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COTTON INSECT PESTS IN 2004

Peter B. Goodell, *IPM Advisor*
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Cotton insects are influenced by rainfall and temperature. Rainfall and its pattern of distribution across the San Joaquin Valley as well as the timing of occurrence determine plant composition and duration of plants in the landscape. Temperature regulates the rate at which insects develop and reproduce as well as the duration of plant hosts. The more heat, the faster generations turn over, but also the faster host plants utilize available moisture. Insect population densities that threaten cotton depend on the optimal balance between these two factors. Enough rainfall must fall to allow good development and distribution of weedy hosts and enough heat must be available to allow insects to turn over generations in the shortest possible time.

Since the San Joaquin Valley is located in a Mediterranean climate, the probability of rainfall is almost nonexistent after May. Thus, any insects found on weed hosts outside cultivated areas will be required to move into crops or face starvation. This movement is determined by the factors mentioned before, rainfall and temperature. In years when hosts are available and temperatures are adequate, multiple generations can develop and higher densities of pests can move into cultivated areas later in the season. In years when rainfall is limiting, plant hosts may dry up and force movement within the first generation and before cotton is susceptible to damage.

Predicting pest pressure caused by a complex of insect pests is a fool's errand. However, experience gained over several decades and collaboration with many seasoned pest control advisors and growers allow us to interpret and extrapolate a rational estimate of insect pressure.

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MINIMIZING SEED RETURN AS A WEED MANAGEMENT STRATEGY

Anil Shrestha, *IPM Weed Ecologist*
Kearney Agricultural Center

The old adage goes "*One year's seeding—seven years' weeding.*" Although one may not think of herbicide-resistant weeds while quoting this old adage, the importance of this message has increased with the advent of herbicide resistance in weeds. It is very likely that herbicide-resistant weeds will produce seeds that will germinate and produce plants that are also herbicide-resistant. As we keep eliminating "susceptible" plants, the population of the "resistant" plants will increase. This may change the volume and diversity of the seed bank and call for a change in our current weed management strategies. For growers who do not rely on chemical weed control, herbicide-resistant weeds may not be an issue. However, it is equally important for them to understand "weed seed banks" because they are the main source of weeds in agricultural fields. Most weeds start their life cycle from a single seed in the soil. If these weeds escape control, they grow and produce thousands more seeds. These seeds are returned to the soil seed bank and become the source of future weed populations. An example of number of seeds that can be potentially produced by a single mature weed plant is shown in Table 1.

Table 1. Seed production capability of some weed species.

Weed Species	# of seed produced per plant
Barnyardgrass	300,000
Redroot pigweed	117,400
Common lambsquarters	72,450
Common Purslane	52,300
Shepherds Purse	38,500
Prickly lettuce	27,900
Smartweed	19,300
Yellow Foxtail	6,420
Wild Oat	250

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Support for this publication is provided by California Cotton Growers through their Cotton Incorporated State Support Program.

Cotton Insect Pests in 2004 :

(continued from page 1)

General Conditions

Planting and emergence conditions were excellent at the beginning of the cotton season in 2004. Most fields had an early advantage in the following ways:

- Vigorous growth, healthy stands and early development (according to the calendar) increase the plant's ability to withstand pest pressure
- Grower confidence is improved as fewer problems are encountered
- Such "strong growing seasons" place the focus on production management rather than pest management, including irrigation, nutrition and cutout
- Much of the cotton was planted in a shorter time frame, creating the opportunity for more continuous regional management and preventing the situation in which great differences in cotton development are found in fields scattered across the landscape.

Lygus

Lygus is not expected to be a widespread problem in 2004. The lack of rainfall after March and the higher than normal temperatures have removed plant hosts from the Valley and its associated foothills. Any non-irrigated areas have been completely dry, in many cases, since sometime in April. The exception in some areas was the presence of small-pod mustard (*Hirshfeldia incana)* which is found along many Valley roadsides. This yellow mustard is an excellent host for *Lygus* but fortunately is abundant only where rainfall accumulated along roadsides. Its limited distribution will not make it a major source of *Lygus*, but could be a local source in some fields. As of the week of May 3, both adults and nymphs were present, with the the nymphal population probably being the second generation and varying second to fourth instars. Several uncultivated fields monitored at the time had London Rocket and other *Lygus* hosts which were allowed to build through the winter and continued to support significant *Lygus* populations during May.

Since cotton development in most fields was generally further along than typical in April and May this year, the plants should have time to compensate for losses that might occur early on in the season. Early fruit loss has been demonstrated to enhance yield potential in years of heavy, early boll set by allowing plants to grow more vegetative and take advantage of the full season.

Lygus pressure in cotton will be expected to develop later in the season in localized situations as the populations move from neighboring crops being readied for harvest. This movement will be more concentrated to cotton in areas with little or no alfalfa to attract the migrating *Lygus.*

Beet Armyworm

The relationship between weed hosts and Beet armyworm (BAW) is not well understood. In years with higher rainfall and more weeds in May and June, multiple flights seem to affect cotton, even later in the season. With the general lack of any weeds (except in irrigated fields), we might presume that BAW pressure might be lower this year than last.

Aphids

Predicting aphid population pressure in cotton is truly a fool's errand. As yet we do not understand (or even know) if winter weather patterns have any influence on the development and distribution of populations of cotton aphids.

Silverleaf whitefly

Temperature is the key driving force for developing whitefly problems. The hotter the growing season, the shorter the time required for population turnover (completion of life cycle). Using January 1 as a starting point, 2004 as of May 10 was 12 days ahead of the long term temperature average at Shafter (Kern County) for developing whitefly generations. This is based on accumulated degrees using a 50 degree F base, 90 degree F upper developmental threshold and 582 dd per generation. Although more moderate temperatures prevailed later in May, any return to higher than normal temperatures could be expected to bring significant silverleaf whitefly populations earlier than last year, with potential for more broadly distributed whitefly in the San Joaquin Valley, especially late-season.

General Considerations

Monitor the crop and pest situation closely. Early season problems could be easier to manage this year, with fewer *Lygus* and beet armyworm problems expected than in typical years. Aphid is an unknown player at this point, but care should be taken to treat mid-season only when the population exceeds the threshold for treatments. Whitefly should be watched closely, with Insect Growth Regulators (IGR's) considered as the first line of defense in mid-season.

Manage the use of insecticides carefully to avoid unnecessary pressure on a single mode of action such as pyrethroids or neonicotinoids. Plan your strategy in advance and rotate between different modes of action. To help improve timely management decisions and reduce late-season pest problems, follow crop development closely and terminate the crop when the plants are ready, not according to a calendar.

THE RELATIONSHIP BETWEEN LYGUS COUNTS AND SQUARE RETENTION: A NEW LOOK AT AN OLD PEST

Andy Zink and Jay A. Rosenheim
UC Davis Entomology Dept,

We have been conducting research in an attempt to refine our understanding of the relationship between *Lygus* counts and square retention in cotton fields. In particular, we have been focusing on what we are calling the "*Lygus* enigma", which is simply the recognition that growers sometimes see levels of square shed that are much higher than expected given the numbers of *Lygus* collected in sweep nets. The difficulty of predicting damage from *Lygus* counts is a major problem in developing a sound approach to managing *Lygus* populations. Given that insecticides applied to control *Lygus* can disrupt natural control of aphids, mites, and worms, it is clearly important to treat for *Lygus* only when the cotton crop really needs to be protected.

Our work addresses three potential explanations for the unpredictability of *Lygus* impact on square shed:

- Sampling problems: is our standard sweep net sampling technique providing us with a good estimate of *Lygus* population density?

- Variable *Lygus* feeding behavior: are *Lygus* bugs fundamentally variable in the extent to which they feed on cotton squares?

- Variable cotton plant responses to *Lygus* feeding damage: are cotton plants sometimes more sensitive to *Lygus* damage, shedding more squares than usual in response to a given level of *Lygus* damage?

In this article we address evidence for each of these three explanations, showing that all three are probably contributing to the difficulties in predicting square shed from *Lygus* sweep net counts.

Sampling Problems. We have been using large field cages as a sampling device to quantify the absolute numbers of *Lygus* nymphs and adults in cotton fields. Comparing these cage samples with sweep net samples from the same fields revealed that, in general, nymphs are much more difficult to collect in sweep nets relative to adults. However this is only true for the smallest immature stages (the 1st through 3rd instars, which are presumably less damaging). The much larger 4th and 5th instar nymphs were captured at a rate that was comparable to adults. Importantly, we also found that sweep nets are a reliable predictor of *Lygus* densities across all developmental stages. Therefore we recommend continued use of sweep nets as a sampling device.

It should be noted that, while 4th and 5th instar nymphs are equally likely to be captured in sweep nets, relative to adults, they are much more difficult to locate and find within the net itself. Whereas adult *Lygus* can be counted by simply waiting for them to crawl up and out of the net, field scouts need to take the additional time to sift through the net contents if they are to obtain a good count for nymphs.

Can we take a short-cut, and simply assume that numbers of adult *Lygus* in fields are good indicators of the number of nymphs also likely to be present? Our data suggest that the answer is 'no'. We have found that the densities of *Lygus* adults are often not a good predictor of nymph densities in the same field: some fields are dominated by adults, and other fields are dominated by nymphs. An example will show the potential pitfall associated with ignoring the densities of nymphal *Lygus*. Below we plot the density of *Lygus* nymphs and adults for four fields sampled in the San Joaquin Valley in 2002.

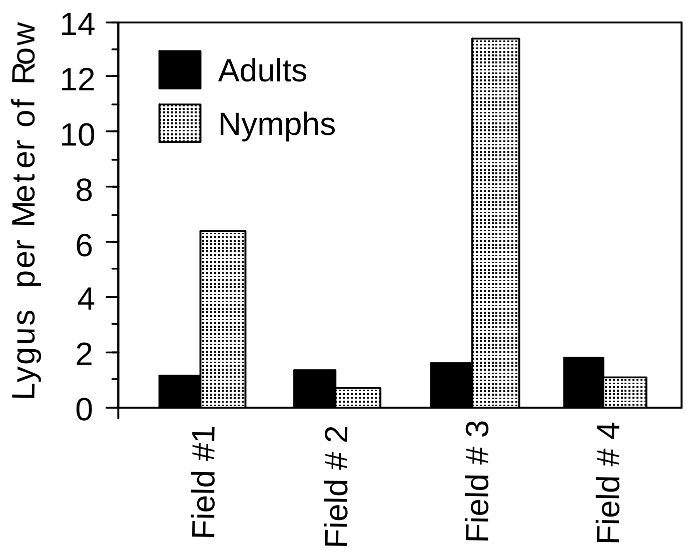

Figure 1: The absolute number of *Lygus* nymphs and adults per meter of row, taken from whole cage and plant sampling.

In these four fields, the density of adult *Lygus* is quite similar (between 1 and 2 *Lygus* adults per meter of cotton row, or equivalent to a 3-5 count for adults in a *Lygus* sweep sample). Some growers might decide to spray for a 3-5 count, others might choose not to. But these 4 fields actually face radically different potentials for *Lygus* feeding damage: Fields 2 and 4 have very few nymphs, and might not sustain significant damage. Fields 1 and 3, on the other hand, harbor very large populations of nymphs, and are likely to sustain very heavy damage and potentially a devastating crop loss. These results underscore the importance of sampling not only for adults, but also for nymphs. We recommend that field scouts pay particular attention to 4th and 5th instar nymphs in their sweep nets, because our data suggest that these insects may be as important (or more important) than adults for predicting crop damage.

Our work also suggests, however, that problems with sampling are not the entire story. In 2003 we sampled over twenty commercial cotton fields that were classified by PCA's as having 1) a greater than expected square shed or 2) an expected level of square shed, given the *Lygus* densities that were measured in that field. We then sampled these same fields extensively and found that our measures of *Lygus* density, square damage, and square shed matched those of the PCA's. Even with careful attention to measuring the densities of both nymphal and adult *Lygus*, some fields still appeared to sustain much more square shed than would have been expected from observed *Lygus* densities. This suggests that some other factors such as variable *Lygus* behavior (hypothesis two) or variable plant response (hypothesis three) are also important.

Variable *LYGUS* Feeding Behavior. At the outset of our work, we explored the possibility that the '*Lygus* enigma' might be due to variable *Lygus* feeding behavior. Were *Lygus* in some cotton fields more interested in feeding on squares than *Lygus* in other fields?

We first explored the hypothesis that *Lygus* might be switching between feeding as an herbivore (on the cotton plant) and feeding as a predator (on soft-bodied insects also found on cotton). It has long been known that *Lygus* is an omnivore, capable of feeding as a predator, and our own observations in cotton had confirmed this years ago. However, we did not know whether *Lygus* fed as predators often enough to really make a difference. That is, did *Lygus* ever really switch from a primarily herbivorous feeding mode to a primarily predatory feeding mode? We conducted observations of over 80 *Lygus* bugs (total time about 55 hours) to quantify their predatory behavior. The answer was very clear: at least under the conditions found in California cotton, *Lygus* act as predators only very, very rarely. We can therefore consider *Lygus* to act as simple herbivores. Omnivory does not seem to be contributing to the *Lygus* enigma.

We have also documented other sources of variation in *Lygus* behavior. For example, we have demonstrated that adult male *Lygus* spend less time feeding on squares than do adult females. Some cotton fields have *Lygus* adult populations more heavily dominated by females than other cotton fields. Nevertheless, the variation in *Lygus* sex ratio does not appear to be large enough to generate a large amount of variation in crop damage.

Because the numbers of *Lygus* nymphs vary widely among fields, we wanted to know if *Lygus* nymphs generate significant damage to cotton plants. To address the relative impact of *Lygus* nymphs versus adults, we have sampled almost forty fields spread across three years. In each field we used sweep net samples to collect *Lygus* adults and nymphs, which we identified to developmental stage (1st through 5th instar). In addition, we dissected the first position squares of several plants to quantify damage to anther sacs and mapped plants to quantify retention at the first position of top five nodes.

Analysis of these data suggested that densities of adult *Lygus* are positively correlated with both square damage and square shed. Interestingly, 4th and 5th instar nymphs showed an even stronger pattern, suggesting that they may be more important than adults for generating damage to cotton plants. In contrast, however, the density of 1st through 3rd instar nymphs showed no relationship to square damage or square shed. However it may be important to monitor these small nymphs, not for current damage to plants, but for an indication of future damage after they have molted into later instars (or adults).

We have discovered in other work that even when viewed across entire cotton growing seasons, some fields have *Lygus* populations dominated by nymphs, whereas other cotton fields harbor mostly adults and few nymphs. This was an unexpected result. It suggests that there are separate ecological factors controlling the density of nymphal and adult *Lygus*, instead of the more typical pattern, where nymphs and adults make up relatively consistent portions of the overall bug population.

One possible explanation for the variable contribution of nymphs to the overall *Lygus* population is that predators or parasites may be limiting the survival of *Lygus* nymphs in some fields but not in others. We measured the densities of predators in our study sites and found a negative relationship between the season-long density of big-eyed bugs (*Geocoris*) in a field and the season-long density of *Lygus* nymphs. There was no such relationship between *Geocoris* and *Lygus* adults. This suggests that healthy populations of *Geocoris* (monitored with sweep nets) may be an effective way to predict lower densities of nymphs and lower levels of damage. *Geocoris* can capture and kill nymphal *Lygus* (and may also eat some eggs), but are not powerful enough to capture *Lygus* adults, so fields with lots of *Geocoris* may have many adult *Lygus* but few nymphs.

This summer we are conducting more controlled experiments that will address the impact of different *Lygus* developmental stages on square damage and shed. In addition, we have begun collaborations with other colleagues that see similar trends in the effect of nymphs on damage. For example, Peter Ellsworth has been finding that *Lygus* nymphs (particularly late-instar nymphs) have a much larger impact than adults on cotton yields.

Cotton Plants Vary in Their Response to *Lygus* Damage. Interestingly, the results from our work in commercial cotton fields in 2003 revealed that fields with higher than expected square shed (i.e. enigmatic fields) were not a result of higher than expected feeding damage to squares (quantified as the number of developing anther sacs that were killed by *Lygus* feeding). Indeed, we found an overall positive, and straightforward, relationship between *Lygus* densities and feeding damage to squares. What we saw instead was that different fields experiencing the SAME level of *Lygus* feeding damage responded differently in square shed: some fields (the less sensitive ones) retained >90% of the early squares, whereas other fields retained <70% of their squares.

To understand this unexpected result, it is important to realize that *Lygus* do not really "kill" the square outright. Instead, the *Lygus* produce some feeding damage (often a relatively small amount of damage), and this triggers a response by the plant to shut off the flow of nutrients to that square. So, it could be said that the cotton plant "decides" to either retain a square or to shed a square. What we need to understand now is: why do plants in different fields seem to be making different choices?

Preliminary experimental work suggests that the "sensitivity" of a square to a given amount of *Lygus* damage is due to square size and location on the plant, as well as its overall "neighborhood: (i.e. host plant physiology and damage to other squares throughout the plant). In ongoing work, we are also exploring the role of soil macronutrients and salinity. This work will be conducted in both a field and greenhouse setting, involving collaborations with plant physiologists, to identify other plant-based factors affecting the propensity of cotton plants to shed squares that are damaged by *Lygus.*

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INSECTICIDE RESISTANCE MANAGEMENT AND QUALITY COTTON

Peter B. Goodell, *IPM Advisor, UC Statewide IPM Project*

The cotton industry in California is dedicated to producing high quality cotton, not only in fiber characteristics but also in cleanliness. For cotton produced in the San Joaquin Valley, preventing sticky cotton is job # 1. Maintaining an effective tool box of control products against aphids and whitefly must also be a priority if growers and Pest Control Advisors are to meet quality goals. The chart on the other side of this page (page 6 of this newsletter) summarizes cotton insecticides and their modes of action (MoA) as defined by the Insecticide Resistance Action Committee (IRAC). IRAC is a collection of crop protection representatives, University researchers and regulators whose goal is to educate about insecticide resistance management (IRM) and assist in the implementation of insecticide resistance management practices. This chart can be printed out as a PDF file by accessing the file via the UC Cotton web site at: **http://cottoninfo.ucdavis.edu**. More information from IRAC is available at **http://www.irac-online.org/index.asp**

This leaflet is designed to assist in making good IRM decisions. The suggestions presented are practices based on best approaches suggested by IRAC and others working to maintain the efficacy of insecticides. These are not definitive guidelines but rather general suggestions in designing an IRM program.

Using the MoA Index. The Mode of Action (MoA) classification can form the basis for an effective and sustainable IRM program. Insecticides are assigned to specific groups based on their target site. For example, organophosphates and carbamates are assigned to group 1, whose primary target sites of action are acetylcholine esterase inhibitors. However, the mechanism that Organophosphates (OP's) attack this target site is different from carbamates. Thus, OP's are assigned a 1B classification while carbamates are assigned 1A. Pyrethroids affect the sodium channel modulators and are classified as group 3. **Any tow insecticides classified by the same MoA index have the same mode of action, whereas unique numbers indicate that these products could be rotated as part of an Insecticide Resistance Management (IRM) plan.** For example, if Centric™ (Group 4A) were used against aphids and another application was needed several weeks later, utilizing Lorsban™ (Group 1B) would be a better IRM choice than Provado, which is in the same group (4A) as Centric.

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Insecticide Resist. Mgmt. *(continued from page 5)*

General Insect Resistance Mgmt. (IRM) Guidelines: MoA rotation is an important component of an IRM approach. However, an overall IRM and IPM approach should consider:

- Regular scouting, twice weekly or at least weekly;
- Treat only when necessary based on action thresholds (if available), consider natural enemies, other pests;
- Include effective biological and cultural controls to suppress pest populations;
- Rotate between different modes of actions, understand which products use which mode of action;
- Do not use products from the same MoA index more than twice per season;
- Consider best placement of a product based on pest (or pests), time of year, pest pressure and potential secondary consequences;
- Use products at recommended rates. Reduced doses quickly select populations with average tolerance levels;
- Keep application equipment in a well-maintained operating condition

Insecticides Associated with Cotton Production

Chemical Name	Trade Name	Class	IRAC MoA	Signal Word	Comments
aldicarb	Temik	Carbamate	1A	Poison / danger	
carbaryl	Sevin	Carbamate	1A	Caution	
carbofuran	Furadan	Carbamate	1A	Poison / danger	At planting
methomyl	Lannate	Carbamate	1A	Poison / danger	
oxamyl	Vydate	Carbamate	1A	Poison / danger	
thiodicarb	Larvin	Carbamate	1A	Warning	
chlorpyrifos	Lorsban	Organophosphate	1B	Warning	
dimethoate	Dimethoate	Organophosphate	1B	Warning	
malathion	Malathion	Organophosphate	1B	Caution	
methamidophos	Monitor	Organophosphate	1B	Poison / danger	
methidathion	Supracide	Organophosphate	1B	Warning	
naled	Dibrom	Organophosphate	1B	Danger	
oxydemeton	Metasystox - R	Organophosphate	1B	Warning	
phorate	Thimet	Organophosphate	1B	Poison / danger	
profenofos	Curacron	Organophosphate	1B	Warning	
endosulfan	Thionex, Phaser	Organochlorine	2A	Poison / danger	
bifenthrin	Capture	Pyrethroid	3A	Warning	
cyfluthrin	Baythroid	Pyrethroid	3A	Danger	
cypermethrin	Ammo	Pyrethroid	3A	Caution	
cypermethrin zeta	Mustang	Pyrethroid	3A	Warning	
esfenvalerate	Asana	Pyrethroid	3A	Warning	
permethrin	Pounce	Pyrethroid	3A	Caution	
pyrethrins	Pyrethrin	Pyrethroid	3A	Caution	
imidacloprid	Provado, Gaucho, Admire	Chloronicotinyl	4A	Caution	
thiamethoxam	Centric, Cruiser	Chloronicotinyl	4A	Caution	
acetamiprid	Assail	Chloronicotinyl	4A	Caution	
spinosad	Success		5A	Caution	
avermectin	Zephyr		6A	Warning	Mites
pyriproxyfen	Knack		7C	Caution	
pymetrozine	Fulfill		9B	Caution	
hexythiazox	Onager		10A	Caution	Mites
bacillus thuringiensis israelensis	Dipel		11B	Caution	
bacillus thuringiensis aizawai	Xentari		11C	Caution	
bacillus thuringiensis kurstaki	Javelin		11C	Caution	
propargite	Comite		14A	Danger	Mites
tebufenoxide	Confirm		16A	Caution	
buprofezin	Courier		17A	Caution	
methoxyfenozide	Intrepid		18	Caution	
dicofol	Kelthane		20	Caution	Mites
indoxocarb	Steward		22A	Caution	
cyfluthrin(12%), imidacloprid(17%)	Leverage	mixture	3A, 4A	Warning	

** updates will be posted on the UC cotton website* **http://cottoninfo.ucdavis.edu** *as they become available*

MoA = mode of action classification assigned by IRAC. View complete Mode of Action list at Insecticide Resistance Action Committee (IRAC) website: http://www.irac-online.org

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NEONICOTINOID RESISTANCE MANAGEMENT IN COTTON

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Seven Insecticides ... Three Active Ingredients … One Mode of Action: Neonicotinoid Resistance Management Considerations. Preventing and managing resistance to insecticides is essential for the productivity of farming operations. When resistance develops, growers often are forced to spray more often, resulting in increased applications and expenses.

In the San Joaquin Valley, neonicotinoids have become very important for controlling aphid and whitefly populations to prevent sticky cotton. Currently there are seven neonicotinoid insecticides registered in cotton, including two seed treatments, one soil applied product, and four foliar products (Table 1). All of these products target sucking insects, all use one of three active ingredients (acetamiprid, imidacloprid, or thiamethoxam), and all function with the same basic mode of action.

Table 1. Neonicotinoid insecticides registered for cotton in California as of early 2004.

Product	Active Ingredient	How used?	Primary Targets
Gaucho	imidacloprid	Seed treatment	Thrips and aphids
Cruiser	thiamethoxam	Seed treatment	Thrips and aphids
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

Preventing and managing resistance to neonicotinoids is in the best interest of growers, chemical companies, and all allied industry personnel. Managing this resistance means considering the use of all neonicotinoid products. Chemical companies agree that resistance to one of these products would result in insects that have resistance to other neonicotinoid insecticides. The most current data (Table 2) from Kern County illustrates the use of various neonicotinoid insecticides on cotton, but reminds us that other crops also use this class of insecticides. For example, Kern County vegetable crops such as bell peppers, melons, potatoes, and tomatoes are sprayed with neonicotinoid materials (Table 3). Grapes and citrus are also routinely treated for control of the glassy-winged sharpshooter and vine mealybug. Populations of cotton aphid could be exposed to imidacloprid in citrus, then move to melons where they might be exposed to imidacloprid again, and then move to cotton where they might again be sprayed with acetamiprid (Assail) or thiamethoxam (Centric).

Table 2. Use of neonicotinoids in Kern County [1].

- 106,871 acres in Kern County were treated with neonicotinoids in 2002
- Cotton made up 39,666 acres out of the total, including:
    - 97.6% of total thiamethoxam (23,252 acres)
    - 84.0% of total acetamiprid (14,645 acres)
    - 2.7% of total imidacloprid (1,759 acres)
- Grapes and citrus made up 90% of the acres treated with imidacloprid

Silverleaf whitefly could be similarly exposed throughout the year while moving among crops such as peppers, tomatoes, melons, and cotton. So, not only do growers need to develop management plans that help avoid the development of resistance in late-season cotton aphid, but they must also realize that cotton is not the only available aphid and whitefly host. Pests may have been previously exposed to these products earlier during the growing season, thus making resistance management in cotton even more important.

Table 3. Percent acreage of selected Kern County crops sprayed with neonicotinoids in 2002 [1].

Field Crops	Percent of total acreage by crop sprayed (%)
cotton	90.9
Vegetable Crops	
bell peppers	39.0
watermelon, cantaloupe	21.6
potatoes	21.3
tomatoes	9.7
Perennial Crops	
grapes	58.2
citrus	21.6

Preventing or limiting the development of resistance is the responsibility of all growers. Please consult the following recommendiations while developing a personalized resistance management plan for your cotton fields during this season.

Steps to Resistance Management in Cotton

1. Monitoring. Know densities of aphid, whitefly and natural enemies. Keep track of life stages present in field and if populations are increasing or decreasing;
2. Thresholds. Use insecticides only when pest populations reach treatment thresholds. These thresholds can be found at the UC IPM web site at: www.ipm.ucdavis.edu by clicking on the link for "Pest Management Guidelines", and then "cotton"
3. Use Good Application Techniques. Strive for consistent, even coverage of a product through well-calibrated and maintained equipment. This will improve product efficacy and consistency of performance.
4. Protect Beneficials. Encourage biocontrol by avoiding broad spectrum pesticides. Beneficial organisms feed on insects regardless of whether they are resistant or not, and can help remove resistant genes from populations of insects that survive pesticide applications.
5. Utilize cultural controls. Controls that do not promote resistance can help reduce it. Avoid excessive fertilization that can increase crop growth and induce aphids. Terminate the crop as soon as possible for the given fruit load to reduce the risk of late-season stickiness problems that will require additional sprays.
6. Rotate Pesticide Chemistries. Limit applications of neonicotinoids to two or less per season. Where more than one application is necessary for silverleaf whitefly control, separate them by products such as Knack or Courier that have different modes of action.

[1] **Sources** - data for tables. *All data in the article were obtained from the 2002 Kern County Crop Report from the Kern County Agricultural Commissioner's office and from Kern County data in the 2002 California Pesticide Use Report from the California Department of Pesticide Regulation.*

Minimizing Seed Return as a Weed Management Strategy *(continued from page 1) :*

The Soil Weed Seed Bank

Soil weed seed banks are reserves of viable seeds present on the soil surface and in the soil. The seed bank consists of enormous numbers of new seeds recently shed by plants and older seeds that have persisted in the soil, sometimes for many years. Many of these seeds die within a few years or are removed from the seed bank by other processes. However, some seeds can remain viable for decades and produce new plants and additional new seeds. Examples of the longevity of seeds of some common weed species is shown in data presented in Table 2.

Table 2. Seed longevity (period the seeds can survive under typical soil and climate conditions) of some common weed species.

Weed Species	Seed Longevity (years)
Downy brome	2
Pigweed	2.5
Black mustard	50
Vetch	50
Curly dock	80
Stinging nettle	665 (estimate)

It has been estimated that only 1 to 9 percent of viable seeds produced in a given year develop into seedlings; the rest remain viable and will germinate in subsequent years depending on conditions and the depth of the burial of the seeds. The majority (about 90 to 95 percent) of the seeds entering the seed bank are from annual weeds. Similarly, 70 to 90 percent of seeds will be of a few dominant species adapted to current cropping system.

What Happens to the Seeds in the Seed Bank?

Several things can happen to these weed seeds in the seed bank (Figure 1). They may:

- Be preyed upon by insects or vertebrates
- Die due to various physiological reasons
- Be attacked by pathogens
- Get buried too deep in the soil, preventing emergence
- Become dormant due to physiological reasons
- Be physically damaged by agricultural implements
- Germinate, emerge, grow and produce more seeds

Limiting the Weed Seed Bank

Preventing weeds from setting seeds may not benefit the current crop, but it will pay off in the long term. Any seed that is produced will only add to the seed bank and contribute to future weed populations. Several approaches can work to reduce the seed bank:

- Minimize weed escapes in the field. Post-harvest management helps prevent seed set by weeds that continue to grow after crop harvest.

- Bury seeds deep into the soil profile to prevent them from germinating. Conversely, if seeds in the shallow zone are stimulated to germinate, for example by pre-irrigation, the emerged seedlings can be controlled and prevented from producing seeds.
- Prevent weed seeds from entering the fields by keeping canal banks and irrigation systems weed free, install screens on inlets.
- Clean equipment properly after use in a weedy field.
- Apply caution when applying manure as it can contain viable weed seeds.
- Rotate crops and herbicides because this can help in changing the composition of the seed bank from undesirable to desirable species.
- Manipulate cropping systems (e.g., row spacing, plant population, time of planting etc) to make the environment unfavorable for the weed to complete its life cycle.
- Encourage processes that cause loss of seeds from the seed bank (Figure 1).
- Identify species of weed seeds that require disturbance (tillage) and those that do not and make management decisions to limit seed return.
- Manage weeds along field edges and headlands because seeds produced by these plants can be dragged on to the field by machinery or irrigation water.
- Avoid livestock movement from weed infested areas to crop lands.

Studies from Nebraska suggest that preventing weed seed production can cause a reduction of weed seeds from the soil at a rate of 25% per year in cultivated soils and 12% per year in undisturbed soil. In summary, weeds should be prevented from producing seeds. Doing so will limit future weed populations and addition of 'herbicide resistant' weed seeds to the seed bank. "An ounce of prevention is worth a pound of cure."

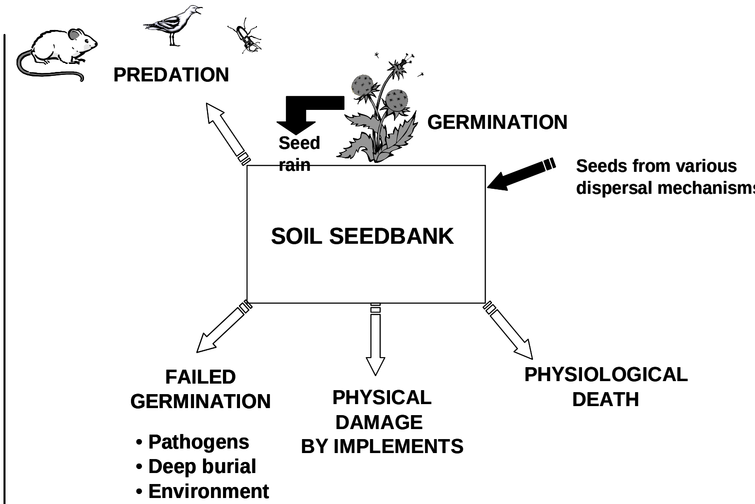

Figure 1. The seed bank cycle (inputs to the seed bank are shown with black arrows, losses in white arrows).

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Wilson, R. G. and J. Furrer. 1996. Where do weeds come from? Univ. Nebraska-Lincoln Coop. Extension (http://www.ianr.unl.edu/pubs/weeds/g807.htm)

ANNOUNCEMENTS and INFORMATION

- **JUNE 24** — **Cotton Production Meeting (Madera & Merced Counties): 12- 3 PM with lunch** San Juan Ranch Park **/** North on Elgin Ave, just west of Dos Palos Coop Gin, follow signs to the park *(for info: contact Ron Vargas, UCCE: ph:* ***(559) 675-7879*** *)*
- **AUG. 5** — **Annual Precision Agriculture Field Day (Kings and Tulare Counties)** Sheely Farms (*for info: contact Kings Co. UCCE at* ***(559) 582-3211, Ext. 2730*** *or Tulare Co. UCCE at* ***(559) 685-3309***

INFORMATION AVAILABLE ON OUR UCCE COTTON WEB SITE (http://cottoninfo.ucdavis.edu)

◊ **FUSARIUM UPDATES (field scouting, identification and containment recommendations):** check March, 2004 update for containment information, July or Sept., 2003 for scouting info and pictures

◊ **TO RECEIVE AN E-MAIL UPDATE (to let you know when new updates or newsletters are available on the web) -** go on the web site and click on "would you like to receive updates via email?"