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Integrated Resistance Management (IRM)

Preventing and managing resistance to insecticides is essential for the productivity of farming operations. Resistance usually develops to the insecticide receiving the most widespread use; commonly an insecticide that provides a grower with the highest efficacy at the lowest cost. When resistance occurs, growers must usually switch to less effective products, more expensive ones, use more applications and/or higher rates, or all of the above. Also, resistant pest populations often migrate from field to field meaning that resistance developed in one field in one part of the county can have negative effects on the pest control practices of farmers throughout the region.

There are several strategies that can be incorporated to help prevent and manage resistance. Ideally, these strategies should be used prior to the onset of resistance to help ensure that it never develops. In the case where resistance exists, lack of adoption of good resistance management strategies will likely result in complete control failure.

Steps in a resistance management plan:

1. Monitoring- Knowing the structure of pest complexes is the first step towards resistance management. Repeated sampling allows a farmer to know if densities of primary pests are increasing or decreasing, the status of secondary pests, and the densities of beneficial organisms. Pesticide recommendations made in the absence of monitoring pests, or without information on beneficials, may be unnecessary and only contribute to resistance and disruption to the whole pest complex.

2. Using thresholds- Insecticide recommendations should only be written when economic thresholds have been exceeded. For pests of over 50 crops, threshold information can be found at the UCIPM web site (www.ipm.ucdavis.edu) by clicking the link for Pest Management Guidelines. Thresholds on the UCIPM site provide a good starting point for making treatment decisions, and should be modified to adapt to individual field situations, including status of biocontrol organisms, lag times between when a recommendation can be written and when the application is actually made, or depending on the mode of action and anticipated efficacy of the pesticide.

3. Use good application techniques- Pesticides need to be applied according to the label. Improper calibration of equipment or equipment problems such as blocked nozzles can encourage resistance by resulting in off-label pesticide rates and decreased effectiveness due to irregular coverage.

4. Protect beneficial organisms- Beneficial insects parasitize or prey upon pests regardless of whether or not they possess resistance genes to an insecticide. Beneficial insects not only help by eating resistant insects, but also help avoid the need for insecticides. It is rare that an insect develops resistance to a biocontrol organism.

5. Utilize cultural controls- Cultural controls such as resistant varieties, modifications of planting and harvesting time, water and fertilizer management, and other tactics help reduce pesticide use and therefore are beneficial in a resistance management program. In fact, many 'secondary pests' would normally be 'primary pests' if biological or cultural controls didn't keep their densities low.

6. Rotating modes of action of pesticides- It is not enough to rotate insecticides, or even rotate active ingredients; managing resistance requires rotating modes of action! Be familiar with the mode of action

of the pesticide options available, and avoid back-to-back applications within any one mode of action category (more info in the IRAC article in the newsletter). Rotating with oils is always beneficial from a resistance management standpoint since insects are unlikely to ever become resistant to oils, and oils kill insects regardless of whether or not they possess resistance genes to another insecticide. Making tank mixes of insecticides is another way to rotate chemistries, but the benefits of two modes of action in one tank can be offset by encouraging resistance to both materials at once. The exception to this rule would be mixing pesticides with oils.

Neonicotinoid insecticides- an overview and need for resistance management

Introduction

Since the first registration of a neonicotinoid insecticide in 1989, pesticide products containing active ingredients in this chemical class have quickly become some of the most widely used insecticides in California. Neonicotinoids (Table 1) can be used as contact materials or systemically against sucking insects (primarily species of aphids, whiteflies, leafhoppers and scales). Currently there are three active ingredients from this chemical class registered in California; imidacloprid, thiamethoxam, and acetamiprid. In 2002 there were over 45,000 applications of these products made statewide to over 1 million acres of farmland.

Use of neonicotinoid insecticides continues to increase statewide due to their effectiveness on target pests, reduced impact on natural enemies, and the increasing numbers of crops and situations in which they can be applied. Use of neonicotinoids can also be expected to increase as more products become registered by multiple crop protection companies that seek to increase their market share of 'neonicotinoid chemistry'. Registration of neonicotinoid products is currently being expedited as a result of the Food Quality and Protection Act of 1996 that allows the fast-tracking of registrations for 'reduced-risk' materials as older pesticide chemistries are phased out.

Neonicotinoid use also continues to play an increasing role locally in the San Joaquin Valley. For example, the entire areawide program for glassy-winged sharpshooters relies nearly 100% on Admire and Assail, both neonocotinoids. Last fall alone approximately 35,000 acres of citrus in the southern half of Tulare County were sprayed with Assail, while approximately half of that acreage was again slated for treatment this spring (this time with Admire). Admire use in the San Joaquin Valley is also expected to increase in crops such as grapes due to continued increases in acreage infested by vine mealybug, which is still in the expansion phase of its spread statewide.

Neonicotinoid resistance management

Neonicotinoids affect the nervous systems of insects, and are classified as nicotinic choline receptor agonists. According to the producers of these chemicals and the international Insecticide Resistance Action Committee (see associated newsletter article), all neonicotinoid insecticides have this same mode of action. This is of great concern from a resistance management standpoint due to the ability of insects to develop cross-resistance.

Chemical companies consider it highly likely that an insect that develops resistance to any product in Table 1 will also be resistant to any other product in the entire table. This means that they will not only be

Table 1. Trade names of insecticides containing neonicotinoids that are registered in at least one tree, field or vegetable crop in California[1].

	Imidacloprid	thiamethoxam	acetamiprid
Seed treatment	Gaucho®	Cruiser®	
Soil	Admire®	Platinum™	
Foliar	Provado®	Actara®	Assail™
Foliar	Leverage™	Centric®	

[1]Other imidacloprid labels include: Merit® (ornamentals), Imicide™ (ornamental trees), Pointer™ (ornamental trees), Marathon® (greenhouses), Advantage® (fleas on pets), Advantix™ (fleas on pets), Grubex® (grubs in lawns), various products (fly baits), and various products (cockroach baits).

Other acetamiprid labels include: Tristar™ (ornamentals) resistant to other products with the same active ingredient, but will be resistant to all products of all other active ingredients. This should be of enormous concern to growers and chemical companies who have come to rely on the use of these products.

One example of why resistance management needs to be taken very seriously is the current situation with cotton. There are currently seven neonicotinoid insecticides registered for thrips, lygus, aphid and whitefly control (Table 2). Two of these products, Centric and Assail are being used routinely to ensure the quality of the San Joaquin Valley's cotton line by preventing sticky cotton. The repeated use of neonicotinoids in cotton should concern growers since aphid and whitefly have historically been some of the first insects to develop resistance. Legally, growers could use a neonicotinoid insecticide early in the season as a seed treatment, mid-season as a foliar for lygus, and then late-season multiple times for aphid and whitefly without violating any label restrictions. It is essential that growers recognize that all seven of these insecticides have the same mode of action, and that they consider resistance management when putting together annual IPM plans.

Consider the scenario should our use patterns result in resistance. For example, imagine what would happen to silverleaf whitefly management in crops like cotton, melons, lettuce, peppers and tomatoes in the absence of neonicotinoids. Growers would in many cases rely on older classes of broad spectrum pesticide chemistries known to have resistance issues and be disruptive to many biocontrol organisms.

Resistance to neonicotinoids could also have serious implications to the efforts against glassy-winged sharpshooter. Neonicotinoids are very effective against this pest and make up nearly 100% of the insecticides used against it statewide. Should resistance develop, even the accomplishments of the highly successful areawide management programs could be rendered useless, and diseases spread by this vector, such as Pierce's disease, could spread like wildfire throughout grape-growing regions of the state.

These are just two of many very possible threats to our current IPM strategies if resistance to neonicotinoids develops. Growers are encouraged to use valuable pest control products wisely, and in rotation with other chemistries outside of this chemical class. It is the responsibility of all growers and pest control advisors to make sure that their recommendations to individual fields do not result in resistance that could end up affecting us all.

Table 2. Neonicotinoid insecticides registered in California for cotton.

Product	Active ingredient	How used	Primary targets
Gaucho	imidacloprid	Seed treatment	Thrips and Aphid
Cruiser	thiamethoxam	Seed treatment	Thrips and Aphid
Admire	imidacloprid	Soil applied	Thrips, Aphid, Whitefly
Leverage*	imidacloprid	Foliar	Lygus
Assail	acetamiprid	Foliar	Aphid and Whitefly
Centric	thiamethoxam	Foliar	Aphid and Whitefly
Provado	imidacloprid	Foliar	Aphid and Whitefly

* Leverage also contains the pyrethroid cyfluthrin

The Insecticide Resistance Action Committee (IRAC)

The Insecticide Resistance Action Committee (IRAC) was formed in 1984 to help decrease incidence of resistance to commercial insecticides and acaricides. The Committee is primarily made up of representatives of a wide range of chemical companies, all of which want to maintain the effectiveness of their products. In an attempt to encourage good resistance management strategies, this group develops educational materials that help growers, PCAs, extension personnel, and other crop protection professionals become educated about insecticide mode of actions and resistance management strategies. The Committee also facilitates transfer of information among chemical companies as they develop resistance management regulations to be included on product labels.

One of the most valuable resources from IRAC is a table that classifies insecticide active ingredients by mode of action. This table is reviewed and updated annually and can be found at the following web site http://www.irac-online.org/resources/moa.asp. For example, in reference to the neonicotinoid article at the beginning of this newsletter, anybody who accesses this table can determine that acetamiprid, imidacloprid, and thiamethoxam are all in the IRAC category 4A, meaning that they all have the same mode of action, and resistance to any one of them will likely result in resistance to them all. Similar tables have been established and can be accessed for herbicides (http://www.plantprotection.org/hrac/) and fungicides (http://www.frac.info/publications.html).

Pest management professionals are encouraged to consult this on-line resource when learning about new or established insecticides. Educated decisions about resistance management can only be made by somebody with knowledge about how different insecticides work.

David Haviland—Entomology Farm Advisor- Kern Co.

University of California Cooperative Extension
Kern County Farm and Home Advisors
1031 S. Mt. Vernon Avenue
Bakersfield, CA 93307