Widespread Resistance of the Alfalfa Weevil to Pyrethroid Insecticides in the Western United States

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Alfalfa *(Medicago sativa* L*)* is an important component of agriculture in the western United States, providing forage to both the dairy and beef cattle industries, and exported as compressed bales. For several decades the primary defoliating insect pest of alfalfa (alfalfa weevil, *Hypera postica* Gyllenhal) has been managed using pyrethroid insecticide sprays. Originally developed from the natural insecticide pyrethrum, several synthetic analogs have been developed for agriculture, including 7 active ingredients registered for use on alfalfa: permethrin and bifenthrin (type I pyrethroids) and lambda-cyhalothrin, alpha-cypermethrin, zeta-cypermethrin, beta-cyfluthrin and gamma-cyhalothrin (type II pyrethroids). Alfalfa producers have relied on these insecticide products because of their efficacy, cost effectiveness and safety. Field reports from 2015 (Alberta, Canada) and 2016 (California, USA) suggested reduced efficacy or complete failure of pyrethroids to control alfalfa weevil populations. Research during 2020 and 2021 confirmed resistance to lambda-cyhalothrin in Big Horn County Montana. Using technical active ingredient and a glass vial bioassay, 24-hour contact toxicity of lambda-cyhalothrin measured as the LC_{50} (lethal concentration resulting in 50% mortality) ranged from 0.02 to 0.10 µg/cm^2 in susceptible fields. In contrast, populations from Big Horn County did not reach 50% mortality at the highest concentration of lambda-cyhalothrin tested (3.30 µg/cm^2).

More than 70 commercial alfalfa fields in six different western region states (Arizona, California, Montana, Oregon, Washington, and Wyoming) were surveyed for lambda-cyhalothrin resistance during 2020 and 2021. Fields with alfalfa weevils resistant to lambda-cyhalothrin were identified from all six states (resistance ratios >100) indicating that resistance genes are widespread. Several fields were also assayed for resistance to permethrin (type I pyrethroid) and zeta-cypermethrin (II pyrethroids). These preliminary results suggested cross-resistance between Type II pyrethroid active ingredients and variable and/or limited cross-resistance to permethrin (type I pyrethroid). To further assess cross-resistance, five pyrethroid active ingredients were assayed against lambda-cyhalothrin resistant alfalfa weevils from Arizona, Washington and Montana, during 2022, and the commercial products tested in corresponding field trials. Integrated resistance management (IRM) strategies to slow pyrethroid resistance (including rotating mode of action groups, applying chemical control tactics only when economic thresholds have been met, and utilizing mechanical, cultural, and biological control tactics) will be discussed.

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