ALFALFA INSECT MANAGEMENT IN THE SOUTHWESTERN UNITED STATES

Eric T. Natwick and M. Lopez[1]

ABSTRACT

Many insect pests and spider mites attack alfalfa grown for hay in the irrigated low desert agricultural valleys of southeastern California and southwestern Arizona. Management of some major pests is discussed. An aphid complex of spotted alfalfa aphid (SAA) *Therioaphis maculata* (Buckton), blue alfalfa aphid (BAA) *Acyrthosiphon kondoi* Shinji, cowpea aphid (CPA) *Aphis craccivora* Koch, and pea aphid (PA) *Acyrthosiphon pisum* (Harris), are mostly cool season (November through April) pests. The Egyptian alfalfa weevil (*Hypera brunneipennis* Boheman), larvae often require management during February and March. Among the complex of Lepidopterous worm pests, beet armyworm, *Spodoptera exigua* (Hübner), alfalfa caterpillar, *Colias eurytheme* Boisduval, and Granulate cutworm, *Agrotis subterranea* (Fabricius) are the three most economically important and occur mostly during the warm season of May through October. A complex of leafhoppers including *Empoasca solana* DeLong, *E. mexara*, and *E. fabae* (Harris) can occur some years at levels requiring management between April and October. These pests must be carefully managed for profitable alfalfa hay production. Considerable progress has been in integrated pest management through host plant resistance, cultural practices, and preservation of natural enemies. However, insecticide applications often still needed and are commonly used to maintain insect pest population densities below damaging levels. Proper sampling and use of established of treatment thresholds are still a part of alfalfa IPM. Experiments were conducted at the University of California Desert Research and Extension Center to compare efficacy of registered and unregistered insecticidal crop protection chemicals for insect pest control in alfalfa. Results of insecticide efficacy experiments indicate that most but not all insect pests in alfalfa are susceptible to insecticides currently registered by US EPA.

INTRODUCTION

Although integrated pest management (IPM) strategies have reduced the alfalfa grower's reliance on insecticides, these crop protection chemicals are still important IPM tools. Insecticides are applied to a large portion of the alfalfa acreage in the low desert region of the Southwestern United States each year for insect pest management.

Alfalfa caterpillar, *Colias eurytheme* is a warm weather pest with up to seven generations between May and October in the low desert. The adults are yellow butterflies with black spots and can become abundant begin in May. Alfalfa caterpillar butterflies flying over tall alfalfa have most likely emerged from that field and are migrating to regrowth in other fields, so treat is usually not warranted. The lifecycle or alfalfa caterpillar is synchronized to the cutting cycle of alfalfa; developing from egg to adult between cuttings. Football shaped eggs are laid singly,

[1] E. Natwick and M. Lopez, UCCE, Imperial County, 1050 E. Holton Rd., Holtville, CA 92250; Email: etnatwick@ucdavis.edu.
In: Proceedings, 2011 Western Alfalfa & Forage Conference, Las Vegas, NV, 11-13 December, 2011. UC Cooperative Extension, Plant Sciences Department, University of California, Davis, CA 95616. (See http://alfalfa.ucdavis.edu for this and other alfalfa conference Proceedings)

standing on end, on the upper surface of leaves in fields with regrowth under 6 inches; begin checking fields for caterpillars when butterflies are present. These fields need to be checked with a sweep net for caterpillars. Larvae hatch in 3 to 10 days, grow to about an inch long and pupate in approximately 2 weeks. Alfalfa caterpillars are green with white stripes down their sides and are distinguished from beet armyworm by their velvety appearance (Anonymous 1985).

Alfalfa caterpillars consume entire leaves including the veins and midrib; large larvae are most destructive. *Cotesia medicaginis* is a small, black wasp parasitic about 0.25 inch long that attacks the alfalfa caterpillar. The wasp lays an egg inside very small caterpillars. The wasp egg hatches into a larva that consumes the body contents of the alfalfa caterpillar. Parasitized larvae are lighter in color, swollen toward the rear and somewhat shiny rather than velvety on the surface like normal healthy caterpillars. The wasp larva can be exposed by grasping the caterpillar at each end of the swelling and pulling it apart. A parasitized alfalfa caterpillar dies before it reaches 0.5 inch in length (Anonymous 1985).

Management guidelines. Cutting hay early to avoid damage is an option. However, timing of early cutting is critical to obtain satisfactory yield and to avoid serious damage. Monitor fields weekly from June through October, checking 2 to 3 times per week during periods of heavy infestations, by taking 5 sweep counts in 4 to 5 field locations. Check for *Cotesia medicaginis* parasitism. Treatment with an insecticide when field counts average 10 non-parasitized caterpillars per sweep. *Bacillus thuringiensis* (Bt) may give satisfactory control of alfalfa caterpillars without adversely affecting beneficial species, and leaves no undesirable residue on the hay. When caterpillars ingest Bt, they cease feeding, but may remain on plants 3-4 days before dying (Anonymous 2006).

Beet armyworm is a common pests in desert alfalfa from June through September, occasionally damages alfalfa in April or May in the low desert valleys of Southern California. White cottony scales covered egg masses are deposit on the upper side of leaves. Eggs hatch in a few days and larvae reach full size in 2 to 3 weeks. Larvae pupate on or under the soil surface. Adults are brown nocturnal moths with a 1¼ wing span. Moths emerge to re-infest alfalfa or may infest other crops. There are at least 5 generations of beet armyworm per year in the low desert; the final generation overwinters as pupae in the soil. Beet armyworm larvae are smooth-skinned and are usually olive green, but color varies from bright green to purplish green. Larvae have very fine dark stripes on their backs and pale yellow stripes on each side. An intense black spot on the lateral margins of the second thoracic segment above the second set of true legs is a distinguishing characteristic. First instar larvae web terminal leaves together and skeletonize the webbed leaves. Later instar larvae dispersing throughout the crop canopy. Spiders and various species of predacious bugs prey on the armyworm larvae. *Hyposoter exigua* wasps prey on beet armyworm by depositing an egg in the larvae. A *Hyposoter exigua* larva hatches from the egg and consumes the internal contents of the armyworm larva (Anonymous 1985).

Management guidelines. Monitor fields weekly by taking 5 sweep counts at each of 4 to 5 locations per field using a standard sweep net. To sample for parasitism by *Hyposoter exigua*, pull the heads from ½ inch long armyworms, squeeze the body contents out from the anal end toward the head end; larvae will be pushed out of parasitized armyworms. Check fields 2 to 3 times per week when heavy populations begin to develop. Treat with an insecticide when there

are 15 non-parasitized ½ inch armyworms per sweep (Anonymous 2006).
Cutworms are frequent pests on bed-planted alfalfa. Granulate cutworm, *Agrotis subterranea* (Fabricius), and the variegated cutworm, *Peridroma sausia* (Hübner), are two species that most commonly attack desert alfalfa. Cutworm adults are night-flying moths in the tan and brown colored moths. White to greenish eggs deposited in irregular masses, on alfalfa leaves or stems often near the base of the plant. Eggs darken as they approach hatching. Larvae can grow up to 2 inches long. The heavy-bodied larvae appear as smooth-skinned caterpillars of various colors and patterns and frequently roll into a C-shape when disturbed. Larvae hide under loose soil, in soil cracks or under duff during the day, moving to plants at night to feed (Anonymous 1985).

Variegated cutworm populations may develop in weedy areas and migrate into stands of seedling or mature alfalfa. Stands of seedling alfalfa can be severely damaged when cutworms cut the seedlings off at, or just below the soil surface. Established fields are damaged when cutworms cut off new growth or feed on the alfalfa foliage (Anonymous 1985).

Granulate cutworm is a serious pest of bed planted alfalfa, but can also be a pest of flat-planted, flood irrigated alfalfa. Low desert alfalfa is most frequently attacked by granulate cutworm from May through October, but the pest is resident in fields throughout the year. Established alfalfa fields can be severely injured when granulate cutworms cut off new shoots at or below ground level following hay harvest. The pest often goes undetected after cutting and hay removal. The problem becomes apparent when the field is watered back and there is little or no re-growth due to cutworms feeding. Cutworms feeding on shoots, suppress re-growth, deplete starch reserves in the crowns, thereby weakening the plants, and increasing their susceptible to disease. The granulate cutworm is nocturnal, but will move from daytime hiding places and climb into the alfalfa canopy to feed in the late afternoon or evening.

Management guidelines. Cutworms are most injurious in fields with high plant residue. Pre-plant tillage and abatement of weedy refuge areas around fields help prevent cutworm infestations (Anonymous 2006). Flood irrigation will drown many cutworm larvae. Flood irrigation during daylight hours will attract Egrets, Ibis, gulls and other birds that prey on the cutworm as the advancing water forces the larvae from hiding. Cutworms can be detected by looking under duff and carefully digging to a depth of one inch deep in loose soil around alfalfa crowns. Treatment with an insecticide may be warranted when cutworm numbers exceed one or two per row foot or severe damage is apparent. Historically, pyrethroid insecticides or indoxacarb have been efficacious for granulate cutworm control in the low deserts. Recently, Intrepid is more frequently used for cutworm control. Pyrethroid insecticide use may cause secondary outbreaks from pest such as spider mites and beet armyworm.

Alfalfa weevil, *Hypera postica*, and Egyptian alfalfa weevil, *Hypera brunneipennis*, are similar in appearance, dark gray and about 0.20 inch long beetles with a long snout. Some Entomologists believe they are actually one species. The weevil larva is legless, has a brown head and is light green with a white stripe down the back, and is about 0.25 inch long when fully grown. Larvae complete their growth in 3 to 4 weeks, spin a cocoon and pupate either in the leaves of the plant or on the ground. There may be three to four generations a year, and it is not uncommon to find this pest in the field throughout the year, but the first generation causes the economic damage usually between mid-February and mid-April in the low desert. In areas of

higher elevation where frost may occur into April, the alfalfa weevil, larvae may start appearing in alfalfa fields from mid-April through mid-June. Egyptian alfalfa weevil larvae may be found at lower elevations from late January through April and pupate toward the end of March through April. The numbers of Egyptian alfalfa weevil larvae will decline rapidly through April and newly emerged adults will be appearing in fields during April and May.

Egyptian alfalfa weevil adults leave alfalfa fields late in the spring to find places to spend the summer under tree bark, under litter in wind breaks, in buildings, etc. Adult weevils spend the summer and most of the fall in a resting state called aestivation. When night-time temperatures drop below 42° F, adult Egyptian alfalfa weevils will emerge from aestivation, fly to alfalfa fields, feed, and mate. Females chew holes in the stems of alfalfa plants and lay eggs. Adult females insert 10 to 30 smooth, shiny, yellowish eggs are into the centers of living and dead stems 3 to 6 inches above the soil surface or into stems in debris on the ground. A single female may deposit from 400 to a 1,000 eggs during a single season. Eggs usually hatch in 5 to 10 days and larval development takes about a month. Hatching larvae make their way into the alfalfa terminals. The adult weevils do not cause economic damage, but this is an indicator of the levels of larval populations which will be present from January through March.

Management guidelines. Egyptian alfalfa weevil is usually a problem during the first cutting, although some adults and larvae may persist into the second or third cutting. Alfalfa weevil is attacked by the parasitic wasp *Bathyplectes curculionis*. This wasp is present throughout the range of the alfalfa weevil. *B. curculionis* does not control Egyptian alfalfa weevil. Egyptian alfalfa weevil has spread into most areas of California the occupied niches previously occupied by the alfalfa weevil. *B. anurus* is a larval parasite that has been introduced and has become established at two sites in Central Valley, CA alfalfa. At the present time *B. anurus* is only found at very low levels. *Microctonus aethiopoides* is a parasite of the adult weevil and is well established and abundant in bur-clover rangeland in Glenn, Colusa, and Tehama counties, and also is established in alfalfa in Shasta, Butte, and San Luis Obispo counties in California.

To sample for weevil larvae, divide the field in to 4 or more sections and take 5 sweeps in each section. Divide the total number of weevil larvae by the total number of sweeps to get the field average. The treatment threshold is the same for both species of alfalfa weevil, an average of 20 larvae per sweep. Adult weevils do not cause economic damage, but do signal the end of Egyptian alfalfa weevil larval infestations for the year. Serious damage can sometimes be prevented by cutting the crop as soon as most of the plants are in the bud stage. On short alfalfa early in the season or on stubble following cutting that cannot be checked with a sweep net, treatment is indicated when growth is retarded because of weevil feeding.

Pea Aphid (PA) and Blue Alfalfa Aphid (BAA) can be serious pests during the spring months in the low desert. PA is distinguished from blue alfalfa aphid by lighter antennae with dark bands at each joint. BAA has uniformly dark antennae. PA first appears in December or January but is usually less abundant than BAA until later in the spring, but PA may persist into early summer as they are more heat tolerant. PA are found over most of the plant with heavy infestations and can deposit large quantities of honeydew which can fouling of harvesting equipment and supports the growth of sooty molds lowering hay quality. Regrowth may be stunted following cuttings with moderate to heavy aphid populations. Several species of

predacious bugs and parasitic wasps attack these aphids. Sample alfalfa fields for PA by taking 5 to 6 stem samples in at least 5 locations per field weekly when aphids appear, then every 2 to 3 days as numbers approach the treatment threshold. The PA treatment thresholds vary with the height of re-growth e.g. for plants under 10 inches the threshold is 40 to 50 aphids per stem, the threshold is 70 to 80 per stem for plants 10 to 20 inches tall and the threshold is 100 or more PA per stem for plants over 20 inches tall.

BAA is distinguished from pea aphid by uniformly dark antennae. PA has lighter antennae with dark bands at each joint. In the low deserts, BAA usually first appears in December or January when it may be more abundant than PA. Both species are common throughout the spring, but PA is more heat tolerant and may persist into early summer. In susceptible alfalfa varieties, BAA may stunt growth and infested plants have smaller leaves, shorter internodes, leaf curling, yellowing, and leaf drop. Several species of predacious bugs and parasitic wasps attack these aphids. Sample alfalfa fields weekly when aphids appear, then every 2 to 3 days as numbers approach the treatment threshold of 40 to 50 BAA per stem.

Spotted alfalfa aphid (SAA) first appeared in Arizona and California in the 1950's, causing severe damage (Stern and Reynolds 1958). A combination of introduced parasites and resistant varieties brought the pest under control (Lehman 1978, Nielson et al 1970). SAA still occasionally causes problems in susceptible varieties are grown (Natwick 1987). SAA is capable of stunting susceptible varieties. High aphid densities deposit sticky excrement of sugars and amino acids “honeydew”. Honeydew can foul harvesting equipment and supports the growth of sooty molds reducing marketability of hay. Since 1996, a few growers have had SAA appear in highly resistant alfalfa varieties. SAA began appearing at economically damaging levels on highly resistant alfalfa varieties in Saudi Arabia, Southern California and Western Arizona during the 1990’s requiting insecticide treatments to prevent damage to hay crops. It would be incorrect to state or assume that there is a new host plant resistance breaking biotype of SAA. The reasons for occasional SAA aphid buildup in some alfalfa fields remain unknown, but susceptible alfalfa plants can be killed by SAA and this is not the case with the resistant varieties being planted. There have been few reports of crop loss or need for insecticide application in alfalfa cultivars highly resistant to SAA. It is reasonable to believe that cultivars highly resistant SAA will continue to keep the pest in check along with natural enemies. In low deserts, treatment may be justified when levels reach 20 aphids per stem during the warm season of May through October and 40 aphids per stem during the cool season of November through April.

Cowpea Aphid (CPA) is the only black aphids commonly found on alfalfa. Historically, CPA was an occasional invader of new stands of alfalfa during the winter and occasionally infesting older alfalfa stands, but not causing economic injury (Natwick 1999a). In December, 1998, CPA built to economically damaging levels on alfalfa in Imperial County, California (Natwick 1999b). During the spring of 1999, cowpea aphids spread to alfalfa in high and low desert regions of California and is now reported as an alfalfa pest in Arizona, Iowa, Kansas, Nevada and Texas. CPA is a small, dark to black insect, 1.4 to 2 mm long. Adults are shiny black and immature aphids may be lightly dusted with wax. Colonies start on the growing points of the host plant, but unabated can quickly infest the entire plant. CPA has a broad host range with a marked preference for Leguminosae, but is found on plants in several plant families including weed and crop species. Nearly 30 virus diseases are transmitted by CPA (Blackman and Eastop

1984) including alfalfa enation, a serious virus disease of alfalfa in Europe, North Africa and Saudi Arabia (Hampton 1990). Historically, CPA has been a warm weather pest found on several crops and weeds including cotton (Anonymous 1996). In addition to the western United States, CPA has emerged as a pest of alfalfa in South America and in Saudi Arabia (Summers 2000a). When an alfalfa field is threatened by a rapidly growing population of cowpea aphid, treatment with an insecticide may be warranted. Treat CPA at the aforementioned BAA thresholds. The aphid parasites in the Genera: *Lysiphibus* and *Diaraetiella*, have been reared from CPA mummies collected from both the high and low desert and numerous aphid predators have been observed feeding on cowpea aphid including: bigeyed bugs, damsel bugs, lacewings, lady beetles, and syrphid fly larvae (Summers 2000b).

Spider mites are pests in alfalfa grown for seed, but are not common in alfalfa grown for hay. Historically, spider mites have not caused wide spread damage to alfalfa grown for hay. Serious damage to hay fields has generally associated with water stress. Spider mites infestations are usually confined to the lower leaves. Spider mites feed by inserting long needlelike mouth parts into leaves removing plant sap. Leaves become stippled with chlorotic spots. Infested leaves are covered with webbing and turn yellow. With severe feeding leaves turn brown from necrosis and desiccation causing defoliation. Damage starts in the lower plant canopy moving upward. Feeding damage can reduce yield, quality and retard regrowth.

When infested fields are watered, the problem often clears up in a matter of days (Anonymous 1985). In recent years, spider mites have been more common in low desert alfalfa fields grown for hay. The cause of this phenomenon is not fully understood. Pyrethroid insecticides have been implicated as causal agents for secondary outbreaks of mites in other crops. However, there has not been a clear cause and effect relationship established between pyrethroid insecticide use on alfalfa and mite outbreaks in alfalfa grown for hay. Definitive monitoring and treatment guidelines have not been developed because spider mites are a sporadic problem in alfalfa grown for hay. Spider Mite Species in Western Arizona & Southern California Alfalfa from March through October include: carmine spider mite (*T. cinnabarinus* Boisdival); desert spider mite (*T. desortorum* Banks); strawberry mite (*T. turkestani* Ugarov & Nikolski); and twospotted spider mite (*Tetranychus urticae* Koch)

Management guidelines. When possible avoid using the pyrethroid insecticides to control alfalfa hay pests. Damaging populations are most commonly encountered under stress conditions. Minimizing crop stress through improved irrigation and proper best management practices. When infested fields are watered, the problem often clears up in a matter of days. Chemical control of spider mites in alfalfa hay is usually not recommended. When severe infestations occur, sulfur may be used to suppress the populations.

***Empoasca* spp. leafhoppers.** Several species of leafhoppers *Empoasca* spp. leafhoppers may be found in alfalfa. The adult leafhoppers are about 0.125" long, bright green, wedge-shaped bodies. Nymphs have green wedge-shaped bodies and run rapidly forward, backward, or from side to side when disturbed. Other leafhoppers in alfalfa are brown or gray or if green are much larger than *Empoasca* and usually cause no damage. *Empoasca* may be found throughout the year, but are most abundant during the warmer months. Central Valley alfalfa damage occurs during July, August, and occasionally September. In the Imperial Valley, damage may occur from May

through September. A yellow, wedge-shaped area at the tip of the leaf is the most common damage symptom. Plants may become stunted, having shortened internodes. The leaf margin and surrounding tissue may turn red. This symptom may be confused with boron deficiency.

Management guidelines. Sample the field with a standard sweep net at the first sign of injury. Leafhopper infestations often start on field margins so include field edges in your samples. Taking 10 sweeps in 4 to 6 areas over the entire field and count the adults and nymphs. When an alfalfa field is two or more weeks from harvest, treat if counts reach 5 leafhoppers per sweep. If alfalfa is to be harvested in 10 days to 2 weeks treat if counts reach 10 per sweep. If alfalfa is within a few days of harvest, early cutting will control leafhoppers. A leafhopper infestation of treatable magnitude may be confined to the first 50 to 100 feet of the field margin. If this is the case, treat only the field edges where high leafhopper counts are found.

The threecornered alfalfa hopper, *Spissistilus festinus* (Say) is a treehopper commonly found in desert alfalfa is. Populations buildup in the spring and persist into the fall. They feed by inserting their needle like mouth parts into stems, sucking out juices. Adult female hoppers girdle stems by depositing eggs, causing the stem and leaves to turn red, purple or yellow above the girdle. Adults are light green, thick bodied, triangular insects about ¼ inch long that readily fly when disturbed. Nymphs are grayish white, soft bodied, and have saw toothed spines on their backs. Nymphs are confined to the lower portions of the plant and may not be picked up in a sweep net. There are rarely enough threecornered alfalfa hoppers in alfalfa fields to cause economic damage. Definitive monitoring and treatment guidelines have not been developed because threecornered alfalfa hoppers are a sporadic problem in alfalfa.

INSECTICIDE EFFICACY EXPERIMENTS FOR INSECT PEST CONTROL

Insecticide efficacy studies for worm pest management were conducted during the summers of 2005, 2007, 2008 and 2010 at the UC Desert Research and Extension Center. A stand of alfalfa, var. CUF 101, was used for the experiment. Plots in each experiment were arranged in a randomized complete block design with four replications. Insecticide treatments and rates as fluid ounces of formulated product per acre for each experiment by year are listed in the Tables 1 - 4. Insecticide treatments for the worm control experiments were broadcast applied 28 July 2005, 11 September 2007, 5 August 2008 and 18 August 2010. Populations of worm pest species were measured in each plot with a standard 15 inch diameter insect sweep net consisting of ten 180^{o} sweeps. Samples were taken in the "days after treatment" (DAT) as indicated and results for each insecticide treatment and the untreated controls treatments for each of the four experiments are listed in Tables 1-4.

In 2005 all insecticide treatments controlled beet armyworm, alfalfa caterpillars, and alfalfa webworms with post treatment means that were significantly less than the untreated control (LSD, $P<0.05$) 4-DAT, 7-DAT and 14-DAT (Table 1). In 2007, all insecticide treatments except Lorsban 4E at 32 fl oz per acre had post treatment means significantly lower than the untreated control 3-DAT; 7-DAT all treatments except Lorsban 4E at 32 fl oz per acre and Lorsban Advanced at 64 fl oz per acre had means that were significantly less than the untreated control; and all insecticide treatments had means significantly less than the mean for the control 14-DAT (LSD, $P<0.05$) (Table 2). There were no differences among the means for alfalfa caterpillar due

to the high variability within the very low population level.

Table 1. Numbers of Beet Armyworms and Alfalfa Caterpillars Following Insecticide Treatments to Alfalfa, Holtville, CA, 2005.

Treatment	oz/ac	Beet Armyworm / Sweep			Alfalfa Caterpillar /Sweep			Alfalfa Webworms / Sweep		
		4DAT[z]	7DAT	14DAT	4DAT	7DAT	14DAT	4DAT	7DAT	14DAT
Check	-----	2.00 a	5.75 a	2.50 a	4.25 a	6.00 a	3.50 a	3.25 a	3.50 a	3.50 a
Intrepid	6.0	0.00 b	0.25 bc	0.00 d	0.00 b	0.00 b	0.25 b	0.00 b	0.50 b	0.50 b
Intrepid	8.0	0.00 b	0.00 c	0.75 bc	0.25 b	0.00 b	0.00 b	0.00 b	0.00 b	0.25 b
Success[y]	6.0	0.00 b	0.00 c	0.00 d	0.00 b	0.00 b	0.00 b	0.50 b	0.50 b	0.25 b
Radiant[y]	5.8	0.00 b	0.25 bc	0.25 cd	0.00 b	0.00 b	0.25 b	0.00 b	0.50 b	0.00 b
Lock-On	32.0	0.25 b	0.75 b	1.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
Steward	6.7	0.25 b	0.50 bc	0.00 d	0.00 b	0.00 b	0.25 b	0.00 b	0.00 b	0.25

Means within columns followed by the same letter are not significantly different.
[y] Success and Radiant were not registered for use on alfalfa at the time of this publication's printing.
[z] Days after treatment

Table 2. Numbers of Beet Armyworms and Alfalfa Caterpillars Following Insecticide Treatments to Alfalfa, Holtville, CA, 2007.

Treatment	oz/ac	Beet Armyworm / Sweep				Alfalfa Caterpillar /Sweep			
		3DAT[z]	7DAT	14DAT	24DAT	3DAT	7DAT	14DAT	24DAT
Check	------	2.25 a	3.00 a	5.00 a	0.75	0.50	0.25	0.50	0.50
Steward	6.7	0.50 b	0.75 bc	1.25 b	0.25	0.00	0.00	0.00	0.00
Lorsban 4E	32.0	1.00 ab	1.50 abc	0.50 b	0.25	0.25	0.00	0.00	0.75
Lorsban 4E	64.0	0.50 b	1.00 bc	0.75 b	0.00	0.00	0.25	0.00	0.00
Lorsban Advanced	34.0	0.25 b	0.00 c	1.50 b	1.00	0.00	0.25	0.00	0.00
Lorsban Advanced	68.0	0.00 b	1.75 ab	2.00 b	0.25	0.00	0.00	0.00	0.25
Belt 480 SC	2.0	0.00 b	0.00 c	0.50 b	0.25	0.00	0.00	0.00	0.00
Belt 480 SC	3.0	0.25 b	0.00 c	1.00 b	0.25	0.00	0.00	0.00	0.25

Means within columns followed by the same letter are not significantly different.
[z] Days after treatment

In 2008, beet armyworm means for all insecticide treatments were significantly lower (P=0.05) than the untreated check 3-DAT and 7-DAT (Table 3). All insecticide treatments, except Intrepid at 6 ounces and Baythroid, had significantly lower beet armyworm means than the untreated check 14-DAT, and only the three rates of Belt 480 SC had means significantly lower than the untreated check 21-DAT.

In 2008, alfalfa caterpillar means were significantly lower (P=0.05) in all insecticide treatments compared to the untreated control 3-DAT and 7-DAT (Table 3). All insecticide treatments, except the 6 ounce rate of Intrepid, had significantly lower alfalfa caterpillar means than the untreated check 14-DAT. None of the insecticide treatments had means for alfalfa caterpillar that were significantly lower than the mean for the untreated check 21-DAT.

Table 3. Numbers of Beet Armyworms and Alfalfa Caterpillars Following Insecticide Treatments to Alfalfa, Holtville, CA, 2008.

Treatment	oz/ac	Beet Armyworm / Sweep				Alfalfa Caterpillar /Sweep			
		3DAT[z]	7DAT	14DAT	21DAT	3DAT	7DAT	14DAT	21DAT
Check	-----	0.85 a	1.20 a	5.25 a	4.63 ab	0.95 a	0.25 a	0.75 a	0.28 ab
Steward	6.7	0.00 c	0.01 c	3.10 bc	4.55 ab	0.03 c	0.00 b	0.33 b	0.20 ab
Lorsban Advanced	32.0	0.05 c	0.08 c	3.00 bc	3.30 bcde	0.10 bc	0.00 b	0.25 b	0.43 a
Intrepid	6.0	0.03 c	0.18 c	3.98 ab	3.98 abcd	0.13 bc	0.00 b	0.40 ab	0.23 ab
Intrepid	7.0	0.05 c	0.05 c	2.43 bcd	4.13 abc	0.13 bc	0.00 b	0.10 b	0.10 b
Baythroid XL	2.8	0.50 b	0.88 b	5.33 a	5.33 a	0.38 b	0.03 b	0.23 b	0.43 a
Belt 480 SC[y]	1.0	0.00 c	0.13 c	1.38 cd	2.28 cde	0.00 c	0.00 b	0.15 b	0.05 b
Belt 480 SC[y]	2.0	0.00 c	0.00 c	0.78 d	2.13 de	0.00 c	0.00 b	0.10 b	0.18 b
Belt 480 SC[y]	3.0	0.03 c	0.05 c	0.55 d	1.43 e	0.10 bc	0.00 b	0.13 b	0.08 b

Means within columns followed by the same letter are not significantly different.
[y] Belt was not registered for use on alfalfa at the time of this publication's printing.
[z] Days after treatment

In 2010, all insecticide treatments had beet armyworm and alfalfa caterpillar means were significantly lower (P=0.05) than the untreated control 3-DAT and 7-DAT (Table 4). All insecticide treatments, except the 6 ounce rate of Intrepid, had significantly lower alfalfa caterpillar means than the untreated check 14DAT. None of the insecticide treatments had means for alfalfa caterpillar that were significantly lower than the mean for the untreated check 21DAT. All insecticide treatments except Voliam Xpress at 5 fl oz per acre and Warrior II had significantly fewer beet armyworms than the untreated check 21-DAT. All insecticide treatments except Voliam Xpress at 5 fl oz per acre, Warrior II and Belt at 3 fl oz per acre had significantly

fewer alfalfa caterpillars than the untreated check 14-DAT. There were no differences among the treatments for alfalfa caterpillar numbers 21-DAT.

Table 4. Numbers of Beet Armyworms and Alfalfa Caterpillars Following Insecticide Treatments to Alfalfa, Holtville, CA, 2010.

Treatment	oz/ac	Beet Armyworm / 10 Sweeps				Alfalfa Caterpillar / 10 Sweeps			
		2DAT[z]	7DAT	14DAT	21DAT	2DAT	7DAT	14DAT	21DAT
Check	**-----**	**3.75 a**	**11.75 a**	**2.75**	**12.25 a**	**10.50 a**	**7.75 a**	**1.75 a**	**4.75**
Voliam Xpress 1.25 ZC	**5.0**	**0.75 bc**	**0.50 b**	**0.00**	**5.75 ab**	**1.50 bc**	**0.50 c**	**1.00 ab**	**4.75**
Voliam Xpress 1.25 ZC	**7.0**	**0.25 bc**	**0.25 b**	**0.50**	**4.00 bc**	**1.75 b**	**0.00 c**	**0.00 c**	**2.50**
Voliam Xpress 1.25 ZC	**9.0**	**0.00 c**	**0.50 b**	**0.50**	**5.50 bc**	**0.50 bc**	**0.75 c**	**0.25 bc**	**5.75**
Warrior II	**1.92**	**0.75 bc**	**2.75 b**	**2.50**	**9.75 ab**	**0.50 bc**	**4.00 b**	**0.75 abc**	**7.50**
Intrepid	**8.0**	**1.25 b**	**3.25 b**	**1.00**	**4.00 bc**	**0.25 bc**	**0.50 c**	**0.25 bc**	**5.50**
Belt 480 SC[y]	**2.0**	**0.25 bc**	**0.00 b**	**0.25**	**1.50 c**	**0.00 c**	**0.00 c**	**0.00 c**	**3.00**
Belt 480 SC[y]	**3.0**	**0.25 bc**	**0.00 b**	**0.25**	**3.75 bc**	**0.50 bc**	**0.50 c**	**1.00 ab**	**1.00**
Belt 480 SC[y]	**4.0**	**0.00 c**	**0.00 b**	**0.50**	**1.75 bc**	**0.25 bc**	**0.00 c**	**0.25 bc**	**2.75**

Means within columns followed by the same letter are not significantly different.
[y] Belt was not registered for use on alfalfa at the time of this publication's printing.
[z] Days after treatment

Insecticide efficacy studies for Egyptian alfalfa weevil and aphid management were conducted during the spring of 2009, 2010 and 2011 at the UC Desert Research and Extension Center. A stand of alfalfa, var. CUF 101, was used for the experiment. Plots in each experiment were arranged in a randomized complete block design with four replications. Insecticide treatments and rates as ounces of formulated product per acre for each experiment by year are listed in the Tables 5 - 10. Insecticide treatments for the weevil and aphid control experiments were broadcast applied 19 February 2009, 24 February 2010, and 8 March 2011. Populations of Egyptian alfalfa weevil larvae and aphid pest species were measured in each plot with a standard 15 inch diameter insect sweep net consisting of ten 180^{o} sweeps. Samples were taken in the "days after treatment" (DAT) as indicated and results for each insecticide treatment and the untreated controls treatments for each of the four experiments are listed in Tables 5-10.

In 2009 all insecticide treatments controlled Egyptian alfalfa weevil larvae and pea aphid (Table 5), as well as blue alfalfa aphid and cowpea aphid (Table 6) with post treatment means that were significantly less than the untreated control (LSD, $P<0.05$) 4-DAT, 7-DAT, 14-DAT and 21-DAT. In 2010, all insecticide treatments controlled Egyptian alfalfa weevil larvae with post treatment means that were significantly less than the untreated control 5-DAT, 7-DAT, 14-DAT and 21-DAT (Table 7). All insecticide treatments controlled blue alfalfa aphid in 2010, with post treatment means that were significantly less than the untreated control 5-DAT, 7-DAT, 14-DAT

and 21-DAT (Table 8).

Table 5. Egyptian Alfalfa Weevil Larvae and Pea Aphids per Sweeps, Holtville, CA, 2009.

Treatment	oz/ac	Alfalfa Weevil Larvae/Sweep				Pea Aphids/Sweep			
		4 DAT[z]	7 DAT	14 DAT	21 DAT	4 DAT	7 DAT	14 DAT	21 DAT
Check	-----	23.36 a	22.54 a	13.18 a	9.74 a	14.32 a	15.40 a	2.64 a	3.18 a
Cobalt	19.0	0.10 b	0.32 b	0.58 b	0.76 b	0.28 b	0.12 b	0.02 b	0.14 b
Cobalt	26.0	0.04 b	0.96 b	0.32 b	0.56 b	0.34 b	0.72 b	0.02 b	0.30 b
Lorsban Advanced + Steward	16.0 + 9.0	0.84 b	0.76 b	0.40 b	0.96 b	0.30 b	0.04 b	0.32 b	0.92 b
Furadan 4F[y]	16.0	0.06 b	0.16 b	0.62 b	0.96 b	0.78 b	0.30 b	0.22 b	0.80 b

Means within columns followed by the same letter are not significantly different.
[y] Furadan is no lingered registered for use on alfalfa.
[z] Days after treatment

Table 6. Blue Alfalfa Aphids and Pea Aphids per Sweeps, Holtville, CA, 2009.

Treatment	oz/ac	Blue Alfalfa Aphid/Sweep				Cowpea Aphids/Sweep			
		5 DAT[z]	7 DAT	14 DAT	21 DAT	5 DAT	7 DAT	14 DAT	21 DAT
Check	-----	355.74 a	397.08 a	51.30 a	25.78 a	33.20 a	35.36 a	4.12 a	1.02 a
Cobalt	19.0	2.06 b	1.54 c	3.62 b	5.92 cd	6.64 b	1.46 b	0.52 b	0.08 b
Cobalt	26.0	1.86 b	15.28 b	2.06 b	4.32 d	9.02 b	2.52 b	0.56 b	0.16 b
Lorsban Advanced + Steward	16.0 + 9.0	2.48 b	1.20 c	3.26 b	8.88 bc	8.96 b	1.36 b	1.40 b	0.90 a
Furadan 4F[y]	16.0	3.22 b	5.58 c	9.52 b	10.52 b	8.70 b	1.06 b	0.74 b	0.10 b

Means within columns followed by the same letter are not significantly different.
[y] Furadan is no lingered registered for use on alfalfa.
[z] Days after treatment

In 2011 all insecticide treatments controlled Egyptian alfalfa weevil larvae (Table 9) with post treatment means that were significantly less than the untreated control (LSD, $P<0.05$) 3-DAT, 7-DAT and all insecticides except Centric 40WG had significantly fewer weevil larvae than the control 14-DAT and 21-DAT. In 2011, all insecticide treatments controlled pea aphid with post treatment means that were significantly less than the untreated control 3-DAT, 7-DAT and all insecticides except Mustang EW and Danitol had significantly pea aphids than the control 14-DAT (Table 9); there were no differences among the treatments for pea aphid numbers 21-DAT. All insecticide treatments controlled blue alfalfa aphid in 2011, with post treatment means that were significantly less (LSD, $P<0.05$) than the untreated control 3-DAT, 7-DAT, and 14-DAT (Table 10). There were no differences among the treatments for blue alfalfa aphid numbers 21-

DAT. All insecticide treatments except Mustang had significantly fewer cowpea aphids than the control 7-DAT in 2011, but there were no differences among the treatments for cowpea aphid 3-DAT, 14-DAT and 21-DAT.

Table 7 Egyptian Alfalfa Weevil Larvae and Pea Aphids per Sweeps, Holtville, CA, 2010.

Treatment	oz/ac	Alfalfa Weevil Larvae/Sweep				Pea Aphids/Sweep			
		5 DAT[z]	7 DAT	14 DAT	21 DAT	5 DAT	7 DAT	14 DAT	21 DAT
Check	------	93.75 a	33.00 a	12.25 a	19.25 a	7.75	6.00	1.25	11.25
Lorsban 4E	32.0	42.75 b	7.50 b	1.75 b	5.75 b	1.00	0.75	0.75	7.50
Mustang EW	4.3	0.50 d	0.50 cd	0.50 bc	0.50 c	0.00	0.00	0.75	0.50
Stallion	9.25	2.50 c	1.75 c	0.25 bc	1.50 c	0.00	1.50	1.25	1.00
Stallion	11.75	0.50 d	0.00 d	0.00 c	0.75 c	0.00	0.75	0.75	4.25
Avaunt[y] + Dimethoate 267	10.0 + 16.0	1.25 cd	0.00 d	0.00 c	1.50 c	1.50	2.25	1.25	5.50
Warrior II	1.5	0.75 d	1.25 cd	0.00 c	0.75 c	0.25	0.25	0.25	4.75

Means within columns followed by the same letter are not significantly different. [y] Avaunt is not registered for use on alfalfa, but Steward with the same a.i., indoxacarb, may be used on alfalfa. [z] Days after treatment

Table 8. Blue Alfalfa Aphids per Sweeps, Holtville, CA, 2010.

Treatment	oz/acre	Blue Alfalfa Aphid/Sweep			
		5 DAT[y]	7 DAT	14 DAT	21 DAT
Check	------	125.25 a	36.00 a	6.00 a	106.50 a
Lorsban 4E	32.0	12.50 b	5.75 b	0.50 c	27.25 b
Mustang EW	4.3	8.00 b	3.25 b	0.75 c	27.25b
Stallion	9.25	10.75 b	6.25 b	0.50 c	19.25 b
Stallion	11.75	5.25 b	4.25 b	0.00 c	26.75 b
Avaunt + Dimethoate 267	10.0 + 16.0	9.75 b	4.00 b	4.00 ab	23.50 b
Warrior II	1.5	5.75 b	2.75 b	1.25 bc	15.25 b

Means within columns followed by the same letter are not significantly different. [y] Days after treatment

An insecticide efficacy studies for leafhopper and threecornered alfalfa hopper management were conducted during the summers of 2009 at the UC Desert Research and Extension Center. A stand of alfalfa, var. CUF 101, was used for the experiment. Plots in each experiment were arranged in a randomized complete block design with four replications. Insecticide treatments and rates as ounces of formulated product per acre for each experiment by year are listed in the Tables 11. Insecticide treatments were broadcast applied 8 July 2009. Populations of *Empoasca* spp. leafhoppers and threecornered alfalfa hoppers were measured in each plot with a standard 15 inch diameter insect sweep net consisting of ten 180^{o} sweeps. Samples were taken in the

2DAT, 7-DAT and 14-DAT. All insecticide treatments had means for leafhoppers that were lower (P = 0.05) 2DAT. There were no differences among the treatment means for either leafhoppers or threecornered alfalfa hoppers 7-DAT or 14 DAT.

Table 9. Egyptian Alfalfa Weevil Larvae Pea Aphids per Sweeps, Holtville, CA, 2011.

Treatment	oz/ac	Alfalfa Weevil Larvae/Sweep				Pea Aphids/Sweep			
		3DAT[z]	7 DAT	14 DAT	21 DAT	3 DAT	7 DAT	14 DAT	21 DAT
Check	------	29.88 a	13.25 a	2.38 a	1.63 a	40.85 a	10.98 a	0.85 a	0.75
Mustang EW	4.3	0.25 c	0.45 c	0.48 b	0.63 b	0.58 c	0.50 bc	0.28 abc	0.68
Stallion	9.25	0.43 c	0.08 de	0.10 bc	0.50 b	0.20 c	0.03 c	0.00 d	0.83
Stallion	11.75	0.30 c	0.05 de	0.25 bc	0.35 bc	0.33 c	0.10 bc	0.15 bcd	0.08
Endigo 2.06 ZC[y]	4.0	0.48 c	0.18 cd	0.25 bc	0.65 b	0.35 c	0.00 c	0.03 d	0.40
Endigo ZCX[y]	4.0	0.45 c	0.15 cde	0.15 bc	0.33 b	0.28 c	0.03 c	0.00 d	0.23
Centric 40 WG[y]	3.5	3.73 b	3.30 b	1.73 a	1.98 a	0.48 c	0.03 c	0.05 d	0.95
Voliam Xpress	9.0	2.83 c	0.63 c	0.63 b	0.28 bc	1.13 c	0.28 bc	0.13 bcd	0.33
Cobalt Advanced	24.0	0.35 c	0.13 de	0.20 bc	0.20 bc	0.13 c	0.15 bc	0.10 cd	0.40
Danitol[y]	21.3	0.25 c	0.00 e	0.00 c	0.05 c	5.93 b	1.03 b	0.45 ab	0.33

Means within columns followed by the same letter are not significantly different, LSD; *P*= 0.05. .
[y] These insecticides are not registered for use on alfalfa.
[z] Days after treatment.

Table 10. Blue Alfalfa Aphids and Cowpea Aphids per Sweeps, Holtville, CA, 2011.

Treatment	oz/ac	Blue Alfalfa Aphids / Sweep				Cowpea Aphids / Sweep			
		3DAT[z]	7 DAT	14 DAT	21 DAT	3 DAT	7 DAT	14 DAT	21 DAT
Check	------	139.68 a	28.78 a	2.20 a	0.83	0.75	0.38 a	0.18	0.10
Mustang EW	4.3	2.43 c	1.30 b	0.28 bc	0.58	0.23	0.35 a	0.00	0.03
Stallion	9.25	0.50 de	0.23 cde	0.28 bc	0.35	0.08	0.10 bc	0.00	0.03
Stallion	11.75	0.50 e	0.28 bcde	0.28 bcd	0.63	0.23	0.03 c	0.10	0.00
Endigo 2.06 ZC[y]	4.0	1.08 cde	0.08 de	0.18 bcd	0.35	0.20	0.00 c	0.00	0.00
Endigo ZCX[y]	4.0	0.83 cde	0.00 e	0.25 bc	0.18	0.10	0.10 bc	0.03	0.05
Centric 40 WG[y]	3.5	2.93 c	0.93 bc	0.08 cd	0.38	0.40	0.30 ab	0.10	0.00
Voliam Xpress	9.0	3.50 cd	1.00 bcde	0.05 d	0.58	0.38	0.08 bc	0.00	0.05
Cobalt Advanced	24.0	0.43 e	0.23 bcde	0.20 bcd	0.48	0.18	0.03 c	0.03	0.00
Danitol[y]	21.3	12.43 b	1.98 bcd	0.55 b	0.53	0.13	0.05 c	0.03	0.05

Means within columns followed by the same letter are not significantly different, LSD; *P*= 0.05.
[y]Not registered for use on alfalfa at the time of publication.
[z] Days after treatment.

Table 11. *Empoasca* sp. Leafhoppers and Threecornered Alfalfa Hoppers in Alfalfa. Holtville, CA. 2009.

Treatment	oz/acre	Leafhoppers / Sweep			3-cornered Alfalfa Hoppers / Sweep		
		2 DAT	7 DAT	14 DAT	2 DAT	7 DAT	14 DAT
Check	-----	24.45 a	2.85	3.45	3.63	1.68	4.95
Lorsban Advanced	16.0	5.98 cd	0.48	2.13	2.23	0.55	4.58
Lorsban Advanced	32.0	17.13 b	1.48	1.38	2.00	1.53	3.48
Dimethoate E267	16.0	6.75 cd	1.93	2.53	1.75	2.90	4.20
Warrior II	1.6	11.70 bc	1.33	1.75	1.53	1.73	4.28
Mustang Max	4.0	4.78 cd	0.75	2.55	0.63	9.50	3.25
Lannate LV	32.0	8.45 cd	3.18	1.80	1.60	2.05	3.00
Baythroid XL	1.6	3.83 d	1.70	1.70	1.08	2.00	4.58
Ambush Insecticide	6.4	5.85 cd	2.08	2.53	1.03	2.88	3.98

Means within columns followed by the same letter are not significantly different; $LSD_{0.05}$.

CONSLUSION

Based on the results of the several insecticide efficacy studies on alfalfa shown above in this report, there several insecticidal products registered for worm pests (), alfalfa weevil larvae () and the complex of aphids commonly found in alfalfa (). The alfalfa insect pests that are difficult to control with currently registered insecticide are the *Empoasca* spp. leafhoppers.

LITERATURE CITED

Anonymous 1985. Integrated pest management for alfalfa hay. Univ. Calif. Statewide IPM Proj., Publication 3312. 96 pp.

Anonymous 2006. UC IPM Pest Management Guidelines, Alfalfa. http://www.ipm.ucdavis.edu/PMG/selectnewpest.alfalfa-hay.html.

Blackman, R. L. and V. F. Eastop. 1984. Aphids on the World Crops: An Identification and Information Guide, Wiley - Interscience Publication. 466 pp.

Hompton, R. O. 1900. Alfalfa enation. Pg. 53 *In* D. L. Stutevill and D. C. Erwin Ed. Compendium of Alfalfa Disease 2nd Edition.

Lehman, W.F. 1978. Breeding alfalfa for tomorrow. Proceedings Eighth California Alfalfa Symposium, pp. 1-9.

Natwick, E. T. 1999a. New Aphid Invades California Alfalfa Fields. California Alfalfa & Forage Review, Vol. 2, No. 2: 1 & 6.

Natwick, E. T. 1999b. Insecticide efficacy evaluation for cowpea aphid control in alfalfa, 1999. Imperial Agric. Briefs Newsletter, April: 6.

Natwick, E.T. 1987. Weevil and worm management for low desert alfalfa production. Proceedings Seventeenth California Alfalfa Symposium, pp. 94-100.

Nielson, M. W., H. Don, M. H. Schonhorst, W. F. Lehman, and V. L. Marble. 1970. Biotypes of the spotted alfalfa aphid in the western United States. J. Econ. Entomol. 63:1822-5.

Stern, V.M., and H.T. Reynolds.1958.Resistance of spotted alfalfa aphid to certain organophosphate insecticides in southern California. J. Econ. Entomol. 51: 312-6.

Summers, C. G. 2000a. Cowpea aphid spreads. California Alfalfa & Forage Review, Vol. 3, No. 2: 1 & 8.

Summers, C. G. 2000b. Tiny pest threatens California's alfalfa crop. California Alfalfa & Forage Review, Vol. 3, No. 1: 1 & 7-8.