INSECTICIDE RESISTANCE IN ALFALFA WEEVIL AND RELATED IMPLICATIONS IN OTHER ALFALFA INSECT PESTS

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ABSTRACT

Field failures in controlling alfalfa weevils are becoming more frequent in multiple western states the past several years with insecticide resistance now documented in at least three states (California, Colorado, Washington), primarily to the active ingredient lambda-cyhalothrin (active ingredient in products such as Warrior II with Zeon Technology®). Some states are noting lack of control by chlorpyrifos (active ingredient in products such as Lorsban®) as well. Resistance is highly localized, which reflects both insecticide use pattern and short-range dispersal of alfalfa weevils. Insecticide resistance is expected to necessitate producers to rotate insecticides, often to a more expensive product. In fields that have both damaging levels of aphids and alfalfa weevils, a second insecticide will also probably be necessary as the product currently registered for best alfalfa weevil control based on university trials (indoxacarb, active ingredient in Steward®) has very little activity against aphids. Testing is underway in several states to determine the extent of insecticide resistance. Coordinated testing will be conducted across the western states beginning in 2020.

Key Words: Insecticides, alfalfa weevil, resistance, pyrethroid, lambda-cyhalothrin, chlorpyrifos, beta-cyfluthrin

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INTRODUCTION

The alfalfa weevil has been a major pest of alfalfa for many years, and insecticides have been a major tool for weevil management, being applied when weevil populations are causing economic loss. This can result in insecticide resistance development in alfalfa weevils. Currently there are reports of lack of control and/or insecticide resistance in alfalfa weevils in the western US. This is not a new phenomenon.

Timeline of Insecticides and Resistance in US alfalfa weevils

1946 - Chlorinated hydrocarbons started being applied for control of alfalfa weevils

1962 – Knowlton (Utah) reported that 4 oz./acre of either Heptachlor or Dieldrin applied in early spring failed to control alfalfa weevil adults and larvae in 1961-1962 (Adler and Blickenstaff, 1964).

Subsequent years noted many reports of resistance to multiple organochlorine insecticides that were documented in the 1960s (Aldrin, DDT, BHC/β-Hexachlorocyclohexane, Lindane, Dieldrin, Heptachlor, Isobenzan/Telodrin, Methoxychlor) (APRD, 2019).

1969 - Furadan® (active ingredient = carbofuran) became available for usage on alfalfa. Provided excellent control of both alfalfa weevils and aphids.

2009 – Furadan® usage on alfalfa cancelled. There are no known reports of alfalfa weevils developing insecticide resistance to Furadan® during or after this 40 year period

2015 – Reports from Canada of lack of control and/or resistance to the insecticide active ingredient lambda-cyhalothrin (Glen, 2015; Glen, 2017).

2015 and subsequent years – There has been lack of control and/or documentation of insecticide resistance in various western US states. The results differ by state.

Arizona

No reports of insecticide resistance. Testing of alfalfa weevils in a dose-response to lambda-cyhalothrin noted excellent control at high rates.

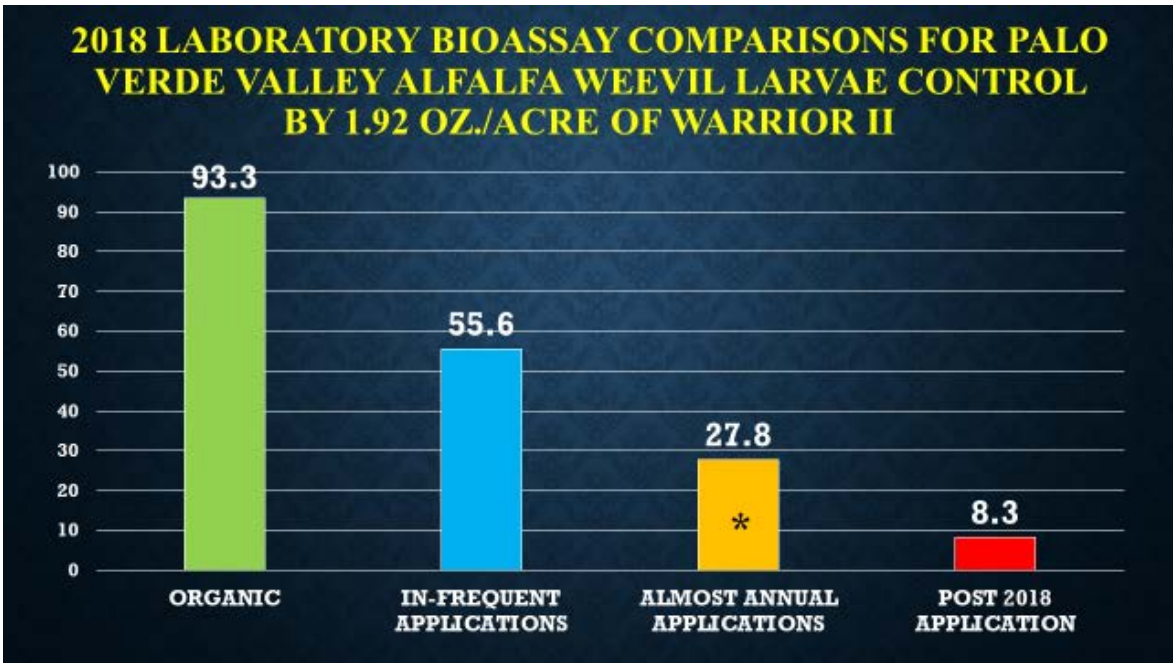
California

Resistance to the pyrethroid insecticides has been documented in both northern California (western strain alfalfa weevils, Siskiyou County, Scott's Valley) and southern California (Egyptian strain alfalfa weevils, Riverside County, Blythe). In northern California resistance to two pyrethroid insecticides was verified to both lambda-cyhalothrin and beta-cyfluthrin (active ingredient in Baythroid XL)).

Percent Weevil Mortality from Pyrethroids	
Field Site	**Recommended Rate**
Organic field	92%
Conventional Fields, 1-4	3%-15%

Table 1. Alfalfa weevil percent mortality after treatment with beta-cyfluthrin or lambda-cyhalothirn at various rates, Scott's Valley, California (Orloff et al,. 2016).

In southern California resistance was discovered after field failure of a lambda-cyhalothrin application. Laboratory bioassay 2018 results from a range of sites in the Palo Verde Valley (Blythe area) noted a range of resistance levels that was correlated to applications of lambda-cyhalothrin in recent years. The same pattern was noted in 2019 testing.



Colorado

Fairly certain there is resistance in Colorado alfalfa weevils, based on efficacy of three modes of action at three locations over two years. All three insecticide modes of action worked well in 2016 but failed at two of three locations in 2017. A lambda-cyhalothrin dose response was developed and used in a limited local survey this year (2019). Evidence for resistance was found

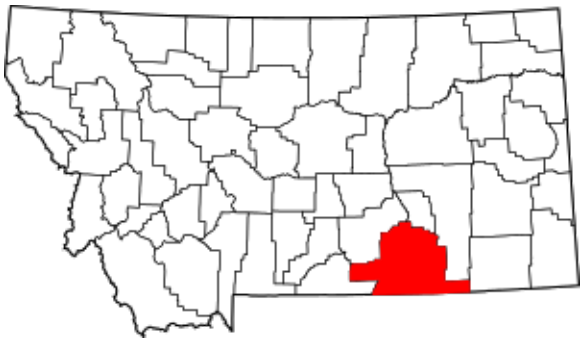
at seven of nine locations on the front range (eastern side) of northeastern Colorado between Denver and the Wyoming state border.

Idaho

Extension personnel are not aware of any evidence of insecticide resistance in alfalfa weevil in Idaho, however it is worth noting that no one is known to be looking for it.

Montana:

The first concerns of pyrethroid insecticide resistant alfalfa weevils in Montana were reported during the 2019 production season before first cutting in June. Several areas in the southern region of Big Horn County Montana reported failure of 2 or 3 repeated applications of pyrethroid insecticide (a.i. lambda-cyhalothrin) to control alfalfa weevils. The Montana State University (MSU) Extension Specialist for cropland entomology visited and scouted six alfalfa fields in this area just prior to first harvest in June. Sweep consistently yielded high numbers of alfalfa weevil larvae, averaging in the range of 40+ per sweep, supporting the field observation of control failure. Insects were taken to the MSU entomology laboratory for testing but bioassays for resistance were inconclusive since the alfalfa weevil larvae were already in an advanced 4th instar stage and pupation began during the bioassay. Additional testing to determine resistance levels to lambda-cyhalothrin will be conducted in southern Big Horn county next season in 2020.

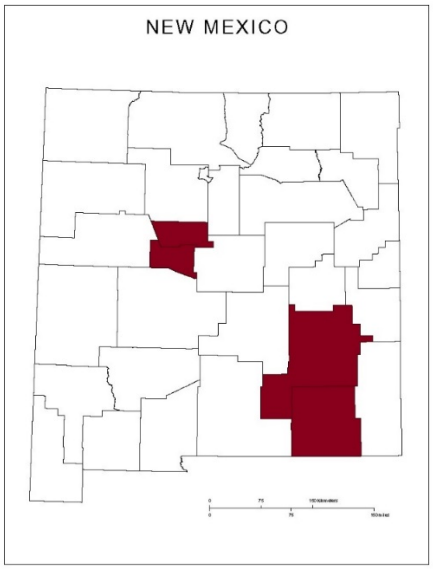


New Mexico

We do not have any formal reports of insecticide resistance, however consultants have told New Mexico State University Extension that they are not getting control from pyrethroids alone. Some are still willing to use Cobalt™ (a mixture of lambda-cyhalothrin and chlorpyrifos) but it is unclear if any of the control is due to the pyrethroid component.

The area of heaviest insecticide use is likely the upper Rio Grande Valley south of Albuquerque. They have the highest populations and damage, much higher in the last few years than it was 15-20 years ago. There is a fair amount of insecticide use in Chaves County which historically was the highest hay acreage although lately some of it has been replaced with corn and pecans.

The areas of concern are the Pecos Valley and the area south of Albuquerque (Valencia and Socorro Counties primarily). One of the consultants near Albuquerque says he is not comfortable not using a pyrethroid as part of the mix but will not use certain formulations. He thinks some of the EC formulations still work but typically uses a combination of specific pyrethroids plus chlorpyrifos but won't use Cobalt™. It is unclear what's going on since we don't have any real data.



Nevada – No report

Oregon

Most Oregon alfalfa is grown east of the Cascade Mountains. Lake (55,000 acres), Klamath (50,000 a), Malheur (48,000 acres), Harney (40,000 acres), Morrow (18,000 acres), and Umatilla (40,000 acres) are the top five counties for alfalfa acreage (USDA 2018). In northeastern OR counties, the life cycle is cyclical, with some years experiencing severe weevil pressure, and others almost non-existence.

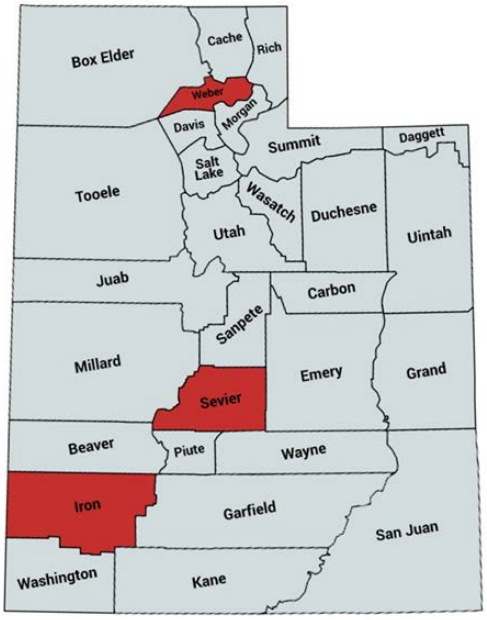
Two large growers in northeastern Oregon (Umatilla County, on the Washington border) indicated that they rarely or never sprayed for weevil; in central Oregon, one county agent indicated that he does not get reports of failure of control.

In southern counties, especially near the California border, alfalfa weevil seems to be a recurrent problem, and most of the complaints happen to come from that area. Complaints include failure of pyrethroids and organophosphates. No specific comments were shared related to specific products and reports were not data driven. As such, the actual cause of failures is unknown.

The Oregon State University Irrigated Agricultural Entomology Program focuses on testing the efficacy of chemical material with good results for larva and adult control. Our program has also been working with colleagues in Montana and Arizona, and samples were submitted during the 2019 season to include them on their resistant studies.

Utah

Pesticide trials conducted in Utah (Logan (Cache Co.), Brigham City (Box Elder Co.) and Price (Carbon Co.) included pyrethroid and organophosphate insecticides for control of alfalfa weevils. These products typically provided good suppression.



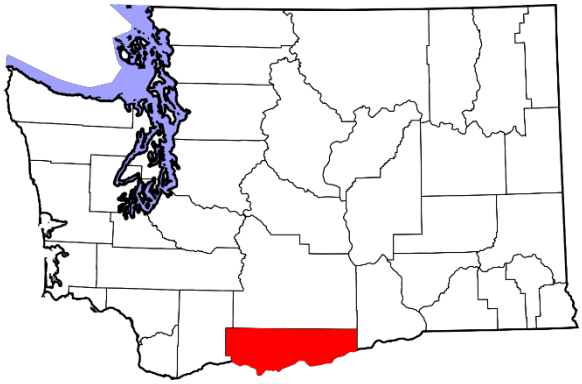
Traditional alfalfa weevil pesticides (pyrethroids and organophosphates) have been noted to be less successful in southern Utah around Cedar City (Iron Co.), and also around Richfield (Sevier Co.) and Farr West (Weber Co.). These areas are where resistance has been mentioned by growers, pesticide applicators, or a Utah State University extension faculty member. No specific tests have yet been completed to evaluate and/or confirm resistance to above noted insecticides by alfalfa weevil in Utah.

A newly funded project looking at pesticide fate modeling in alfalfa will be conducting 'bottle tests' to evaluate LD50's of pyrethroids, organophosphates, indoxacarb, etc., for alfalfa weevil in Utah. While the focus isn't on resistance per se, the design of the study should capture sensitivity of Utah alfalfa weevil populations to these differing insecticide doses.

Washington

In Washington research on alfalfa produced for seed slippage in efficacy of the organophosphate insecticide chlorpyrifos in control of alfalfa weevil *Hypera postica* has been noted. In a unique alfalfa growing area of Washington State we have observed complete field failure of alfalfa weevil control with the pre-mix insecticide Cobalt™. Cobalt™ is an insecticide marketed by Corteva™ Agrisciences and it is a mixture of the organophosphate chlorpyrifos and synthetic pyrethroid lambda-cyhalothrin. It was alarming to see the field failure with this product. This failure was not unique to a single grower. It was observed in multiple fields in an area of Klickitat County near Goldendale, WA.

Goldendale is a small city roughly 100 miles east of Portland, OR. The elevation is about 1,350 feet and it lies in the transition between wet western WA and dry eastern WA.



Wyoming

Extension personnel have received complaints and comments about poor alfalfa weevil control with different pyrethroid insecticides and even chlorpyrifos in Wyoming. Producers have expressed that control measures 'failed'. Several fields which had very poor results were visited by University of Wyoming individuals. Many of the failed control measures were mostly due to lack of monitoring and application timing. One field failure was certainly due to poor timing of treatment brought on by the difficult weather experienced this spring.

No actual testing for resistance has been conducted on Wyoming alfalfa weevils, thus resistance to pyrethroid insecticides in Wyoming has not yet been evaluated or confirmed as currently existing.

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There are a number of factors that are contributing to the current difficulties in controlling alfalfa weevil and that can contribute to resistance. First and foremost is the repeated use of same insecticide/chemistry class. This leads to initial selection of a few individuals that are not killed by that insecticide active ingredient. It should be noted that is in a localized area, and that resistance is usually highly localized.

The second is the weather, specifically winter temperatures. Warmer winters (or lack of extreme cold temperatures) are thought to contribute to increased alfalfa weevil adult survival, thus more eggs are deposited and subsequent weevil populations will be higher. Female alfalfa weevils are generally 400-1,000, but there are some reports of 1,500 eggs/female from other countries. Some reports reference as many as 4,000 eggs/female, but the scientific report with laboratory/ field studies to verify this wasn't readily found/available.

The third factor that is not often discussed is the longevity of alfalfa weevil adults, which can exceed two years (Litsinger and Appel, 1973). There are reports of more than one season of oviposition. These reports indicate that adult weevils, including those that survived insecticide treatments, can be present for more than one year to provide their genetics to the population.

To determine the extent of insecticide resistance in western US alfalfa weevils, Dr. Kevin Wanner from Montana and Dr. Ian Grettenberger from California have received a grant from the USDA NIFA Alfalfa Seed and Alfalfa Forage Systems (ASAFS) Program entitled "Insecticide Resistant Alfalfa Weevils in the Western US: Quantifying the Scope of Resistance and Implementing a Plan to Manage the Threat". One aspect of this project will be the standardization and comparison of alfalfa weevil insecticide resistance levels from across the western US. This project will be funded through 2021.

The fact that there is currently insecticide resistance in alfalfa weevils has additional implications and ramifications for the US alfalfa industry. These include cross resistance to other insecticides in the same insecticide class (previously noted in the organochlorine insecticides in the 1960s). Growers will need to switch/rotate alfalfa insecticide classes to limit development of insecticide resistance. This will probably also mean higher costs to control alfalfa weevils, as alternative chemistries are often more expensive than pyrethroid insecticides.

Another implication is that some situations will require an additional insecticide chemistry for insect control. For example, economically damaging levels of aphids occur in mixed populations with alfalfa weevils in the low desert, and Steward® (indoxacarb) is not very effective on aphids.

The newly registered and potential insecticides for alfalfa target aphids as the pest insect. These new products provide little control of alfalfa weevils, thus creating more resistance selection pressure on existing insecticides that control alfalfa weevils if repeatedly used.

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