Is Aphid Management Sustainable in Desert Head Lettuce?

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Abstract

New restrictions on insecticides for aphid control presents new challenges for lettuce growers. Dimethoate is soon to be unavailable and the future status of other conventional aphicides is uncertain. However, a number of new active ingredients will soon be available that offer lettuce growers valuable alternatives for aphid management in lettuce. The present dilemma and potential for implementing new chemistries into lettuce IPM programs is discussed in this report.

The Desert Aphid Complex

An aphid complex consisting of the green peach aphid, *Myzus persicae*, the potato aphid, *Macrosiphum euphorbiae*, and *Acyrthosiphon lactucae* has seemingly always caused problems for Arizona lettuce growers. Green peach aphid has generally been considered the most important aphid species of the complex because of its relative tolerance to some older insecticides (Kerns, et. al. 1998), and its ability to reach high population levels in lettuce. This has recently changed as two new species have emerged that now pose serious concerns to the lettuce industry

A new exotic aphid species, the lettuce aphid, *Nosanovia ribis-nigri* was found infesting lettuce in the Salinas Valley of California in 1998. This aphid quickly spread throughout the coastal growing areas and is now considered their primary aphid pest (Anonymous 2003). Commonly found on lettuce in Europe and Canada, this pest had never previously been reported in the western U.S. By 2000, the lettuce aphid was found in the desert growing of Arizona, presumably arriving from the coast via lettuce transplants and harvest equipment. Although this aphid reportedly has a narrow host range for composite species, it has quickly become established in the desert growing areas and is now considered a key pest of spring lettuce in Arizona (Palumbo 2003a).

To add further complexity to the aphid situation, another new aphid species, the foxglove aphid, *Aulacorthum solani*, was found infesting commercial lettuce fields in the Yuma area for the first time in 2002 (Palumbo 2003b). This species is principally considered a serious pest of potatoes throughout the U.S, and is only considered an occasional pest of lettuce and leafy vegetables grown in Canada. Although it has been reported on a wide range of hosts in California, it was not previously thought to occur in Arizona. Based on our recent observations over the past 3 years in Yuma, it appears that foxglove aphid has become established in the desert (Palumbo 2003a). Many growers and PCAs now consider foxglove aphid a serious aphid pest in desert lettuce production.

It is not uncommon to find all five aphid species simultaneously infesting lettuce fields in desert cropping systems, and if not controlled populations can quickly build up to very high densities throughout the plant depending on weather conditions ((Palumbo 2003a). Green peach aphids and potato aphids can be difficult to control with contact insecticides because they feed primarily on the lower surface of older lettuce leaves, gradually moving into the heads as population densities increase. In contrast, lettuce and foxglove aphids present a different challenge in controlling aphids in lettuce. These aphid species prefer to feed and colonize in the terminal growth of lettuce plants, and particularly deep within developing lettuce heads. Control of lettuce and foxglove aphids with contact insecticides can be more difficult because of the aphids' preference for the protected terminal growth. Once aphids are detected, it is not uncommon for growers to apply insecticides on a regular basis.

Aphid Management in the Desert

Historically, pest management programs for aphids on vegetable crops in Arizona and California have been developed around the availability of effective insecticides (Kerns and Palumbo 1996). Prior to 1994, meviphos (Phosdrin) was the most effective insecticide available for aphid control and was used extensively. Because it was a highly volatile compound and extremely toxic to aphids, growers were able to apply meviphos near harvest and eliminate aphid infestations deep inside heads. However, worker exposure issues forced the manufacturer to remove the product from the market in 1994. Since then, Arizona growers have relied on two different management approaches to control aphids in lettuce. Both of them are preventative approaches that utilize insecticides to prevent aphids from colonizing and contaminating plants.

One aphid management approach involves the soil application of the systemic, neonicotinoid insecticide imidacloprid (Admire 2F). The compound has low environmental risk and is considered an OP replacement. Long residual control of green peach and potato aphids in lettuce can be achieved by a single, at-planting soil application. Through root uptake, the compound provides significant reduction of aphid colonization on winter lettuce crops for up to 75 days. Furthermore, because Admire is applied as a liquid in the bed preparation or planting operations, there is no additional application costs associated with its use. This prophylactic approach has been the industry standard since 1993 and has been applied on as much as 80% of the head and leaf lettuce acreage planted annually in the AZ and CA deserts (Agnew 2000). However, several recent developments have caused the lettuce industry to seek alternatives to prophylactic Admire use (Anonymous 2003).

First, because of the intense reliance on Admire for aphid and silverleaf whitefly management in the desert, resistance has become a serious concern (Palumbo, et. al. 2003). The recent registration of several new neonicotinoid compounds on cotton, melons and vegetables has expanded the number of compounds available for whitefly and aphid control on these crops. The sustained efficacy of Admire over the past 10 years exceeds the expectations of many who speculated that whiteflies and aphids would quickly evolve resistance (Kerns, et. al. 1998, Palumbo 2003a). However, no field failures have been reported thus far, in part perhaps, because Admire has been used sparingly in cotton and other summer crops. However, the recent registration of new members of this class of chemistry, acetamiprid and thiamethoxam, may lead to much greater use of this class in cotton against whiteflies. If not used judiciously, successive whitefly generations could be exposed to several neonicotinoid compounds on a variety of different crops throughout the year. Such a scenario places increased selection pressure on exposed whitefly and aphid populations and thereby greatly increases the risk of resistance.

In addition, Admire soil treatments do not appear to be as effective against lettuce and foxglove aphids when used at rates that are normally effective against green peach and potato aphids (16 oz or less). Studies at the Yuma Ag Center have shown that Admire applied at-planting does not consistently prevent lettuce aphids from contaminating heads, particularly at higher densities (Palumbo 2000, 2001, 2002). Furthermore, studies conducted in 2003 showed that Admire applied at 16 oz provided season-long control of green peach and potato aphids, but provided less than 80% control of foxglove aphids late in the season (Palumbo 2003a). However, preliminary results in 2004 from field studies at YAC showed that foxglove aphids were controlled in lettuce when Admire was applied at rates of 20 oz or greater (Palumbo, unpublished).

The second approach to aphid management in the desert growing areas of Arizona and California is a preventative foliar approach. Fields not planted with Admire are routinely treated with foliar insecticides upon detection of aphid colonization. With the exception of the foliar formulation of imidacloprid (Provado), foliar aphid control has been achieved almost entirely through the use of high-risk, organophosphate insecticides from germination to harvest. The organophosphates endosulfan, dimethoate, acephate**,** oxydemeton-methyl and diazinon, and the carbamate methomyl are the most frequently used insecticides for foliar aphid control in lettuce (Anonymous 2003, Agnew 2000, Kurtz 1999; Table 2). After years of extensive use, many of these compounds only provide marginal efficacy against green peach aphid, and it is now a common practice for pest control advisors and growers to tank-mix the OPs with a pyrethroid, or other OPs to achieve adequate control (Kerns, et. al. 1998, Palumbo 2003c).

The Problem

Many of the organophosphate uses have been severely restricted due to FQPA (Table 1). For example, the manufacturers of dimethoate have agreed to voluntarily remove its use from head lettuce and other crops effective January 2005. In addition, endosulfan**,** an endocrine disruptor, is rarely used in California due to restrictions for use near water, and new proposed use restrictions will undoubtedly limit its use in Arizona in the future. The uses of acephate and oxydemeton-methyl are currently limited due to their long pre-harvest intervals which prevent their uses during the middle of the season and near harvest. The regulatory impact of FQPA on diazinon suggests that any continued uses in lettuce are questionable. Finally, methomyl and malathion use do not appear to be affected by FQPA, but the provide only marginal efficacy against the aphid complex in Arizona (Palumbo 2003c).

Environmental concerns, particularly occupational risks, are also limiting the use of these compounds. Lettuce production is a labor–intensive farming operation requiring field workers to spend a great deal of time in fields hand hoeing, thinning, irrigating and harvesting crops. To ensure worker safety, these farming operations often dictate when insecticide applications can be made, regardless of the need for pest control. Finally, because of the history of aphid resistance, the risk of aphid resistance to many of these compounds is of growing concern (Kerns, et. al. 1998, Whalon 2000).

Despite all the drawbacks associated with this heavy chemical dependency, western vegetable growers have been reluctant to switch to alternative control practices. Part of the reason for this is that effective, non-chemical control tactics have not been available for aphid management. For example, commonly employed cultural practices such as crop rotation, sanitation and planting/harvest date manipulation are largely ineffective because of the pests wide host range, large reproductive capacity, dispersal behavior, and high damage potential (Kerns et al. 1999). Although numerous parasitoids and predators are known to attack aphids in lettuce, the potential for sustained, economic management with natural enemies in desert cropping systems is limited because lettuce is a short season, high value crop with little or no tolerance for contamination. Biopesticides have also been suggested as alternatives for aphid management. However, studies have shown that materials such as azadirachtin, pyrethrum, entomophagous fungi, oils and soaps have been largely ineffective under field conditions and are not considered viable alternatives.

The Solution

Given the complexities of the desert lettuce cropping systems, it is apparent that newly developed, reduced- and low-risk insecticides offer the most immediate hope as alternatives for conventional sprays (Palumbo and Ellsworth 2001a). Many of the new insecticides being developed today are selective compounds with more environmentally friendly, safer attributes. These compounds possess very safe toxicological profiles through the development of new mechanisms of toxicity and routes of activity (Larson 1997, Table 1). We have identified three new compounds that are either currently registered for use in lettuce, or should be in the near future.

The reduced-risk/OP replacement insecticide pyemetrozine (Fulfill®) has the greatest potential for short-term implementation in lettuce pest management programs. Pyemetrozine belongs to a new, novel chemistry known as the pyridine azomethines (Table 1). A highly selective, anti-feeding compound, it has a unique mode of action that acts specifically on the salivary pump of sucking insects causing rapid cessation of feeding. It is slow acting, but has both contact and systemic activity on aphids and, to a lesser extent on whiteflies. Due to its selective mode of action, pyemetrozine is safe against most non-target organisms. The compound is currently labeled for use in lettuce and cole crops in Arizona and California.

Acetamiprid (Assail®) is another reduced-risk/OP replacement insecticide that is a second-generation neonicotinoid with contact and systemic activity via foliar applications (Table 1). It has excellent activity against sucking pests such as aphids and whitefly, but unlike other compounds in this chemistry it is less efficacious when applied to the soil. As a foliar spray, it is the most efficacious neonicotinoid against whiteflies, and is considered very safe to pollinators. Although it is neonicotinoid, judicious use of this compound, in replacement of prophylactice uses of imidacloprid soil treatments, is suggested to be more a more sustainable use of the class of chemistry (Palumbo, et.al. 2003). The compound is currently labeled for use in lettuce and cole crops in California, with a registration in Arizona expected in 12-18 months.

The third candidate for implementation in lettuce pest management programs is the flonicamid (Table 2). According to a manufacture technical bulletin, flonicamid is a systemic insecticide that is a quick acting compound that immediately suppresses the feeding of aphids and other sucking insects. It is proposed to be non-toxic to beneficials, and has an excellent toxicology profile. Flonicamid has been described as a new chemistry (cyanomethany trifluoromethyl nicotinamide) with a novel mode of action different from other commercially available products (IRAC 2003). It does not work on acetylcholine esterase (OPs and carbamates), or nicotinic acetylcholine receptors (neonicotinoids) and thus appears to be unique and should help with pest resistance management. It is not presently registered for use on any vegetable crop, but review of flonicamid is on EPA's work plan.

We have a considerable amount of experience evaluating these new insecticides against aphids in lettuce. They have shown varying levels of efficacy and control in lettuce depending on the aphid species targeted and timing of application. Against green peach aphid and potato aphid, acetamiprid and pyemetrozine have consistently shown excellent residual activity when applied at low aphid densities and then reapplied at 14-d intervals (Palumbo, et. al. 1998, 1999, 2001). They have also prevented head contamination in lettuce when applied in rotation with each other. Data on flonicamid is more limited, but several trials last year suggest that it may be more efficacious than either of the other new compounds (Palumbo 2003a, Palumbo 2003c) We are currently evaluating flonicamid in small lettuce plots at the Yuma Agricultural Center and data shows that it provides excellent residual activity when applied to moderate densities of green peach aphid. We have considerably less experience evaluating these insecticides against foxglove and lettuce aphids. However, studies have shown that all the compounds can provide good efficacy against these pests if applied at low aphid densities before head formation begins (Palumbo, et. al. 2001, Palumbo 2003b).

Collectively, the chemical attributes and biological activities of pyemetrozine, acetamiprid and flonicamid make them extremely attractive for implementation into an aphid management program. However, as with all new "soft" compounds, implementation of these novel insecticides will require additional information regarding monitoring and application timing to ensure that cost-effective IPM is achieved. As discussed above, the past performance of these insecticides under experimental settings has been highly dependant on spray timing. We know that initiating application at low aphid densities (~1 apterae/plant) has provided consistent protection to marketable heads. Unfortunately, what we don't know is at what population density is *re-treatment* needed to sustain this level of protection from aphids? Can spray intervals be stretched to greater than 14 days and still achieve protection? Ultimately what PCAs need is a simple action threshold that can be used in conjunction with a reliable sampling plan that will assist them in making cost-effective management decisions. In other words, they need a management-based approach that will prevent them from under-or-over applying these new insecticides, while producing a contaminant–free crop.

Future studies have been designed to address these questions on spray timing, and information will be forthcoming. At this time, we feel confident that given the current regulatory status, two things are likely to occur.

1) Lettuce growers and PCAs will continue to lose the use of older, effective OP and carbamate insecticides for managing aphids in head lettuce. However, the continued availability of new active ingredients such as Fulfill, Assail and Flonicamcid will help ensure that they can successfully control aphids in the future.

2) Sustaining the long-term effectiveness of the neonicotinoids, and the newer compounds will require that growers and PCAs vigilantly follow IPM and resistance management guidelines developed for aphid control in desert lettuce crops (Palumbo, et. al. 2003).

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Table 1. Insecticide Alternatives for Aphid management in Lettuce.

Chemical	Trade name	Chemistry	Activity	Environmental Risks [a] Human	Natural enemies	Aquatic/ Avian	Availability / FQPA Restrictions
meviphos	Phozdrin	OP	vapor	***	***	***	EPA cancellation , April 1994
dimethoate	Dimethoate 267	OP	contact	**	***	**	Voluntary cancellation effective Jan 2005 [e]
endosulfan	Thionex, Thiodan,Phaser	Organochlorine	contact	***	**	***	Use reduced to 2 lb ai total /season, Environmental concerns.
acephate	Orthene	OP	systemic	**	***	*	21 d PHI; Head lettuce only
oxydemeton-methyl	Metasystox-R	OP	systemic	**	**	***	28 d PHI; Head lettuce only
diazinon	Diazinon	OP	contact	**	***	***	Continued registration questionable under FQPA/FIFRA., 1 application/crop
malathion	Malathion	OP	contact	**	***	*	REI extended to 24 hr ; 14 d PHI;
methomyl	Lannate	carbamate	contact	***	***	***	Buffer zones required near water; 72 hr REI
bifentrhin	Capture	pyrethroid	contact	**	**	***	7 d PHI
imidacloprid	Admire/Provado	neonicotinoid	systemic	*	*	**	***OP replacement***; 7 d PHI for foliar use
thiamthoxam	Platinum	neonicotinoid	systemic	*	*	**	***OP replacement***; AZ label pending
acetamiprid [b]	Assail	neonicotinoid	systemic/ ingestion	*	*	*	***Reduced risk / OP replacement***; labeled in CA; pending in AZ; 7 d PHI
pymetrozine [c]	Fulfill	pyradine azomethines	systemic/ ingestion	*	*	*	***Reduced risk / OP replacement***; labeled in AZ and CA; 7 d PHI
flonicamid [d]	TBA	cyanomethany trifluoromethyl nicotinamide	systemic/ ingestion	*	*	*	***OP replacement***; currently under EPA review

AZ Crop Profile for Lettuce (Agnew 2000); Pest Management Strategic Plan for California and Arizona Lettuce Production, 2003 (Anonymous 2003)

[a] Source: ETOXNET, http://extoxnet.orst.edu/pips/dimethoa.htm ; ***, Highly toxic; **, moderately toxic; *, minimal toxicity or risk; Human risks includes occupational and dietary risks; Natural enemies include toxicity to aphid natural enemies and transient pollinators.

[b] Source: USEPA / OPP; http://www.epa.gov/opprd001/factsheets/acetamiprid.pdf

[c] Source; Cornel Univ., PMEP; http://pmep.cce.cornell.edu/

[d] Source: IR-4 Project; http://ir4.rutgers.edu/newchemistry.pdf (mode of action is different from other commercially available products)

[e] Source: USEPA / Federal Register: ; http://www.epa.gov/fedrgstr/EPA-PEST/2004/January/Day-28/p1824.htm

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