 22A), effectively reduced the population by 94% (Fig. 1). Interestingly, permethrin, a Type I pyrethroid, provided intermediate control of larvae in this population, compared to lambda cyhalothrin, a Type II pyrethroid (Fig. 1).

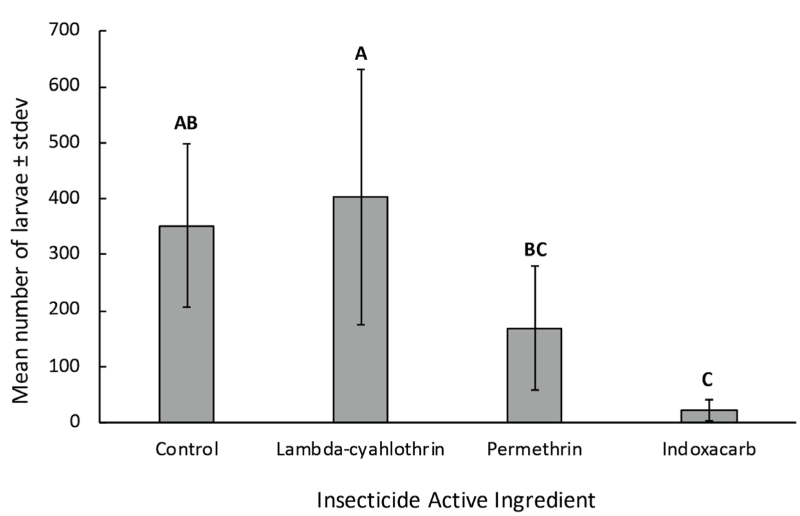

Figure 1. Mean number of alfalfa weevil larvae ($\overline{x} \pm$ stdev) per ten sweeps 13-days after treating field plots located at site 1 Big Horn County, MT, with lambda-cyhalothrin, permethrin and indoxacarb at maximum label rates. Treatment effects are significant, ANOVA, (F=5.67; df= 3, 15; P= 0.012). Treatments with different letters are significantly different, p = 0.05, Tukey pairwise comparison.

The emphasis of our project has been to measure pyrethroid resistance/susceptibility in various alfalfa weevil populations across six western states. Laboratory bioassays use glass vials treated with increasing concentrations of pyrethroid active ingredient. Larvae are added and then mortality/morbidity assessed after 24 hr. These types of assays are crucial for determining just how resistant populations are and to robustly make comparisons between populations. In these studies, we focused on lambda-cyhalothrin, but also included other pyrethroid active ingredients to test for cross-resistance. These additional materials were primarily tested on populations from MT.

We have thus far documented numerous cases of pyrethroid resistance in alfalfa weevil populations, as well as populations that continue to be susceptible. First, one laboratory bioassay trial (Fig. 2) confirmed the field results reported in Fig. 1. When susceptible alfalfa weevil larvae from Powder River County MT sites 1 and 2 were tested, larval mortality increased as the concentration of lambda cyhalothrin in the glass vials was increased (Rodbell and Wanner, 2021). The same trend, however, was not observed for larvae collected from Big Horn County MT sites 1 and 2, where mortality from lambda cyhalothrin never exceeded 30-50% even at the highest concentrations tested (representing more than 30 times the label rate). These laboratory results (Fig. 2) explain the complete failure of lambda cyhalothrin to control alfalfa weevil larvae in the field trial (Fig. 1) and demonstrate extremely high resistance in this population.

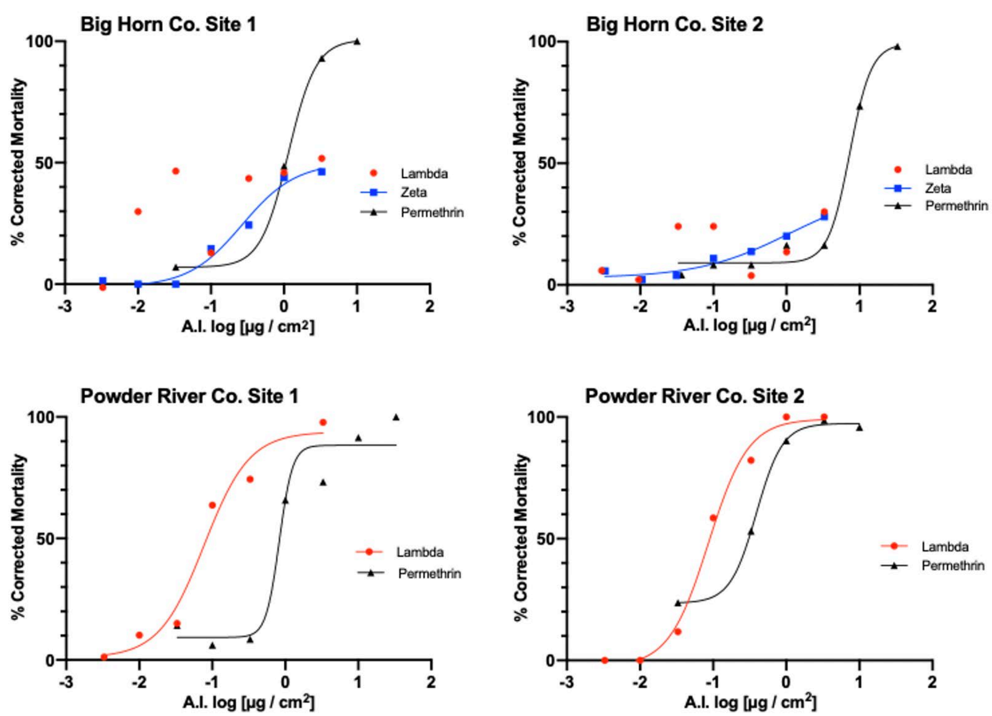

Figure 2. Concentration-responsive mortality by field site in Big Horn and Powder River Counties. Percent mortality plotted against the logarithm of active ingredient concentration: lambda-cyhalothrin (red symbols); zeta-cypermethrin (blue symbols); and permethrin (black symbols).

An additional important trend was noted in this study. Bioassays using zeta cypermethrin (Type II pyrethroid) in addition to lambda cyhalothrin (also Type II pyrethroid) suggest cross-resistance between the different Type II active ingredients used to manage alfalfa weevil populations. Similar to lambda cyhalothrin, mortality caused by zeta cypermethrin did not exceed 30-50% even at the highest concentrations tested, for populations Big Horn County sites 1 and 2 (Fig. 2). Interestingly, the higher concentrations of permethrin (Type I pyrethroid) were able to achieve high levels of alfalfa weevil mortality, supporting the partial control observed for this active ingredient in the field trial (Fig. 1). These results indicate that cross-resistance might not be complete for Type I pyrethroids. However, permethrin is an older pyrethroid that is not as effective as the next generation of pyrethroids such as lambda cyhalothrin, so its usefulness in managing resistant alfalfa weevil populations is questionable.

In California, there are currently multiple locations with known resistance to lambda-cyhalothrin, as determined through prior laboratory alfalfa stem bioassays or our dose-response bioassays. We detected a gradient of resistance, with some populations showing a poor response in mortality to lambda-cyhalothrin. At the same time, our “haphazard” sampling of alfalfa fields where resistance was not suspected revealed populations that remained susceptible to lambda-cyhalothrin and some that were moderately resistant. Some of these populations were still extremely susceptible, with very high mortality even at very low insecticide concentrations.

This data is currently being analyzed and several trends are apparent. Populations fall into three broad categories of resistance relative to label rates: susceptible to lambda-cyhalothrin; moderately resistant; and highly resistant. These results suggest that the genetic basis for pyrethroid resistance is established and wide spread in the Western US region, and pockets of highly resistant alfalfa weevils may result in areas that frequently apply pyrethroid insecticides.

Bioassays that included zeta-cypermethrin (Type II) and permethrin (Type I) confirmed patterns of cross-resistance observed in Montana. Pockets of highly resistant populations in Western Region states also tended to be highly resistant to zeta-cypermethrin and partially resistant to permethrin.

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