CHLORPYRIFOS USE IN ALFALFA – DEFINING AND REFINING CRITICAL USES

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ABSTRACT

State and federal agencies are currently evaluating public health and environmental concerns with chlorpyrifos (Lorsban, Lock-On and other generic formations) that could result in significant use restrictions of this insecticide in alfalfa and other crops. To productively engage stakeholders in discussions with regulators, the California alfalfa industry participated in a facilitated process to identify 10 insect pests for which chlorpyrifos was important and which required growers' continued access to it. Of these pests, chlorpyrifos is imperative for aphid control and will remain vital until such time as new, effective controls are registered for use in alfalfa production. Weevil control without chlorpyrifos would rely heavily on a limited number of pesticide options, increasing the potential for insecticide resistance and exposing growers to extensive crop losses. The importance of this active ingredient for management of aphid and weevil control, however, does not diminish its importance in controlling other identified pests at certain times and situations. IPM practices are in wide use throughout California in alfalfa, including sampling pest populations, assessing the threat to yield and quality and choosing selective and/or reduced risk insecticides when available. Continued improvement in the use of practices that mitigate risks from chlorpyrifos will be emphasized and an outreach program to improve decision making will be developed and delivered as a part of a contract from the California Department of Pesticide Regulation.

Key Words: alfalfa, IPM, chlorpyrifos, regulatory issues

INTRODUCTION

Chlorpyrifos (Lorsban, Lock-On and under several generic names) has played an important role in alfalfa integrated pest management (IPM) due to its efficacy, established international registration status (MRLs), and as a tool against invasive and endemic pest outbreaks. Currently federal and state agencies are evaluating public health and environmental concerns with chlorpyrifos that could result in further use restrictions of this insecticide in alfalfa and other crops.

In 2013, the California Department of Pesticide Regulations (CDPR) contracted with the University of California Statewide Integrated Pest Management Program to convene industry leaders to work together to identify critical uses of chlorpyrifos and develop commodity specific recommendations regarding chlorpyrifos use in their cropping systems.

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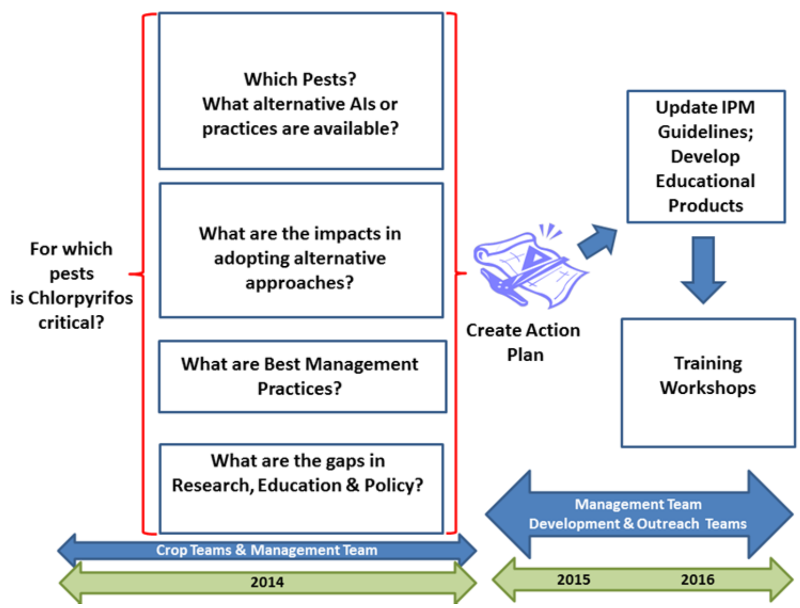
The use of trade names in this publication is solely for the purpose of providing information and the mention of any pesticide in this report is not a recommendation.

The study, *Identifying and Managing Critical Uses of Chlorpyrifos in Alfalfa, Almonds, Citrus and Cotton Project* was developed as a multi-year effort to identify pest management needs and best management practices for chlorpyrifos use in these four important California crops and develop educational programs to support the best use of this important active ingredient (Goodell and Berger, 2014). The project consists of three phases; 1) Develop data which define the critical uses of chlorpyrifos, 2) Develop educational resources aimed at supporting the decision process for utilizing chlorpyrifos in an IPM program and 3) Provide statewide training to reinforce these messages (Figure 1). This paper reports on the first phase of this project as it pertains to alfalfa IPM in California.

Figure 1. Schematic overview of the project "Identifying and Managing Critical Uses of Chlorpyrifos Against Key Pests of Alfalfa, Almonds, Citrus, and Cotton."



These crops were chosen by CDPR because of the role of chlorpyrifos in their IPM systems based on:

- Amount of active ingredient utilized (Figure 2),
- Number of crop production acres throughout the state, and
- Value of these commodities to the California economy

The objectives of the project were to:

- Identify critical uses of chlorpyrifos, if any, in each crop (key pests, key situations, and characterize its importance).
- Define suites of best practices for critical chlorpyrifos applications to help prevent and mitigate risks in each crop, as well as methods for documenting grower uses of those best practices.
- Produce an action plan for critical uses of chlorpyrifos in alfalfa IPM.

- Describe gaps in research, extension and policy that must be filled in order to develop practices that are alternatives to critical uses of chlorpyrifos, as well as additional methods for mitigating chlorpyrifos-related risks and develop an action plan to address those gaps.

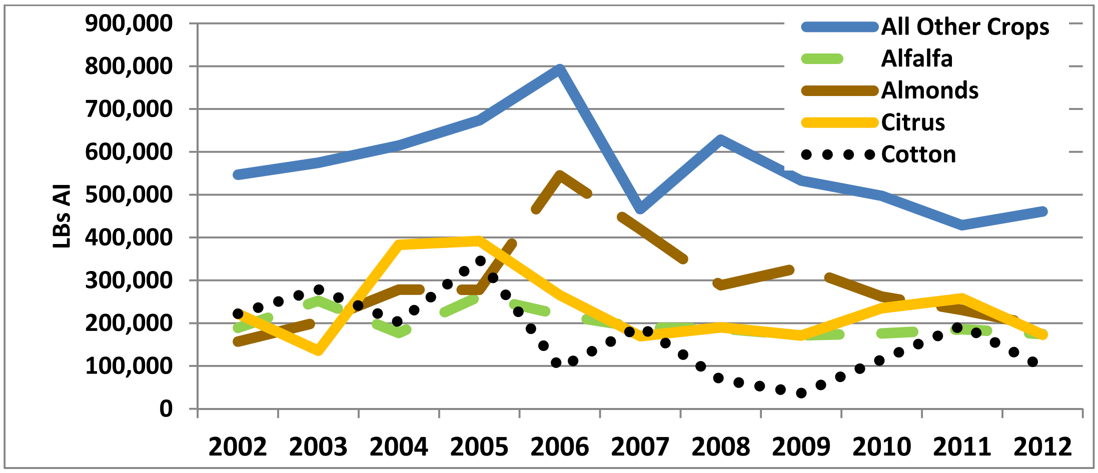


Figure 2. Pounds active ingredient (AI) of chlorpyrifos used in California on selected crops (2002-2012).

CHLORPYRIFOS USE PATTERNS

Of the four crops reviewed, alfalfa had the fewest alternative active ingredients but had a number of alternative practices available, including host plant resistance, timing of harvest, and fostering indigenous natural enemies. Using California Department of Pesticide Regulation's Pesticide Use Reports database, chlorpyrifos use pattern from 2002 to 2012 and the monthly was calculated. The use of chlorpyrifos has held steady at approximately 200,000 pounds per year ((Figures 3 and 4, respectively). The average amount per acre averaged about 0.47 pounds of active ingredient. On average, 79% of applications were made by air with the remainder by ground application. Approximately 35% of the total acres of alfalfa were treated with chlorpyrifos (CDPR PUR data).

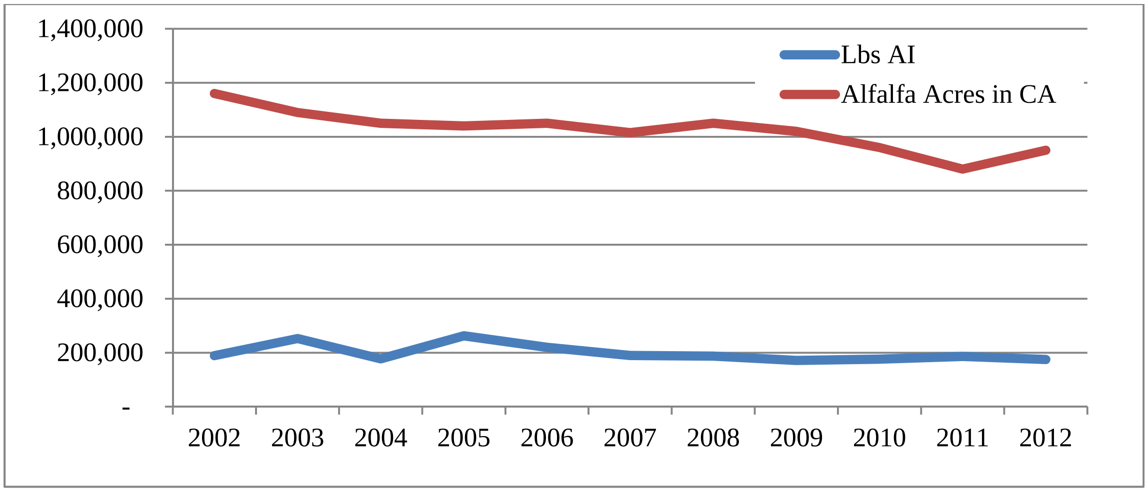


Figure 3. Pounds of chlorpyrifos used and acres of alfalfa in CA (2002-2012).

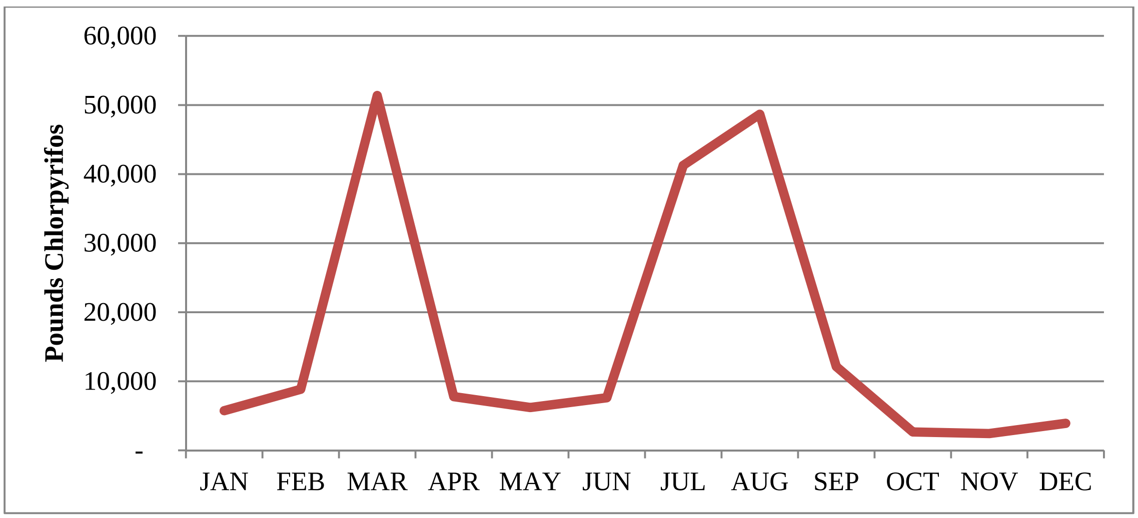


Figure 4. Chlorpyrifos use (lbs AI) in alfalfa by month (2002-2012).

THE PROCESS OF DEFINING "CRITICALITY" AND IDENTIFYING CRITICAL USES IN ALFALFA

The Alfalfa Crop Team consisted of UC scientists, farm advisors, growers, pest control advisers, commodity group representatives, and other stakeholders in a transparent participatory process of discussion and discovery. The Crop Team expressed concerns regarding the outcome of any discussions and feared it might be used to increase regulation. Throughout the meetings, representatives of CDPR assured participating stakeholders that this was a process for developing technical guidance and on a separate track from regulatory rulemaking. CDPR emphasized that rulemaking to reduce chlorpyrifos risks was probable, and that it was impossible to predict what regulatory action would be taken at national and state levels or when that might occur. Just after the conclusion of the Crop Team data gathering, CDPR announced new rule making for the use of chlorpyrifos, including designating it as a state restricted material.

Important pests for which chlorpyrifos is used was reviewed the Alfalfa Crop Team to evaluate and define critical use for their unique pest spectrum. The following process was utilized for alfalfa:

- A list of pests for which chlorpyrifos is a control option in the UC Pest Management Guidelines (Summers et al, 2013) was generated and served as a basis to add or delete pests according to Crop Team knowledge about actual field practices. Additional active ingredients were added or some suggested deleted.
- The Crop Team reviewed alternative pest management options and discussed their value and practicability in managing pest outbreaks including biological and cultural practices (e.g. early harvest or use of tolerant cultivars).
- The Crop Team noted any strengths and weaknesses of alternative options, including risk to environment, human health, and profit. A relative cost ratio of alternative active ingredients to chlorpyrifos.
- Finally, the Crop Teams were asked to identify gaps in research, education, and policy which impact selection of crop protection tools or strategies.

After a series of iterations and reviews, the Team was presented with the final list and asked to define where each pest would reside in the criticality continuum. Much discussion was generated about how the results should be presented and it was agreed the placement in the Critical Use Matrix should not imply more or less importance, but rather the extent of other options one has in managing key and occasional pests. Ten pests fell into three tiers: 1) **key pests** with no or few alternatives, 2) **important pests** with alternatives and 3) **occasional pests** with alternatives (Table 1).

Table 1. Critical uses of chlorpyrifos in alfalfa. For more information on pesticides available, see: http://ipm.ucdavis.edu/PMG/selectnewpest.alfalfa-hay.html

Critical Uses of Chlorpyrifos in Alfalfa			
Criticality Tier	**Pest**	**Number of Modes of Action in Addition to Chlorpyrifos**	**Alternative Practices Available**
Key Pests with Few or No Alternatives	Weevil (Alfalfa and Egyptian)	3	No
	Blue Alfalfa Aphid	2	Yes
	Cowpea Aphid	1	No
Important Pests with Alternative	Alfalfa Caterpillar	5	Limited
	Armyworm (Beet and Yellow-Striped)	5	Limited
	Pea Aphid	1	Yes
Occasional Pests with Alternatives	Cutworm	3	No
	Leafhoppers	3	No
	Spotted Alfalfa Aphid	2	Yes
	Webworm	4	No

RELATIVE COST OF ALTERNATIVE ACTIVE INGREDIENTS

This exercise was conducted with a clear understanding that pricing of insecticides is quite variable according to markets served (e.g. field crops versus orchard), the size of retail operations (major operation or local establishment), and that pricing is often subject to volume discounts to large growers and farming operations. As such, this information represents rough base-line estimates to serve as a guide when comparing chlorpyrifos and alternative products.

Pricing information was solicited from a total of six vendors of agricultural products with a commitment that data sources would remain anonymous and confidential. Participants were selected to represent a wide array of regionality and size of retail operation. Costs for over 70 different active ingredients were requested, including several formulations of chlorpyrifos, alternatives to chlorpyrifos and generic products when available. Not every vendor carried all products due to local markets or limitations of product offerings. Data were collected and averaged to a standardized common unit cost for each active ingredient, e.g. fluid or dry ounce.

To develop a relative cost ratio, the low and high field application rates for each alternative active ingredient listed for that pest was multiplied by the average cost per unit to obtain the range of cost per acre. The high and low application rates per acre for each active ingredient were determined by consulting the UC Pest Management Guidelines for alfalfa or the product label for pest. The relative cost was determined by dividing the alternative active ingredient average cost/acre by the average cost per acre for chlorpyrifos, the lower the ratio, the less expensive the alternate insecticide was compared to chlorpyrifos. For example, for a specific pest on a specific crop:

- *Product A average cost per acre was $2.00*
- *Chlorpyrifos average cost per acre was $1.50*
- *The relative cost ratio would be 1.33, or 33% more costly to use the alternative.*

The cost of alternative active ingredients relative to chlorpyrifos depended on cost per unit of product and the recommended rates per acre. Table 2 presents the relative costs of alternative AIs to chlorpyrifos for control of alfalfa pests. The range of relative costs varied between a low 0.31 the cost of chlorpyrifos to a high of 7.60.

DISCUSSION

Chlorpyrifos has an important role in alfalfa IPM systems. This cropping system depends almost exclusively on its use for the management of blue alfalfa, pea and cowpea aphids. While resistant cultivars are available for the blue and pea aphid, population densities of the former have increased in recent years during the winter, requiring additional insecticide applications.

Alfalfa hay production would be greatly threatened if this active ingredient was not available or efficacious. Thus, it is crucial that the alfalfa industry provide stewardship of this insecticide by employing best management practices before and during its use.

The following list represents IPM and mitigation practices which are already in wide use in alfalfa IPM, but provide a reminder of important considerations:

- Employing preventative practices: host plant resistance, timing of harvests for pest control, and conservation of natural enemies.
- Basic IPM practices: Pest(s) identification, sampling for pests and significant natural enemies, assessment of the potential for natural control, and evaluation of economic threshold levels and damage.
- Selecting the insecticide with the best "fit" for the situation: efficacy, selectivity, pest complex, pre-harvest interval (PHI), and risk to bystanders and the environment (for example, near a school or a waterway).

The last point is particularly important, especially as it relates to active ingredients available in additional to chlorpyrifos. There is a distinct bimodal pattern in monthly use with peaks in March and August (Figure 4). The peak in spring reflects weevil and aphid management, which supports the finding that chlorpyrifos use is critical to control these pests. The summer peak represents 46% of the average annual usage is probably due mostly to worm outbreaks, including alfalfa caterpillar and western yellow striped and beet armyworm. It is uncertain if worms are the target as PUR data does not record the target of a treatment, only the crop site. This worm complex was identified "important but alternative active ingredients are available", indicating an opportunity in which chlorpyrifos alternatives could be used.

Table 2. Relative costs of alternative AIs compared to chlorpyrifos products in alfalfa. Higher ratios mean higher costs than chlorpyrifos alone. If the ratio = 1.0, this indicates the relative cost of the alternative is equal to the cost of using chlorpyrifos.

Tier	Pest	Relative Cost Ratio		Comments
		Low	High	
1	Blue Alfalfa Aphid	0.41	3.17	Resurgent pest in recent years, no narrow spectrum AIs; tolerant cultivars important
	Cow Pea Aphid	0.41	1.23	Newest aphid introduction, no narrow spectrum AIs; no tolerant cultivars
	Alfalfa Weevil	1.22	7.60	Few active ingredients designed for beetles
2	Alfalfa Caterpillar	1.00	4.35	Selective alternative AIs available
	Pea Aphid	0.41	1.23	No narrow spectrum AIs; tolerant cultivars useful
	Armyworms	1.10	3.57	Selective alternative AIs available
3	Spotted Alfalfa Aphid	0.41	1.23	Cultivar resistance is primary management tool
	Cutworm	0.31	3.89	None
	Leafhopper	0.62	2.91	None
	Webworm	0.33	2.78	Primarily high desert area pest
Summary		**0.31**	**7.60**	

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As already stated, chlorpyrifos plays an essential role in winter and spring pest management. However in summer lepidopteran worm management, excellent selective active ingredients are available. Although more expensive (relative cost is between 2 and 3.5 times that of Lock-on), these diamide products (IRAC Group 28, Table 3) are safe to beneficial insects and offer reduced risks to the environment and bystanders. Finally, the use of alterative insecticides preserves the use of chlorpyrifos to those situations (i.e. aphids) for which there are no alternatives.

Alfalfa IPM faces formidable challenges in the next few years as water availability is threatened and demand for quality hay by dairies increases. The Crop Team identified areas in research, extension and policy which could help meet these challenges including:

1. Increase the number of registrations of important insecticide active ingredients for aphid control, especially neonicotinoids. The lack of active ingredients effective against weevils was also highlighted as an important area of research.
2. Additional effort to increase the levels of host plant resistance in alfalfa varieties to meet the increased population densities of alfalfa aphids.
3. More research is required to understand the apparent change in life cycle of weevils and aphids.

In business, as in life, continual improvement is required to meet the challenge of constant change. Managing insect pests in alfalfa will require that we do more and do it better, using all the best IPM practices at our disposal with continued careful thought as to where, how and when we are applying pesticides.

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Table 3. Pest by Active Ingredient for Alfalfa as Identified by Alfalfa Crop Team.

Product			Key Pests, No or Few Alternative AIs or Practices Available			Important Pests with Alternative AIs or Practices Available			Occasional Pests or Pests with Alternative AIs or Practices Available			
Trade Name(s)	**Active Ingredient**	**IRAC Group**	**Aphid, Blue Alfalfa**	**Aphid, Cowpea**	**Weevils**	**Aphid, Pea**	**Alfalfa caterpillar**	**rm, Beet & Yellow**	**Aphid, Spotted Alfalfa**	**Leafhoppers**	**Webworm**	**variegated, granulat**
Coragen	Chlorantraniliprole	28					✓	✓				
Ambush, Pounce	Permethrin	3A								✓	✓	✓
Baythroid	Beta-cyfluthrin	3A	✓	✓	✓	✓			✓	✓	✓	✓
Belt	Flubendiamide	28					✓	✓			✓	✓
Dimethoate	Dimethoate	1B	✓	✓		✓			✓	✓		
Entrust	Spinosad	5			✓							
Imidan	Phosmet	1B			✓					✓		
Intrepid	Methoxyfenozide	18					✓	✓			✓	
Lannate	Methomyl	1A	✓				✓	✓		✓		
Lock-On	Chlorpyrifos	1B					✓	✓			✓	
Lorsban 4E	Chlorpyrifos	1B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lorsban Advanced	Chlorpyrifos	1B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Malathion	Malathion	1B	✓	✓	✓	✓			✓	✓		
Mustang	Zeta-cypermethrin	3A	✓	✓	✓	✓			✓	✓	✓	
Sevin	Carbaryl	1A								✓	✓	
Steward	Indoxocarb	22A			✓		✓	✓				✓
Warrior	Lambda - cyhalothrin	3A	✓	✓	✓	✓			✓	✓	✓	✓
Xentari, Dipel ES	*Bacillus thuringiensis*	11B					✓	✓			✓	