INSECT PEST MANAGEMENT ISSUES IN ALFALFA--CHALLENGES AND QUESTIONS

Larry Godfrey, Peter Goodell, Vonny Barlow, Eric Natwick, and Rachael Long[1]

ABSTRACT

Integrated pest management in alfalfa continues to be challenged by changes in the pests, alfalfa production system, environmental conditions, and other undetermined factors. Many of the underlying principles of integrated pest management (IPM) were developed from research conducted in the alfalfa system in the 1960-80's. However, as indicated by challenges in controlling alfalfa weevil larvae in recent years, continued efforts needed to control larvae of the armyworm and cutworm complex on the summer cuttings, alfalfa stem nematode outbreaks in the last ~5 years, and finally the severe and damaging outbreaks of blue alfalfa aphid in the spring of 2013, alfalfa IPM needs to be revisited. Management of aphids in alfalfa and the aphid situation in 2013 will be reviewed.

Key Words: blue alfalfa aphid, host plant resistance, natural enemies

INTRODUCTION

For many years, alfalfa has been a model system for the development, implementation, and use of integrated pest management (IPM) tactics in California. As IPM was developing as a scientific field in the 1950's to 1970's, many of the studies that contributed to the underlying foundation of IPM were conducted in alfalfa. This information was not only used for these scientific endeavors but also extended to growers and implemented in their fields leading to a cost-effective and sustainable IPM program in alfalfa. Identification of pest and natural enemy species, pest biology (number of generations, overwintering, etc.), sampling techniques and protocols, treatment thresholds, degree-day models, pest distribution over the state, etc. were some of the early studies conducted. Management tactics were subsequently developed including 1.) **biological control** methods, i.e., the impact of beneficial organisms (insects and microorganisms) on pests, 2.) **cultural control** measures, e.g., strip harvesting, efficient irrigation, and others, 3.) **host plant resistance** tactics primarily for aphid management but it also contributes to managing other pest species in the context of having well-adapted, vigorous cultivars, and 4.) **insecticidal management** initially with broad-spectrum materials now moving to more reduced risk products. This information has been summarized in a usable format in the UC Pest Management Guidelines http://www.ipm.ucdavis.edu/PMG/selectnewpest.alfalfa-hay.html .

---

[1] L. Godfrey (ldgodfrey@ucdavis.edu),, Extension Entomology Specialist, University of California-Davis, Department of Entomology and Nematology, Davis, CA 95616; Peter Goodell (pbgoodell@ucanr.edu), Cooperative Extension Advisor, IPM, Kearney Agricultural Research & Extension Center, 9240 S. Riverbend Ave., Parlier, CA 93648; Vonny Barlow (vmbarlow@ucdavis.edu), Entomology/IPM /Crop production Advisor, UCCE Palo Verde Valley, 290 N. Broadway, Blythe, CA 92225-1649; Eric Natwick (etnatwick@ucanr.edu), Entomology Advisor, Cooperative Extension Imperial County, 1050 East Holton Road, Holtville, CA 92250-9615; Rachael Long (rflong@ucanr.edu),Farm Advisor for Field Crops, Pest Management, Cooperative Extension Yolo County, 70 Cottonwood Street, Woodland, CA 95695 **<u>In</u>:** Proceedings, 2013 Western States Alfalfa and Forage Symposium, Reno, NV, 11-13 December, 2013. UC Cooperative Extension, Plant Sciences Department, University of California, Davis, CA 95616. (See http://alfalfa.ucdavis.edu for this and other alfalfa symposium Proceedings.)

The success of alfalfa production and IPM has led to the recognition of the environmental attributes and ecological services provided by the crop. For instance, in the entomology area over 1000 species of arthropods (insects and related organisms) have been observed in alfalfa (Pimentel and Wheeler 1973). Only a few of these feed on the alfalfa and are classified as pests, several of these are beneficial through their activities as predators and parasitoids, and the majority have neither a positive or negative effect in alfalfa. Alfalfa has been referred to as the "insectary of the Central Valley" since it is home to many predators and parasitoids that potentially disperse to other crops and provide biological control there as well.

PRESENT SITUATION

In recent years, "changes" have occurred that have upset the alfalfa IPM system. The background and origin of these "changes" have not been clearly defined or explained but have negatively impacted alfalfa IPM. This degradation in alfalfa IPM came to the forefront in 2013 which resulted in crop losses, increased insecticide use, and decreased profitability. Some of the noted changes, and speculation over what has caused these changes, will be detailed.

1. Emergence of cowpea aphid as a pest: This aphid species, *Aphis craccivora*, developed into an alfalfa pest in California about 10-15 years ago (Natwick 1999a, Natwick 1999b, Natwick 1999c, Summers 2000a, Summers 2000b). This pest has marched across the U.S and is now an important alfalfa pest in the Midwest (Berberet et al. 2009). The cowpea aphid has existed in California for many years and is a pest of cowpeas but never seriously infested alfalfa. What has changed? Is this a new species, a new biotype, or what other change occurred? This has never been determined through research. However, insecticide treatments for cowpea aphids, generally with broad-spectrum materials, in the winter months in the high desert and in the late spring and summer in the Central Valley, have helped to destabilize the alfalfa IPM system.

2. Challenges managing the alfalfa weevil complex: In most years, the weevil complex is the most important insect pest of alfalfa statewide. Host plant resistance and predators and parasitoids offer only marginal control of this pest. Therefore insecticides are an integral part of weevil IPM. The reduced risk insecticides that are available for many insect pests have not been developed yet for the alfalfa weevil. The last new active ingredient registered for alfalfa weevil control was indoxacarb in the early 2000's. Several comments were received in 2013 that the insecticides used for Egyptian alfalfa weevil (EAW) were not working as well as in past years and especially in the upper SJV and lower Sacramento Valley; tank mixes and/or two applications were often needed for satisfactory control. In addition, the biology of this pest appears to be changing. Two observations have led to this conclusion. Very high numbers of alfalfa weevil larvae (as high as 75 to 100 larvae <u>per sweep</u>) are now consistently found in alfalfa in the intermountain region; this pest used to be only occasionally a problem in these areas but now is a major IPM challenge. What has resulted in this change in biology? Secondly, the incidence of multiple generations per year of Egyptian alfalfa weevil appears to be increasing. This pest has traditionally been known to have one generation per year. It overwinters as adults with the females depositing eggs within alfalfa stems during warm late fall and winter periods. These eggs subsequently hatch and the larvae feed for a 2-4 week period. These larvae pupate in February to May (high desert to Central Valley area) with the new adults feeding for a few days in alfalfa and then leaving the alfalfa field to aestivate (diapause) during the summer and early

fall. A small percentage of the emerging new adults have been reported to deposit eggs resulting in a second generation and another damaging larval period (Madubunyi 1970). Summers (pers. comm.) reported this to be common in parts of Tulare/Kings Co. in the Central Valley. However in 2013, observations of weevil larvae in Fresno/Merced Co. in June (in some cases at “treatable” levels) indicating a second generation and on the UC-Davis campus on 8 Aug. numerous EAW larvae were found suggesting at least 3 or more generations; this phenomena is apparently spreading over the Central Valley.

3.) Blue alfalfa aphid: This pest emerged in high population densities in 2013. In February and March 2013, developing populations were seen in Kern Co. and certain other areas of the Central Valley (Fresno, Merced, San Joaquin Co.) experienced high populations later – April and May. The Lancaster area and high deserts also saw high levels of blue alfalfa aphid. It is not unusual to see some early season build-up of blue alfalfa aphid and occasionally an insecticide application is needed in the late winter/early spring. But usually the host plant resistance that controls this species “kicks in” and, along with natural enemies (a fungus that infects and kills the aphids and also insect parasitoids and predators), these two IPM tactics combine to manage this pest.

The blue alfalfa aphid (BAA), *Acyrthosiphon kondoi*, was introduced to California in 1974 and first found near Bakersfield (Kono 1975, Summers 1975). It quickly spread to other parts of the Central Valley and to Imperial Valley in 1975 (Sharma et al. 1976). Upon its introduction, significant damage was done to alfalfa. This species often co-occurs with the pea aphid, *A. pisum*. However, one key difference is that the blue alfalfa aphid injects a toxin as it feeds and the combination of the feeding damage and the toxin interacts to greatly stunt the growth of the alfalfa plant. This stunting effect can carry over to the subsequent harvests. Pea aphids remove plant “juices” as they feed but do not inject a toxin and stunt the alfalfa growth to the same degree as BAA; thus the impact of populations on plant growth is less. The blue alfalfa aphid infestations greatly reduced yields and upset alfalfa IPM programs in the mid-1970’s soon after its introduction. However, the development of alfalfa varieties selected for resistance for this species greatly facilitated management. This approach had been used some 30 years earlier for another introduced aphid species, the spotted alfalfa aphid (*Therioaphis maculata*), and this germplasm was evaluated, improved, and ultimately released as ‘CUF 101’ with BAA resistance.

There are several interesting attributes of BAA biology and the host plant resistance 1.) BAA survival and reproduction rates are greater at lower temperatures, such as 10-l5 ^{0}C (50-59 ^{0}F), than at higher temperatures, 20-25 ^{0}C (68-77 ^{0}F). Blue alfalfa aphids develop down to 38 °F so the cool temperatures really do not stop this species (pea aphid prefers slightly higher temperatures); the cool late winter/early spring conditions are ideal for both species but BAA particularly flourish. However, the host plant resistance in alfalfa is not fully functioning during cool periods. Research has shown that at (59 °F) (15 °C) the host plant resistance was only partially effective against BAA, but at 68 °F (20 °C) the plant resistance was fully functioning (Summers 1988). These temperatures would correspond with daily average temperature, not daily high temperatures. So it is not uncommon to see some build-up of BAA and pea aphid in the spring before the temperatures warm, but the outbreak of BAA in 2013 was more serious than normal.

Several aphid management products were evaluated this year by Eric Natwick and collaborators in Imperial Co. Of all of the insecticides evaluated against blue alfalfa aphid, almost every insecticide applied to alfalfa this spring gave initial knockdown with BAA populations resurging 7-10 days later. (Table 1) That mirrors what many PCAs were reporting. Multiple applications and tank mixes of insecticides from different classes of chemistry were among the techniques used for BAA management in 2013. Similar results for aphid management with insecticides in 2013 in the Central Valley are shown in Fig. 1 from Godfrey and collaborators.

Table 1. Blue alfalfa aphid management with insecticides.

Blue Alfalfa Aphids per Sweep, Holtville, CA, 2013.

Treatment	fl oz/acre	1 DPT[w]	3 DAT[xz]	7 DAT	10 DAT	14 DAT	PTA[yz]
Check	--------	105.05 a	58.58 a	38.83 a	82.50 a	39.10 b	54.75
Warrior II	1.92	127.80 a	10.95 bc	8.63 c	15.55 b	24.23 bc	14.84 b
Endigo ZCX	4.0	84.00 a	1.08 f	3.05 c	4.48 b	13.73 c	5.58 bc
Besiege	9.0	103.05 a	5.55 cd	2.93 c	16.63 b	21.60 bc	11.68 b
Cobalt Advanced	24.0	69.75 a	2.23 de	1.60 c	5.73 b	6.60 c	4.11 c
Mustang	4.3	91.48 a	4.53 d	3.20 c	13.13 b	18.13 bc	9.74 b
Stallion 3.025 EC	9.25	95.98 a	3.53 d	2.38 c	14.33 b	13.45 c	8.42 bc
Stallion 3.025 EC	11.75	105.05 a	2.08 ef	2.25 c	5.48 b	22.45 bc	8.06 bc
Danitol	16.0	115.23 a	13.98 b	22.28 b	65.45 a	65.45 a	41.79 a

Blue Alfalfa Aphids per Ten Sweeps, Holtville, CA, 2013.

Treatment	fl oz/acre	PT[w]	3 DAT[x]	7 DAT[z]	14 DAT	PTA[yz]
Check	--------	58.48 a	65.66 a	82.64 a	86.36 a	78.22 a
Paradigm VC	3.84	60.02 a	17.12 b	18.68 b	20.16 b	18.65 b
Baythroid XL	1.9	49.58 a	11.84 b	23.20 b	26.12 b	20.39 b
Mustang	4.3	54.44 a	11.42 b	15.40 b	23.00 b	16.61 b
Lorsban Advanced	24.0	81.56 a	8.20 b	7.28 c	15.34 b	10.27 c
Warrior II	1.92	72.64 a	14.58 b	6.94 c	15.92 b	12.48 bc

Means within columns followed by the same letter are not significantly different, LSD; *P*= 0.05.
[w] Pre-treatment [x] Days after treatment [y] Post treatment average.
[z] Log_{10} (X+1) transformed data used for analysis, actual means reported.

So what caused the blue alfalfa aphid outbreak in 2013, and more importantly is it going to happen again. No one knows for certain. Discussions with PCAs, meetings among researchers, and observations have brought forth several possibilities.

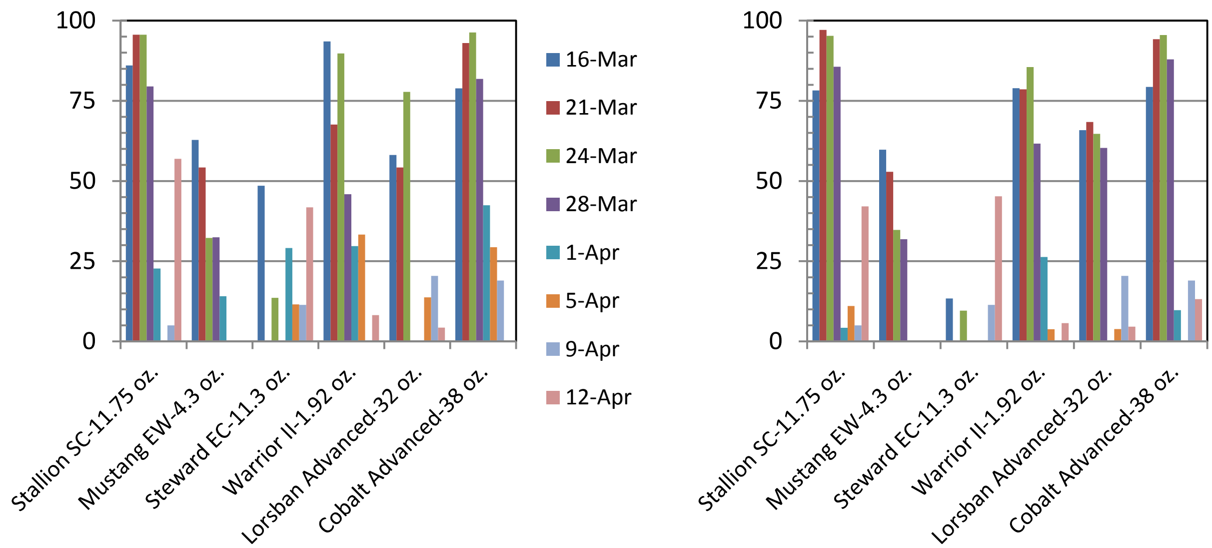
1.) The climatic conditions in 2013 were conducive to the build-up of some pest species, including BAA. Pea aphids were also at very high levels. Whiteflies populations were extremely high in some crops, similarly with leafhoppers. Some years for unknown reasons are ideal for some pest insects and the sucking insect complex appeared to be favored this year in many crops. This is something entomologists have observed and studied for years. With the numbers of pea and blue alfalfa aphids present, even 90% control with insecticides was still leaving too many survivors which quickly rebounded due to high rates of reproduction.

2.) A decline in the number of natural enemies present in the field, even before any treatments were applied, was observed to some extent. We (Godfrey and Long) typically evaluate alfalfa weevil control with insecticides at Davis (usually in the same field) and in 2013 the number of natural enemies was 1.5 per 20 sweeps compared with 6.8 in 2003, 8.7 in 2004, 14 in 2006, 2.3 in 2010, and 2.5 in 2011. In addition, the dry winter may have also contributed to a reduction in the levels of the entomopathogenic (insect-infecting) fungus which needs moist field conditions. Natural enemies normally play an important role in aphid management. Lower densities of lady bird beetles were noted by PCAs in Kern County as well.

3.) The host plant resistance in the alfalfa varieties may be breaking down and being overcome by the aphids. Aphids evolve very quickly to unfavorable conditions. A toxicant in their host plant represents an unfavorable condition and in order to survive they adapt to overcome this. That is the history of host plant resistance. Some pest species overcome the resistance in only a few years and the plant breeders are constantly refining and improving the resistance to stay ahead of the evolving pest. The plant breeders try to stay a few “steps ahead” of the pest in order to maintain effective IPM tools for the growers. The host plant resistance blue alfalfa aphid has been in place for 40 years and we may be seeing that it is being compromised. However to “counter” this idea, no pattern was noted between variety or outbreak/severity compared with nearby fields utilizing the same variety without outbreaks.

4.) The process described above is very similar to a pest developing resistance to an insecticide. The insecticide in an undesirable selection pressure and the pest evolves to overcome this. Another possible explanation for the lack of effective BAA management in 2013 is the development of insecticide resistance to the key materials used, mostly organophosphate and pyrethroid products. As with the alfalfa weevil complex, there have been very few new insecticides registered in alfalfa with activity on aphids.   Some preliminary bioassays were done with BAA in 2013 that showed no significant resistance but a more detailed dose-response analysis is need to more fully address this topic.

PCAs and growers were informally surveyed (Table 2) to attempt to draw some commonalities among aphid-infested fields in terms of insecticide use patterns, alfalfa variety, Roundup Ready alfalfa vs. not, age of stand, and other factors. No definite trends were identified. Economic impacts and damage severity estimates were reported.



T

Fig. 1. Aphid management in alfalfa with insecticides (% reduction compared with untreated plots) targeting EAW larvae applied on 13 March; blue alfalfa aphid (left), pea aphid (right).

Region	Acres Infested	Loss	Stand Age	Damage Severity Ranking; 1= low, 5 =high
Imperial Valley	> 1000 acres	$70/acre, 1/3 ton	3rd yr.	4
Dos Palos	500-1000 acres			
Dos Palos	>1000 acres	$250/acre for 2 cuttings	3rd yr.	5
Dos Palos		$150/acre	2nd yr.	5
Buttonwillow	>1000 acres	½ - ¾ bale	2nd & 3rd yr.	3
Dos Palos	85 acres	$90/acre	2nd yr.	5
Dos Palos	100-500 acres	40% reduction	3-5th yr.	4
Palo Verde Valley	> 1000 acres	$100/acre	2 months to 3rd yr.	5
Palo Verde Valley	> 1000 acres	$125/acre	4th yr.	5

In summary, alfalfa IPM was challenged by aphid outbreaks, primarily BAA, in 2013. Several other unusual changes in the biology of the alfalfa weevil complex were also noted, which impacted IPM of this pest. The reasons for these changes are not clearly defined at this time. Growers should continue to plant alfalfa varieties with high levels of aphid resistance and follow other IPM practices in alfalfa until this situation is more clearly defined and new recommendations can be developed.

REFERENCES

Berberet, R. C., K. L. Giles, A. A. Zarrabi, and M. E. Payton. 2009. Development, reproduction, and within-plant infestation patterns of *Aphis craccivora* (Homoptera: Aphididae) on alfalfa. Environ. Entomol. 38:1765-71.

Kono, T. 1975. Distribution and identification of the blue alfalfa aphid. Proc. 5th California Alfalfa Symposium.

Madubunyi, L. C. 1970. Ecophysiology of the Egyptian weevil (Hypera brunneipennis (Boh.) (Coleoptera: Curculionidae) with emphasis on its diapause and phenology. 242 pp. Ph.D. Thesis, University of California, Berkeley.

Natwick, E. T. 1999a. Cowpea aphids in alfalfa. Pest-O-Gram Nwsl. Jan 19. pp. 1.

Natwick, E. T. 1999b. Insecticide efficacy evaluation for cowpea aphid control in alfalfa, 1999. Imperial Agr. Briefs Nwsl. Apr pp. 6-7.

Natwick, E. T. 1999c. New aphid invades California alfalfa fields, Calif. Alf. & Forage Assn. Rev. Vol.2, No.2.

Pimentel, D. and Wheeler, A.G. 1973. Species and diversity of arthropods in the alfalfa community. Environ. Entomol 2:568–659.

Sharma, R. K., V. M. Stern, R. W. Hagemann. 1976. Blue alfalfa aphid: A new pest in the Imperial Valley. Calif. Agri. 30(4):14-15, doi#10.3733/ca.v030n04p14

Summers, C. G. 1975. The "blue alfalfa aphid" –biology and economic thresholds. Proc. 5th California Alfalfa Symposium.

Summers, C. G., 1988. Cultivar and Temperature Influence on Development, Survival, and Fecundity in Four Successive Generations of *Acyrthosiphon kondoi* (Homoptera: Aphididae). J. Econ. Entomol. 81: 515-21.

Summers, C. G. 2000a. Cowpea aphid spreads. Calif. Alf. Forage Rev. vol. 2. University of California, Davis, CA.

Summers, C. G. 2000b. Tiny pest threatens California alfalfa crop. Calif. Alf. Forage Rev. vol. 3. University of California, Davis, CA