CONTROLLING ALFALFA WEEVIL
EFFICACY, THRESHOLDS, AND FUTURE NEEDS

Rachael Long[1], Thomas Getts[2], Kevin Goding[3], Nicole Stevens[4], Nick Clark[5], Dan Putnam[6], and Ayman Mostafa[7]

ABSTRACT

The alfalfa weevils (Western, Egyptian and Eastern strains) are the most serious pests of alfalfa. The larvae of these insects feeds on the foliage, causing significant yield and forage quality losses to the first and sometimes second hay cutting. These pests were introduced from Eurasia from the early to mid-1900s and have been challenging to control. There are no effective resistant plant varieties, biocontrol is limited, and cultural practices have significant trade-offs with yield and forage quality. The only current effective management practice to control these key pests is the use of insecticides. However, insecticides have their own inherent problems, with few modes of action registered for alfalfa hay and with pesticide resistance, particularly in the Intermountain area of Northern California where weevils are resistant to pyrethroids. This report highlights the status of weevils in California and management practices for controlling these pests. This includes the need for identifying the specific weevil strains in a production area for improved management, developing and implementing economic threshold levels for better monitoring and spray timing, finding new insecticide chemistries, and developing alfalfa host plant resistance for weevil control.

Key Words: alfalfa, weevils, insect pest management

ALFALFA WEEVIL BIOLOGY

The alfalfa weevil complex includes the Western, Egyptian, and Eastern strains that are all likely the same species *(Hypera postica)*. These weevils are the most damaging pest of alfalfa throughout most of the United States. The larvae are voracious feeders of alfalfa, damaging terminals, foliage, and new crown shoots, resulting in significant yield and forage quality losses. Heavily infested fields may appear silver or white when the leaves are skeletonized or consumed entirely and the plants are defoliated. If large numbers of larvae survive harvest they can continue feeding and damage crown buds under the windrows, retarding regrowth. This damage can reduce plant vigor, resulting in reduced stand density and low yields in subsequent harvests (UC IPM 2017).

Alfalfa weevils are introduced pests that originated from Eurasia. The three strains were accidently brought into the U. S. at different times from the early to mid-1900s, likely on imported goods. The Eastern strain is found east of the Rocky Mountains, whereas the western

[1]R. Long, UCCE Farm Advisor, Yolo County, 70 Cottonwood St., Woodland, CA 95695, email rflong@ucdavis.edu; [2]T. Getts, Farm Advisor Lassen County; [3]K Goding, Staff Research Associate, Department of Entomology, UC Davis, [4]N. Stevens, Field Asst., UCCE Siskiyou County, Yreka, CA; [5]Nick Clark, Farm Advisor Kings County; [6]D. Putnam, Extension Agronomist, UC Davis, [7]A. Mostafa, Extension Entomologist, University of Arizona. In: Proceedings, 2017 Western Alfalfa and Forage Symposium, Reno, NV, 28-30 November, 2017. UC Cooperative Extension, Plant Sciences Department, University of California, Davis, CA 95616. (See http://alfalfa.ucdavis.edu for this and other Alfalfa Symposium Proceedings).

and Egyptian strains generally occur west of the Rockies. The Eastern and Western strains co-exist just east of the Rockies (though the Western strain is expanding eastward) and the Western and Egyptian strains coexist in the southwestern U. S. as shown in Figure 1 (Bundy et al. 2005). The strains cannot be visually differentiated from one another; instead, they are separated by different behaviors, as described in Table 1.

Alfalfa weevils generally have one generation per year, though sometimes a second generation can occur, particularly in warmer climates. The Egyptian alfalfa weevil typically leaves the field during the summer time where they aestivate (summer hibernation) in protected areas, such as behind tree bark of eucalyptus trees. The alfalfa weevil often stays in the field year round, but can also be found outside the field. The Egyptian weevil migrates back into alfalfa fields in the wintertime and lays clusters of 5 to 20 eggs in alfalfa stems. Females are prolific and can lay over 4,000 eggs in their lifetimes. When the larvae hatch, they begin feeding on the developing buds. The first cutting is at most risk for alfalfa weevil damage although the second cutting can also be damaged, depending on time of harvest (early versus late), year, and location.

Figure 1. Distribution of the alfalfa weevil *(Hypera postica)* in the United States, including the Western, Egyptian, and Eastern strains, showing where they co-exist (Bundy et al. 2005)

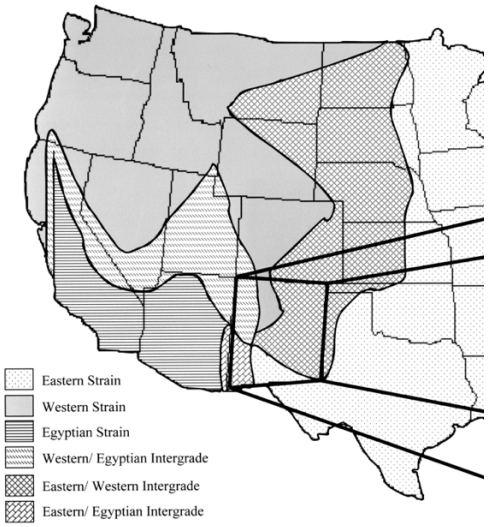


Table 1. Behavioral differences between the Western, Egyptian, and Eastern alfalfa weevil strains. *Wolbachia* may cause the delayed population peak (Bundy et al. 2005; Pellisier et al. 2017; Maund and Hsiao 2012; Radcliffe and Flanders 1998; Rethwisch and Manglitz 1986).

Behavior	**Western**	**Egyptian**	**Eastern**
Aggregate during aestivation	No	Yes	No
Migrate out of fields	No	Yes	No
Pupate	In leaf litter	On plant	On plant
Climate preference	Cool	Hot, dry	Likely moderate
Population peak	1-3 weeks later	1-3 weeks earlier	1-3 weeks earlier
Biocontrol, parasitoid wasps	Yes	No	No
Wolbachia endosymbiotic bacterium	Yes	No	No

ALFALFA WEEVIL MANAGEMENT PRACTICES

Management of alfalfa weevils is challenging in the western United States where outbreaks can be severe. For cultural practices, some growers harvest early, but this practice results in yield losses and weevils that survive the harvesting process can feed on the alfalfa regrowth under the windrows, reducing plant growth. Another cultural practice for weevil management is overseeding alfalfa stands with another forage crop in the fall, such as clover or oat hay, that is not preferred by the weevils. This forage will fill in the stand and make up for a loss of production due to weevil damage on alfalfa plants. However, forage quality changes when growing mixed hay and one must know markets for the hay. For example, pure alfalfa is always of highest quality and is preferred by the dairy industry whereas mixed grass hay is good for the horse hay market.

Natural enemies are generally not effective enough in controlling weevils to the levels needed in many production areas. Although nine different natural enemies (primarily parasitoid wasps) have been released over the years across the United States, they have not established well enough in many areas to provide significant biocontrol. In part this may be due to poor climate adaptation matches. In addition, biocontrol depends on the weevil strain. For the Egyptian alfalfa weevil, the parasitoid wasp *Bathyplectes curculionis*, a significant and effective parasitoid for helping to control the Western strain, encapsulates and kills the parasitoid wasp eggs laid inside the Egyptian strain, killing them. A soil dwelling fungus known as *Zoophthora phytonomi,* of undetermined origin, can cause significant mortality of weevil larvae, particularly in wet years as the fungus needs moisture to be efficacious (Radcliffe and Flanders 1998). Current research is focusing on studying this fungus in California to determine its prevalence.

For resistant plant varieties, work has been done on varieties that branch profusely to outgrow weevil feeding damage, but so far this has not been efficacious enough to prevent significant damage. This year, with a grant from the California Department of Pesticide Regulation, the Principal Investigators, Putnam and Long, will be looking at using tannins as an added feeding deterrent to alfalfa for weevil control. Incorporating tannins in alfalfa would also help improve the digestibility of the alfalfa forage crop, causing less bloat.

Another option, especially for organic growers, is to 'sheep-off' fields. This involves grazing the alfalfa fields with sheep during wintertime when the plants are dormant. Since adult weevils lay eggs in alfalfa stems after migrating into fields, sheep feeding on and trampling on the infested stems can help reduce weevil numbers and damage to the alfalfa the following spring. However, a significant limitation is the availability of sheep (there is limited livestock in some alfalfa production areas). In addition, feeding by sheep does not necessarily reduce weevils to economically acceptable levels. Flaming with propane during dormancy will have a similar affect as the sheep, but is currently too expensive relative to the value of the hay.

With limited alternative options for managing weevils, most growers rely on insecticides for control. There are a number of different insecticides for use in alfalfa production in California, but the number of different modes of action are limited. Currently the options include the organophosphates (Malathion, Lorsban), pyrethroids (Mustang, Warrior, Baythroid), indoxacarb (Steward), and spinosad (Entrust, for organic production with about 70% suppression). For the carbamates, Lannate does not have residual activity and Sevin can cause phytotoxicity in plants. A key issue that is developing in the Intermountain area in Northern California is weevil resistance to the pyrethroids, as shown in Table 2 (Orloff et al. 2016). There are no indications of resistance or poor efficacy of insecticides in the Central Valley. In addition,

there are concerns that chlorpyrifos (Lorsban) registration may be cancelled for crop production in the United States for public health concerns as well water quality issues.

Research is currently focusing on the efficacy of insecticides for weevil control in the Intermountain area. Currently, Steward is the most efficacious material for weevil control. However, this insecticide is more expensive than the pyrethroids and must be ingested (weevils stop feeding after about 4hours) and efficacy could be weather dependent (must be warm enough for weevils to actively feed to ingest the product). Warrior plus Lorsban is also showing good efficacy (Figures 2-5).

Yields for Steward at 5 oz and 8 oz show about a 0.4 tons per acre yield increase over the untreated control plots (Figure 6). Costs for the different insecticide treatments (material only) are shown in Figure 7. In the Central Valley, costs for custom applying insecticides on alfalfa with an ATV are about $10 per acre. All treatments would be justified with the 0.4 tons/acre yield increase at current hay prices (averaging over $200 per ton).

Table 2. Percent weevil mortality from pyrethroids (Warrior and Baythroid), indicating resistance to pyrethroid insecticides in Intermountain alfalfa fields (Orloff et al. 2016).

	% Weevil Mortality from Pyrethroids	
Field Site	**Recommended Rate**	**Double Recommended Rate**
Organic field	92	82
Conventional Field 1	5	10
Conventional Field 2	10	13
Conventional Field 3	3	10
Conventional Field 4	15	8

Figure 2. Number of alfalfa weevil larvae per sweep before treatment and 4, 10, 15, and 23 days after treatment, Site 1, Scott Valley, CA, treated 5/8/17.

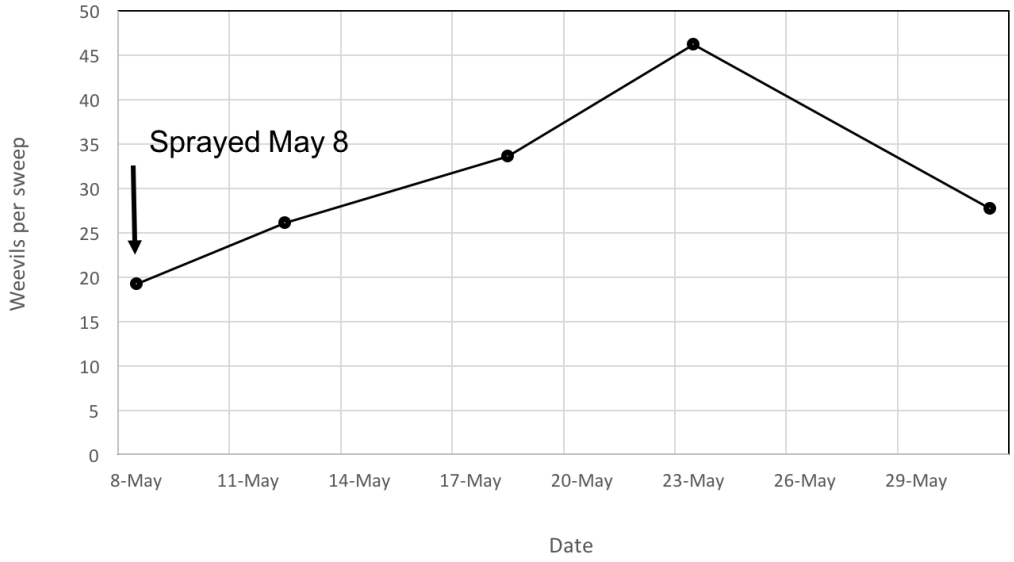


Figure 3. Percent alfalfa weevil larvae control 4, 10, 15, and 23 days after treatment (rates are shown in table below), Site 1, Scott Valley, CA, treated 5/8/17.

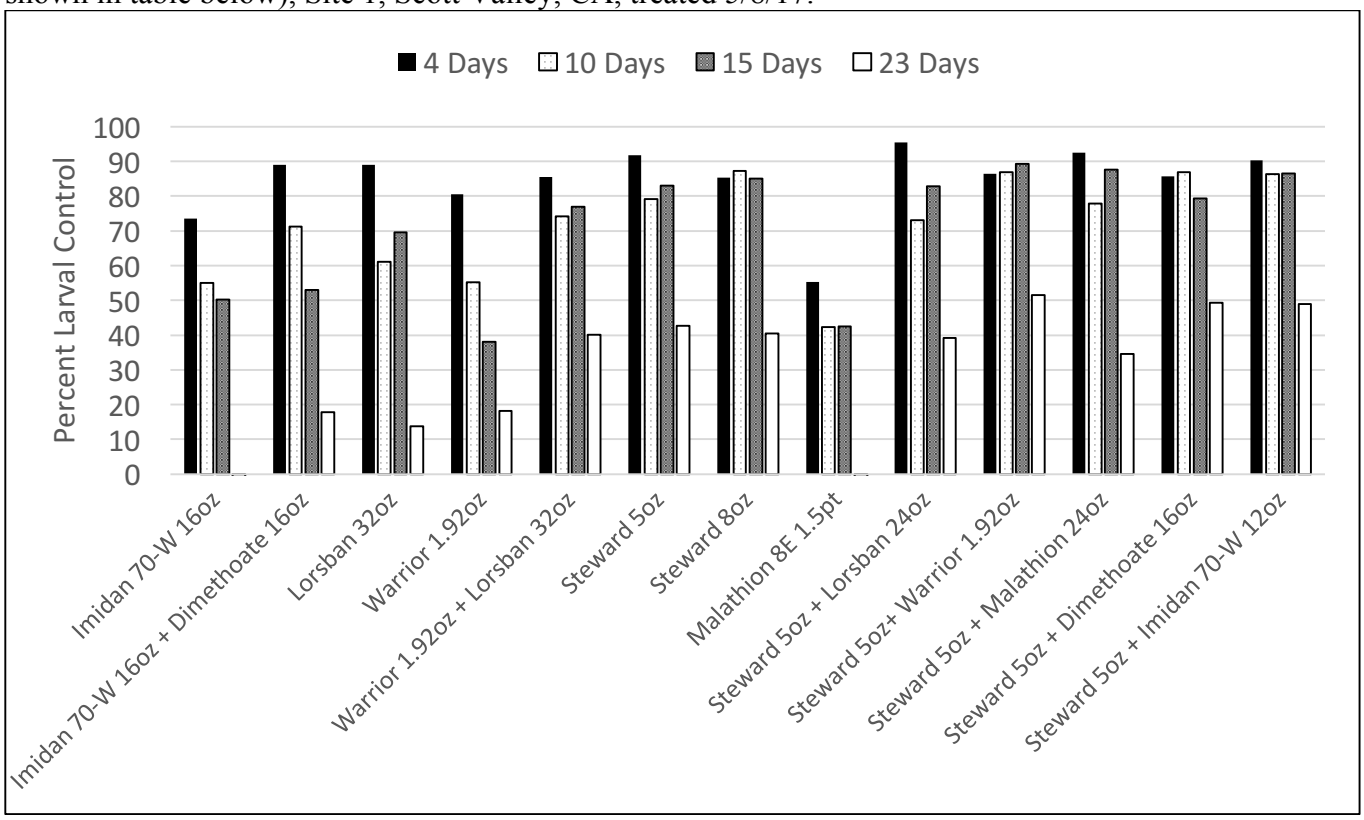


Figure 4. Number of weevil larvae per sweep 5, 13, 19, and 27 days after treatment, Scott Valley, CA, Site 2, treated 5/4/17. Untreated controls were 34, 58, 89, and 37 larvae per sweep on day 5, 13, 19, and 27 days after treatment, respectively.

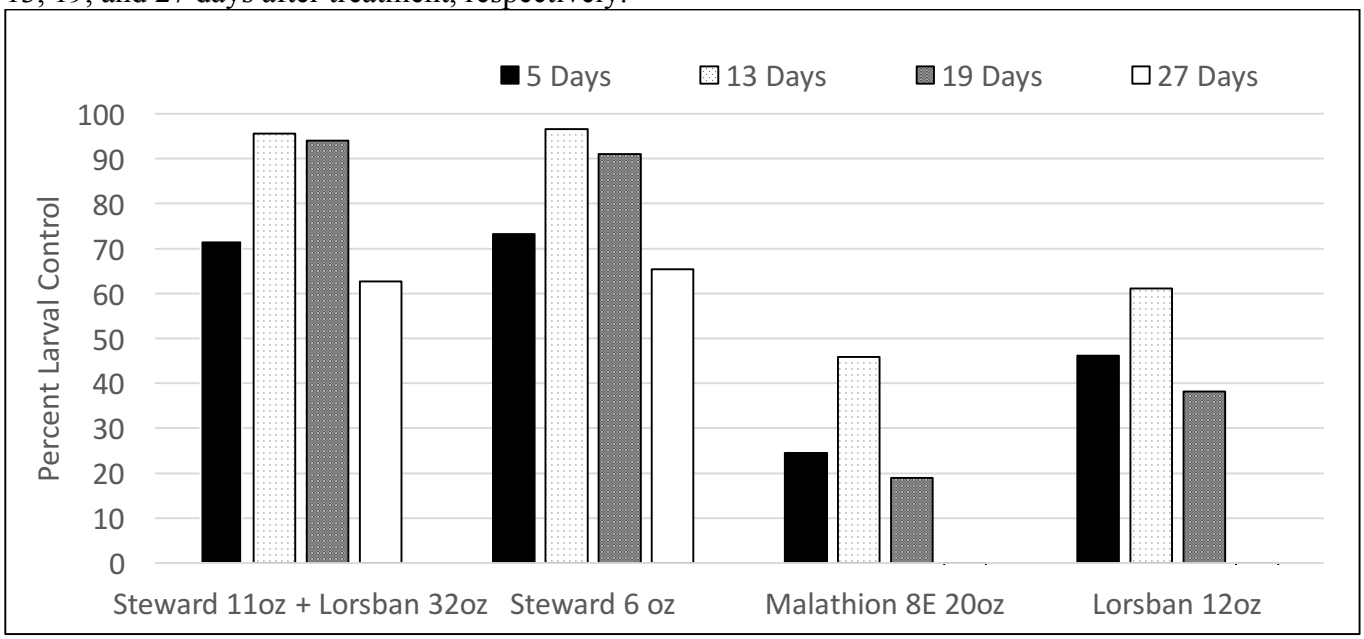


Figure 5. Number of weevil larvae per sweep, 4 and 8 days after treatment, Scott Valley, CA, Site 3, treated 5/15/17 (Lorsban 1.5 pt, Baythroid 2.8 oz, Malation 5E 1.5 pt, Steward 6 fl oz, Lorsban+Baythroid 1.5+2.8 oz and Malathion+Baythroid1.5 pts+2.8 oz.

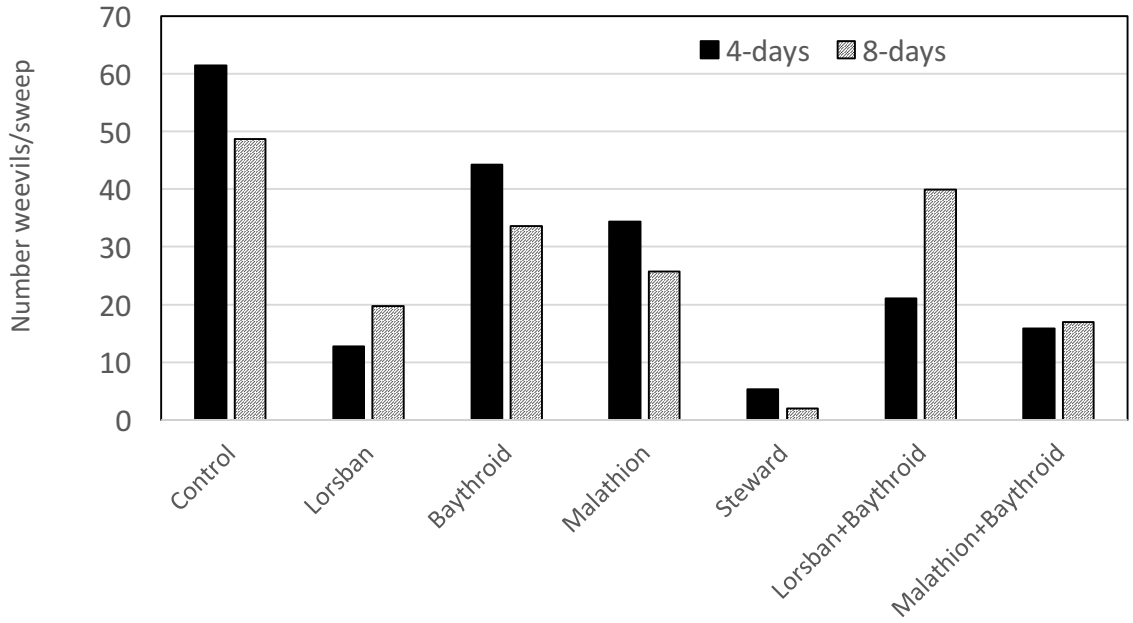
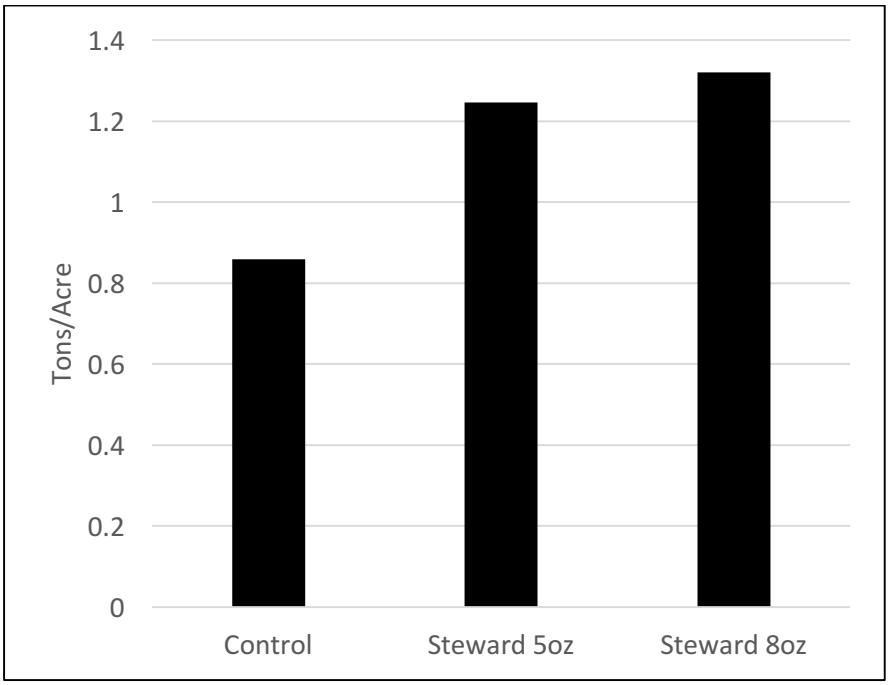
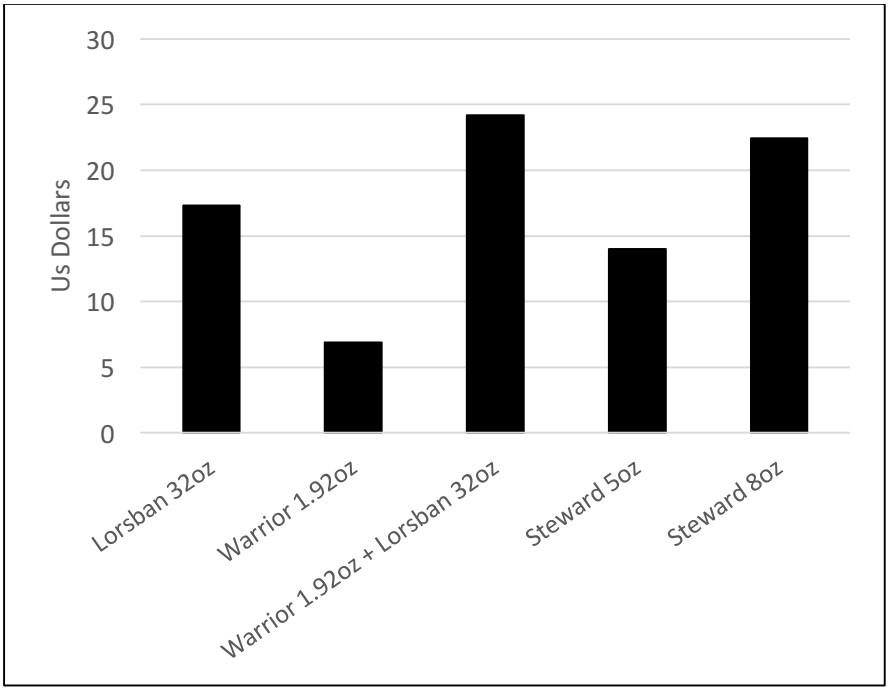


Figure 6. First cutting yield (tons/ac) for the two Steward cutting versus the untreated control (significantly different at $P<0.05$).



z

Figure 7. Cost of the different insecticide treatments for weevil control. These numbers are for the cost of the material only. For application, in the Central Valley, it costs about $10/ac for applying herbicides to alfalfa fields.



CURRENT RESEARCH: WEEVIL TREATMENT THRESHOLDS

The timing of treatment for alfalfa weevils is the focus of current research with weevil thresholds are being studied in California and Arizona. In California, current UC IPM alfalfa guidelines state that fields should be treated when weevil numbers reach 20 per sweep with a standard sweep net (UC IPM 2017). If the alfalfa plants are too short to sweep, one must look for signs of feeding damage on the leaves to determine if a treatment is needed. The importance of monitoring for alfalfa weevils is to ensure sprays are timed to get good weevil control with a minimal number of treatments. If the weevils are treated too early, the effectiveness of the insecticide spray might not last long enough and a second treatment might be needed, which may not be economical.

The original alfalfa weevil threshold studies were done in the 1970's in California. With new varieties and higher hay prices, the threshold needs to be re-evaluated. The economic threshold could be much lower than 20 weevils per sweep, depending on the value of the hay. One approach we are currently testing is to look at yield reductions associated with different weevil counts per sweep. The yield equivalent to cost of treatment (tons per acre) can then be calculated by the cost of the insecticide treatment (dollars per acre) divided by the expected hay price (dollars per ton), so that the threshold is more linked to the value of the hay and cost of the application. Other western states use a similar approach, but instead many use the number of alfalfa weevil larvae per stem as opposed to the sweep net sample. The sweep net sample appears fairly accurate, as long as there is enough forage to sweep (at least 10-in high).

CONCLUSION

The alfalfa weevil complex (Western, Egyptian, and Eastern) are significant pests that can cause yield and quality losses to the first and sometimes second cuttings. Additional research is needed to learn how to better manage these pests, including a better understanding of the different strains that occur in different geographic areas, especially in California. Knowing the alfalfa weevil strains present in local areas is important because genetics and other factors affect alfalfa weevil behavior and subsequent management and control due to strain differences. For example, the Intermountain area may be having more severe weevil outbreaks due to a shift in frequency of the weevil strain from the Western to the Egyptian alfalfa weevil, due to the drought and warmer winters. The two co-existing strains may peak at slightly different times, making for a longer period of weevil infestation. In addition, some products such as Steward are working well in the Intermountain area, but are not as efficacious in Arizona, perhaps due to differences in weevil strains. There is also a significant need to re-evaluate the economic threshold levels for weevils in California and other western states, along with developing and testing new insecticides, understanding insecticide resistance issues, and developing resistant plant varieties.

REFERENCES

Bundy CS, PF Smith, LM English, et al. 2005. Strain distribution of alfalfa weevil (Coleoptera: Curculionidae) in an intergrade zone. J. Econ. Ent., 98(6):2028-32.

Godfrey L, K Windbiel-Rojas, R Lewis et al. 2005. Alfalfa weevils: A new look at an old pest. UC ANR Alfalfa Symposium Proceedings, http://alfalfa.ucdavis.edu/.

Maund CM and TH Hsiao. 2012. Differential encapsulation of two *Bathyplectes* parasitoids among alfalfa weevil strains, *Hypera postica* (Gyllenhal). The Canadian Entomologist 123(1):197-203.

Orloff S, DH Putnam, K Goding, and L Askew. 2016. Alfalfa weevil resistance to pyrethroid insecticides found in Intermountain alfalfa fields, http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=21022.

Peairs FB, GL Hein, and MJ Brewer. 2016. Alfalfa Weevil. High Plains Integrated Pest Management Wiki. (https://wiki.bugwood.org/).

Pellisier ME, Z Nelson, and R Jabbour. 2017. Ecology and management of the alfalfa weevil (Coleoptera: Curculionidae) in Western United States Alfalfa. J. of Integrated Pest Management 8(1):1-7.

Radcliffe EB and Flanders KL. 1998. Biological control of alfalfa weevil in North America. Integrated Pest Management Reviews, 3(4):225-42.

Rethwisch, MD and GR Manglitz. 1986. Parasitoids of *Bathyplectes curculionis* (Hymenoptera: Ichneumonidae) in southeastern Nebraska. J. Kansas Entomol. Soc. 59:648-652.

UC IPM. 2017. University of California Integrated Pest Management Program for Alfalfa Hay, http://ipm.ucanr.edu/PMG/r1300511.html.

This paper is dedicated to our colleague Steve Orloff, who's dedication to the alfalfa industry will forever be remembered and appreciated.