WEEVIL RESEARCH: NEW CHEMISTRIES AND OLD PREDATORS

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ABSTRACT

The alfalfa weevil complex is the most severe insect pest of alfalfa in California. Because weevil larvae are the first insect pests of the production year to require management actions consideration of possible effects on pest management for the rest of the season must be made. Organophosphate and carbamate insecticides have provided acceptable weevil control in the past. However, the occurrence of these pesticides in surface waters has led to an emphasis on alternatives. New classes of products have been registered and others are being considered for registration. Although these new products may facilitate protection of surface waters, they may not have the optimal properties for IPM in alfalfa. Compounding these problems is the out-dated threshold developed in the 1970's used to determine the need for insecticide applications. This threshold of 20 weevil larvae per sweep was based on cultivars not grown anymore and hay values, production costs, yield expectations that are significantly different today than in the 1970's. Studies were conducted in 2002 and 2003 to evaluate the fit of the new and old materials into a current alfalfa IPM program and to examine the impact of the alfalfa weevil complex on alfalfa productivity.

INTRODUCTION

Alfalfa fields, as a short-term perennial crop, support a wide range of arthropods, most of which have neither positive or negative effects on the crop. Van den Bosch and Stern (1969) estimated approximately 1000 species of arthropods in the typical alfalfa field in California. These organisms contribute to the biodiversity of agricultural systems. A few of these insects can be significant competitors with the crop for resources and as such can reduce yields. As in many systems, the most important alfalfa insect pests were accidentally introduced from other countries. The alfalfa weevil complex, Egyptian alfalfa weevil (EAW), *Hypera brunneipennis* and the alfalfa weevil, *Hypera postica*, was introduced from the Mediterranean region/Mid-East area of the world on apparently three separate occasions; 1904 near Salt Lake City, 1939 near Yuma, AZ, and 1951 near Annapolis, MD. The designation of these insects as two species has been under debate, but there are some significant biological and behavioral differences.

Biological control efforts against these pests by U.S. agencies began in 1911. Isolated efforts were undertaken in Utah in the 1920's, California in the 1930's, Arizona in the 1940's and the northeastern U.S. in the 1950's. As the weevil complex became a nation-wide pest, USDA

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coordinated biological control efforts and millions of parasitoids from ~10 species were released. These organisms adapted quickly in the northeastern, midwestern, and north central U.S. In fact, in the northeast, weevil populations declined within 10 years of the releases and insecticide use on alfalfa dropped 73%; economic benefits of $2,200,000,000 to producers in the northeast have been shown (25 times the cost of the biological control program). However, in other regions, the parasitoid species released were less effective. Several researchers have reported that insecticide usage on alfalfa through the 1980's in the West was unaffected by the program. Some additional releases were done in California in the 1980's (new parasite species or strains better adapted to western conditions). Pitcairn and Gutierrez (1989) summarized the history of these releases and stated that three species had established in CA. The larval parasitoids *Bathyplectes curculionis, B. anurus,* and *Tetrastichus incertus* were reported as "widely established", "recently recovered", and "established central California", respectively from the 1982-83 surveys. We are undertaking, beginning in 2004, systematic studies to re-evaluate the incidence of these organisms in alfalfa fields.

EAW larvae are the first insect pests of the alfalfa production year that requires management actions. Although biological control of the weevil larval complex is reportedly poor, biological control of other pests that occur later in the season is very important. The aphid complex (pea, blue alfalfa, spotted alfalfa, and cowpea aphids) is effectively controlled by predators and parasites. Predators such as lady beetles and lacewings readily feed on aphids and parasites such as *Aphidius* sp. kill many aphids. Similarly, build-up of the worm complex (alfalfa caterpillar, beet armyworm, western yellow-striped armyworm, and others) is reduced by predators and parasites such as *Hyposoter* sp. Therefore, control actions undertaken for the weevil larvae must be made with consideration of possible effects on pest management for the rest of the season. Although EAW can reduce yields, ill-designed control programs for this pest can be expensive when aphid and worm outbreaks have to be battled for the rest of the season

EAW larvae are well controlled with insecticides. Organophosphate and carbamate materials have been used extensively for weevil control for several years. In 2002, five of the most commonly used eight insecticides in alfalfa were either an organophosphate or carbamate material (#1=chlorpyrifos, #2=dimethoate, #5=malathion, #7=carbofuran, #8=methomyl). Overall, pesticide (insecticides and others) use in alfalfa was fifth among all California crops in terms of acre-treatments. However, the occurrence of organophosphate insecticides in surface waters, particularly chlorpyrifos (Lorsban®) and diazinon, coinciding with the timing of treatment for Egyptian alfalfa weevil has placed added emphasis on finding alternative means to manage this pest; new regulations aimed at protecting ground and surface waters in California are forthcoming. Pyrethroid insecticides (Warrior®, Mustang®, Baythroid®, and others) have been registered in alfalfa during the last five years and two of these products are now among the most commonly used insecticides in alfalfa. Long et al. (1999) demonstrated the fit of pyrethroid insecticides for this use and the positive attributes for protection of surface waters. These insecticides also have environmental concerns and are coming under scrutiny; they also have the additional concern of having broad-spectrum activity and destroying populations of beneficial organisms, which are important in alfalfa for the management of aphids and lepidopterous larvae, as previously detailed. Recently, indoxacarb was registered for use in alfalfa and is reportedly "easy on beneficials".

In order to efficiently use an insecticide treatment for weevil larvae, a treatment threshold must be in place. The presently used sampling plan and threshold (Summers & Godfrey, 2002) suggests sampling EAW larvae using a standard 15" sweep net. Sampling should be conducted in at least four areas of the field and by taking 5-10, 180º sweeps per area. A treatment is justified when populations reach 20 larvae per sweep. One caution is that the early stage larvae are poorly sampled with a sweep net; therefore careful attention should be given to examining terminals in the late winter/early spring. Tapping the terminals against a white background (paper, etc.) may dislodge the larvae and make them more visible. This is becoming a more significant problem as alfalfa varieties with greater winter dormancy are being grown resulting in weevil larvae on alfalfa with very little growth which is impossible to sweep. Management options for EAW include early harvest and insecticides. Early harvest, within the limits of typical alfalfa production, will kill many of the weevil larvae; however, the regrowth should be monitored for the damage from surviving larvae.

The threshold of 20 larvae per sweep was developed in the 1970's by Koehler & Rosenthal (1975) and is dated causing growers to lack confidence in it. One criticism of this threshold is that it is static, instead of fluctuating with hay values, which vary significantly, and with costs of controls. The research in the 1970's assumed hay values of $50-$70 per ton and treatment costs of $6-8 per acre. In addition, alfalfa cultivars such as 'Lahontan', 'El Dorado Improved', and 'Caliverde 65' were used in this study; these are not commonly grown in the Central Valley today. First harvest yields averaged about 2500 lbs/A in this work conducted in the 1970's whereas yields today for the first harvest are commonly much higher. This threshold has been effectively used for numerous years such that an insecticide application prior to the first cutting for EAW is routine in the Central Valley.

Godfrey and co-workers conducted studies on efficacy of registered and experiential insecticides against EAW in 2002 (Godfrey and Putnam, 2002). Larval populations were slow to develop and never exceeded the accepted threshold value for treatment, peaking at ~14 per sweep. However, there was a doubling of the alfalfa dry and wet weights at harvest between the most effective treatments compared with the untreated. This work continued in 2003 and is slated to be continued in 2004. An additional observation was that several larvae were observed in a sluggish, discolored state and larval mortality appeared high. The reasons for this mortality were not determined. It is hypothesized that a biological agent (parasitoid) or fungal disease could be exerting an effect on the population. This could be an important, unrealized control agent.

PROCEDURES

Threshold Study. The efficacy of registered and experimental insecticides against EAW larvae was evaluated. Treatments were applied with a CO_2 backpack sprayer on 7 March as the population approached the treatment threshold. Plot design included 20 by 50 feet plots with 4 replicates per treatment. Insects were sampled with a sweep net and percentage EAW control was quantified at 3, 6, 10, 14, and 21 days after treatment (DAT). The effect of the treatments on beneficial arthropods was evaluated; the beneficials studied were lady beetles, lacewings, damsel bugs, big-eyed bugs, minute pirate bugs, and spiders. These natural enemies are important for EAW management but probably more important for pea aphid management in the second and third cutting.

Alfalfa was harvested on 23 April with a Carter flail harvester. Fresh weights and dry weights were determined. A subsample of this harvest was used for crude protein and ADF and NDF analyses. In addition, square meter areas were hand-harvested from selected treatments and separated into leaf and stem tissues. These samples were dried and leaf:stem ratios calculated. Finally, nutrient analyses were done on each of these fractions. This study mirrors that done in 2002 and reported previously (Godfrey & Putnam 2002).

Timing Study. In 2003 in a second study, plant injury from EAW larvae was manipulated with an insecticide application at various timings. Warrior®, an effective insecticide on EAW, was applied at the onset of egg hatch (27 February) and every 6 days thereafter. Repeat applications were made in order to keep treated plots free of larval infestation from late-hatching eggs. Samples to assess arthropod populations were collected every 7 days. The other procedures used were as previously described.

RESULTS

Environmental conditions differed substantially between the two study years and this influenced the EAW larval populations and likely also the results. In California, EAW adults oviposit starting in the fall, continue throughout the winter on "warm" days, and complete the egg-laying in the late winter. The pattern of oviposition influences the timing of eclosion, as well as does the degree-day accumulation by the eggs. The late winter/spring conditions (the period of this study) in 2002 compared with 2003 were generally warmer in late Feb., cooler for the first half of March, and significantly warmer during late March and April. Precipitation was greater in 2002 than 2003 during the first ~30 days but 2003 was characterized by unusually wet conditions (for central CA) from mid-February through April. The efficacy of the insecticide treatments was fairly consistent between the two years, but the yield response to weevil feeding differed substantially.

EAW larval populations developed in field plots about 1 week earlier in 2003 than in 2002 (Fig. 1). Populations in 2002 increased rapidly to 27.8 larvae per sweep on 11 March. Densities declined significantly during the next 3 days. In 2003, larval populations increased to a peak on 7 March of 13.25 larvae per sweep.

Insecticide Efficacy and Threshold Study. On the day of treatment, plots averaged 13.25 larvae per sweep. Populations of beneficials averaged 0.33 per sweep. Treatments evaluated are shown in Table 1. Results are shown in Fig. 2. Ten of the seventeen treatments and fifteen of the seventeen treatments reduced larval populations by at least 75% at 3 and 6 DAT, respectively. The best residual control (85% control at 21 DAT) was provided by Baythroid 2EC, F0570 (zeta-cypermethrin), Warrior, and Warrior + Lorsban. Among the other registered materials, performance can be characterized by: 1.) Furadan - good knockdown and residual, 2. Imidan - fair knockdown and fair residual, 3.) Lorsban – fair knockdown and poor residual, and 4.) Steward - fair knockdown and poor residual. The effects of these treatments on beneficials were nil (Table 1). The effects on pea aphids (although populations were overall very low) were good aphid control with Baythroid, Warrior, F0570, Lorsban, and Furadan; no effect with Imidan alone (control was provided with the addition of Pounce or dimethoate) and Steward (low rate); and a doubling of aphid numbers with the high rate of Steward (Table 1). The treatments, and resulting EAW larval control, had no effects on alfalfa nutrient quality with crude protein values ranging from 25.2 to 26.8%, ADF values ranging from 23.2 to 25.8, and NDF values ranging from 27.6 to 30.0. This reinforces the 2002 results.

The insecticide treatments resulted in a range of EAW larval populations. Other insect pests during this part of the season were low (for instance, pea aphids), so the influence of weevil larval feeding on alfalfa yields could be evaluated. Alfalfa yield responded negatively to EAW larval populations in 2002 and 2003. Significant linear relationships were found between average larval numbers and first harvest alfalfa fresh weight yield and first harvest alfalfa dry weight yield. Predictions showed that populations of 10 larvae per sweep reduced fresh weight yields by 22.5% (2003) to 56% (2002) and dry weight yields by 22.8% (2003) to 48.6% (2002). The delayed harvest in 2003, because of cool, rainy conditions in April, and the earlier EAW hatch and damage in 2003, enabled the plants to partially compensate for the damage. The substantial yield losses seen during both years from larval populations that were below the established threshold suggests that the value does need to be updated; however, this work was done in one field with one alfalfa variety so this may not be representative of valley-wide conditions.

Timing Study. Controls were applied to reduce EAW larval populations starting on 27 Feb. (at 5.5 larvae per sweep) and continuing every 6 days until 17 March when the population had already peaked at 23.25 larvae per sweep and declined precipitously. One additional treatment was applied on 29 March. EAW larval populations under these treatment regimes can be seen in Fig. 3. Dry weight alfalfa yields from the resulting larval populations can be seen in Fig. 4. Yields from the three earliest timings were similar and later timings resulted in a yield reduction. A 19.1% yield reduction was seen in the untreated plots.

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Table 1. Treatment list, effects of EAW treatments on populations of beneficials, and on populations of pea aphid on selected dates.

Treatments	**Rate (product/A)**	**Beneficials per 25 Sweeps***	**Pea Aphids per 25 Sweeps ****
1. Baythroid 20WP	3.5 oz.	3.3	5.8
2. Baythroid 2EC	2.8 fl. oz.	3.0	4.0
3. Baythroid 20WP	3.5 oz + Kinetic	2.4	5.5
4. Furadan 4F	1 qt.	2.8	4.8
5. Imidan 70W	1 lb.	2.9	24.3
6. Imidan 70W + Dimethoate	1 lb.+ 1 pt.	3.8	3.3
7. Imidan 70W	1 lb.+ crop oil	2.4	21.3
8. Imidan 70W + Pounce 3.2 EC	1 lb.+ 4 fl. oz.	3.1	2.8
9. Lorsban 4E	1.5 pts.	1.8	2.8
10. F0570 0.8EW	3.2 fl. oz	1.2	2.8
11. F0570 0.8EW	4 fl. oz	2.0	1.5
12. Ciscinammic + Pyganic	1 qt.	1.8	19.8
13. Pyganic	1 qt.	2.7	13.0
14. Steward SC	2.5 fl. oz	2.9	23.0
15. Steward SC	4.6 fl. oz	2.4	50.5
16. Warrior	3.84 fl. oz.	2.1	3.0
17. Warrior + Lorsban	1.97 fl. oz.+ 0.75 pts.	1.7	1.5
18. Untreated	---	2.1	24.8
* average of all sample dates ** 14 days after treatment			

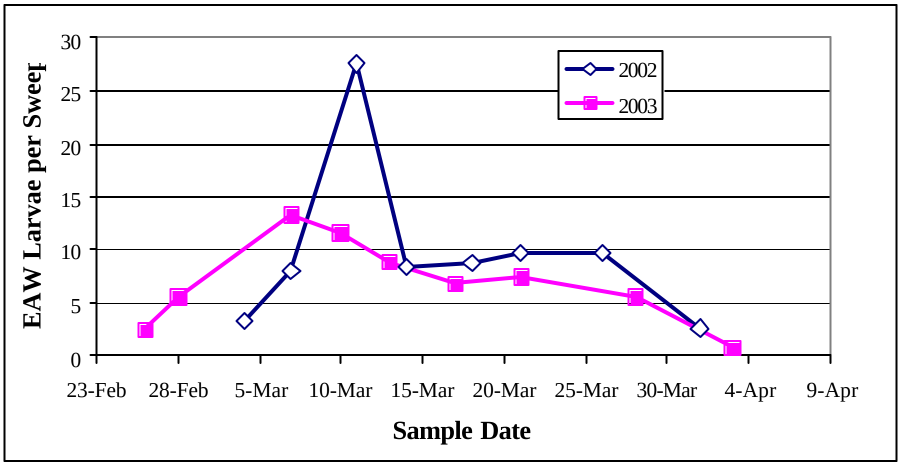

Figure 1. EAW larval population patterns in untreated plots.

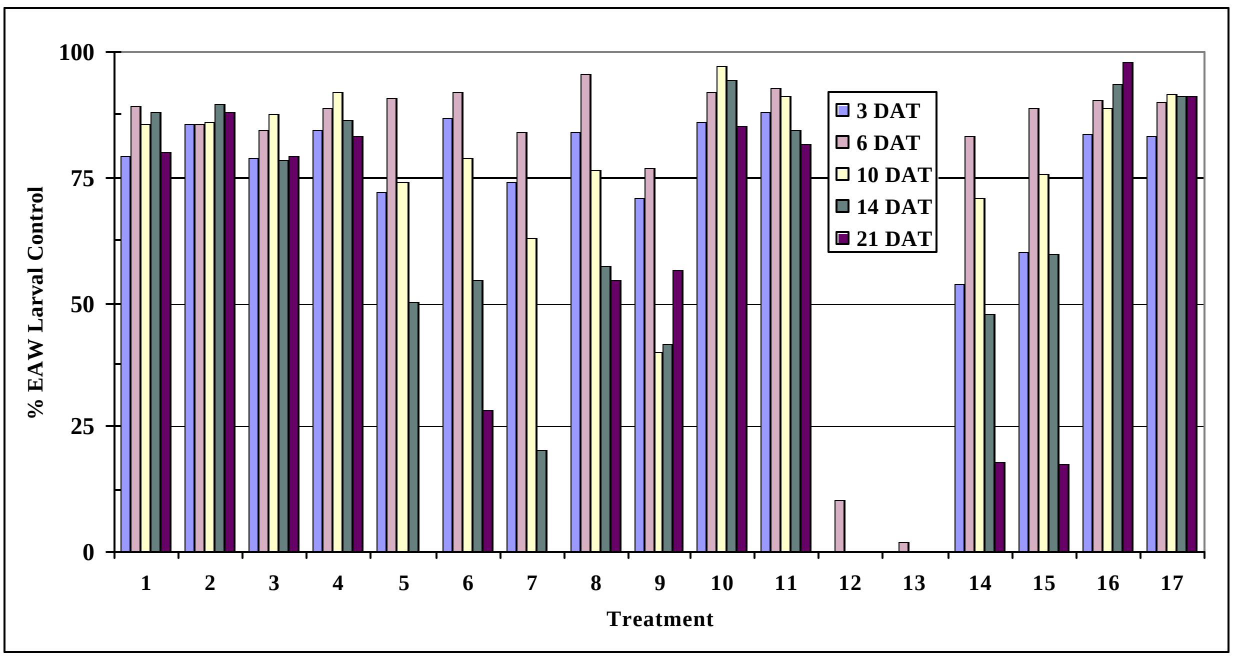

Figure 2. Egyptian alfalfa weevil larval control from insecticide treatments (treatment numbers refer to Table 1) at various days after treatment.

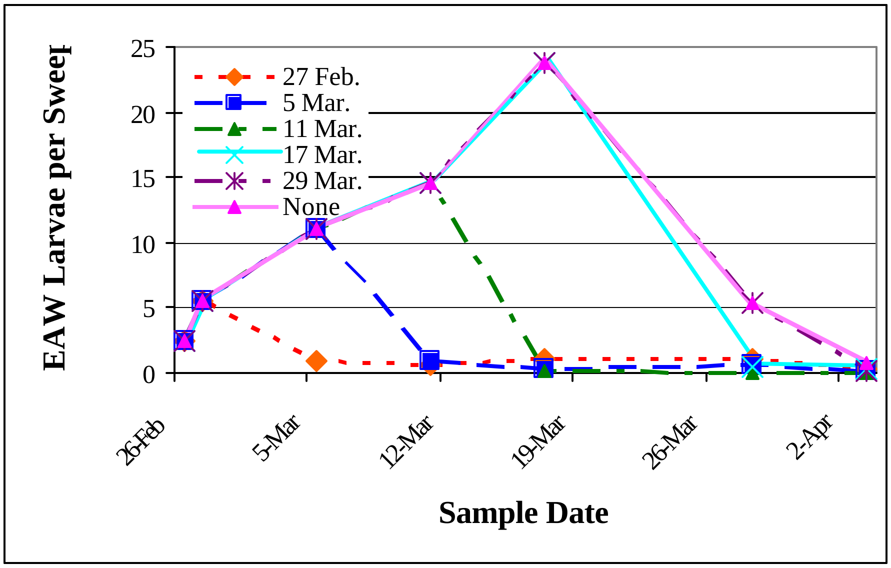

Figure 3. EAW larval populations from timing study, 2003 (controls initiated on indicated dates).

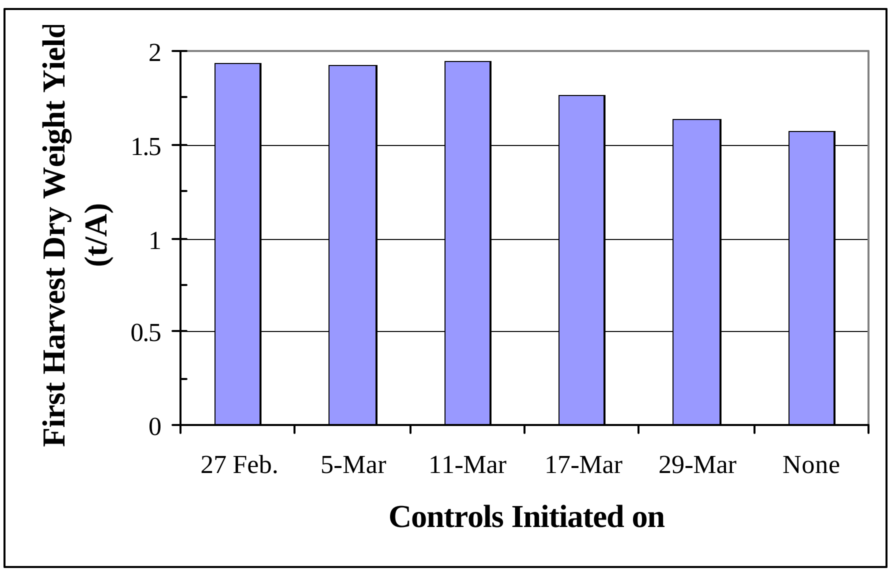

Figure 4. Alfalfa yield response with treatment initiated at various timings, 2003.