Assessing the importance of organophosphates in California agriculture

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Background

The California Department of Food and Agriculture's (CDFA) Office of Pesticide Consultation and Analysis (OPCA) was conceived in 1991 as part of the Governor's Reorganization Plan No. 1, which removed the State's pesticide regulatory program from CDFA and relocated that function within the newly-created Department of Pesticide Regulation (DPR) inside the California Environmental Protection Agency (Cal-EPA).

OPCA's consultative arrangement was conceived primarily as a means of ensuring that economic impacts on California's agricultural industry would be properly considered prior to adoption of new pesticide regulations. The primary means for completing economic impact studies has been via research contracts with experts in the University of California system.

OPCA has sponsored many UC research projects since 1991 on a variety of pesticide topics. A recent multi-year study was completed last February 2003—the report, entitled "The Economic Importance of Organophosphates In California," can be found on the CDFA web site:

http://www.cdfa.ca.gov/publications.htm

The research was conducted by a team of UC Cooperative Extension (UCCE) entomologists and agricultural economists. The investigation focused on the implementation of the federal Food Quality Protection Act (FQPA), enacted in 1996. Much of the underlying data used in this study was derived directly from the Pesticide Use Report (PUR) database maintained by the California Department of Pesticide Regulation (part of Cal-EPA).

Bob Van Steenwyk lead the team of UCCE entomologists that included William Chaney, Richard Coviello, Larry Godfrey, Pete Goodell, Elizabeth Grafton-Cardwell, Eric Natwick, Carolyn Pickel, Nick Toscano, Lucia Varela, and Frank Zalom. The UC Berkeley economists included Mark Metcalfe, Bruce McWilliams, Brent Hueth, David Sunding, Aaron Swoboda, and David Zilberman.

Food Quality Protection Act (FQPA)

With the FQPA, Congress directed the US EPA to consider aggregate risk, cumulative risk and children's special vulnerabilities in reexamining pesticide tolerances. Cumulative risk assessment is especially important to California agriculture, since it is thought that there are shared mechanisms of toxicity between insecticides. Owing to the preponderance of "minor" crops (relatively low acreage but high-value fruits, nuts and vegetables), California agriculture is uniquely susceptible to major pesticide restrictions, since pesticide manufacturers tend to opt in favor of retaining their more profitable field crop uses if major restrictions are imposed.

OPCA's FQPA project focused on the economic importance of one class of insecticides – the organophosphates (OPs). The OPs were the first major class of chemicals that US EPA was to evaluate according to their early FQPA roadmap. The OPs were thought to be particularly vulnerable to EPA evaluation and some early prognosticators predicted that the entire chemical class might be banned. Indeed, two studies funded by the American Farm Bureau Federation assumed total loss of OPs and carbamates pesticides and found significant impacts on society from FQPA implementation. A study by Taylor and Smith (1999) predicted decreases of $17 billion in countrywide economic output, and the loss of 209,000 jobs, while Gray and Hammitt (1999) state "it is difficult to imagine that the benefits of a ban could offset the 10 to 1,000 annual premature fatalities predicted from the income losses that would be caused by elimination of OP/carbamate use."

CDFA's FQPA project—evaluate economic importance of organophosphates

The main goal of the FQPA project was to assess the importance of the organophosphate (OP) pesticides to the California agricultural industry and consumers. This was a somewhat difficult undertaking as the complexities of the pest management interactions had to be considered in conjunction with associated economic interrelationships.

To simplify the project, we had the UC researchers analyze three scenarios:

1) What is the current pest management system?
2) What would California growers do this season if they could not use OPs but all other current options were still available?
3) What type of pest management systems can we expect California growers to be using in four or five years?

For current pest management systems (the first scenario), UCCE entomologists developed typical insect pest management program for a set of important California commodities (see below). The OP-free insect pest management programs (scenario 2) were constructed for immediate implementation without consideration of the cost of the program or consequence of insecticide resistance. The OP-free programs took into account secondary or occasional pests that might require additional control measures. Also, the UCCE entomologists estimated any increased damage or yield loss above current levels that would result from their OP-free insect pest management programs.

For scenario 3, the UCCE entomologists developed a more ecologically sound OP-free insect pest management program using currently available pest management practices and emerging technologies that were anticipated to be registered within four or five years. Again, the UCCE entomologists accounted for secondary or occasional pests that might require additional control measures and any increased damage or yield loss above current levels that would result from the proposed future pest management programs.

Fourteen crops were chosen (based on total value to the state):

Alfalfa
Almonds
Broccoli
Carrots
Cotton
Grapes
Lettuce, Head
Lettuce, Leaf
Oranges
Peach & Nectarines
Strawberries
Tomatoes, Fresh
Tomatoes, Processed
Walnuts

To get a more realistic results, we divided the state into seven growing regions. We modified these regions slightly based on cropping differences for a few commodities.

Counties by Regions (mountain region not shown)

Region	Counties
North and Central Coast	Alameda, Contra Costa, Del Norte, Humboldt, Lake, Marin, Mendocino, Monterey, Napa, San Benito, San Mateo, Santa Clara, Santa Cruz, Sonoma
South Coast	Los Angeles, Orange, San Diego, San Luis Obispo, Santa Barbara, Ventura
Sacramento Valley	Butte, Colusa, Glenn, Placer, Sacramento, Solano, Sutter, Tehama, Yolo, Yuba
Northern San Joaquin Valley	Merced, San Joaquin, Stanislaus
Southern San Joaquin Valley	Fresno, Kern, Kings, Madera, Tulare
Desert	Imperial, Inyo, Riverside, San Bernardino

For each of the crops and regions, UC Cooperative Extension (UCCE) entomologists described the role of OP pesticides in current agricultural practices and projected pest management programs growers would adopt if OPs could not be used. The entomologists provided an estimate of cost and crop yield changes from the adoption of the new pest control practices for both moderate and severe pest pressure. The cost and yield change estimates were used by the economists as parameters for their simulation model. The UCCE entomologists' reports are found in Appendix A of the CDFA paper (http://www.cdfa.ca.gov/publications.htm).

The impact of a ban on OP pesticides depends on the alternative control measures growers might choose and their relative benefits and limitations. Alternatives include carbamates, neonicotinoid, pyrethroids, insect growth regulators, biological control, and pheromones.

The following table (from Appendix A) is an example of a heavy pest pressure scenario for alfalfa.

Insecticide and Miticide Use in an OP free IPM System with Available Technology on Alfalfa in the Lower Desert and Central Valley under High Insect Population Pressure.

Material	Rate Form/ac	# Appl./ Season	Pest	Notes
cyfluthrin (Baythroid 2) or lambda cyhalothrin (Warrior T) or	1/8 pt	2	Weevils	destroys natural enemies, suppresses moderate aphid populations but aphids may rebound
permethrin (Pounce 3.2EC)	1/4 pt			
carbofuran (Furadan 4F)	1 pt	2	Weevils and aphids	same as Baythroid
methomyl (Lannate SP)	1 lb	2	Lepidopterous larvae and aphids	same as Baythroid
Bacillus thuringiensis (Dipel DF and others)	1 lb	1/2	Lepidopterous Larvae	weak on BAW

Information from the above scenario was then used to calculate average regional costs, based on the amount of insecticides used and the percent acres treated. Pounds of pesticide used and acres treated were extracted from the PUR database.

Insecticide and Miticide Use on Alfalfa in the Central Valley Region of CA, 1999 (from Appendix A).

Material*	Lb (ai)	Acres Treated	% Acres Treated	Costs
Bacillus thuringeinesis (Various Products)	494	17,605	3.4	$15,256
carbofuran (Furadan)	32,574	75,481	14.7	$686,650
chlorpyrifos (Lorsban)	153,962	273,266	53.1	$2,912,962
cyfluthrin (Baythroid)	1,046	29,494	5.7	$303,384
dimethoate (Dimethoate)	8,444	22,659	4.4	$83,177
lambda-cyhalothrin (Warrior)	3,852	142,274	27.6	$1,617,907
malathion (Malathion)	51,681	40,067	7.8	$282,693
methomyl (Lannate)	44,418	75,886	14.7	$986,963
permethrin (Pounce, Ambush)	4,088	33,452	6.5	$275,965
phosmet (Imidan)	25,695	37,615	7.3	$266,198

* Pesticides used on less than 1% of the total statewide acreage are excluded from tables (Dept. Pesticide Regulation – Pesticide Use Reports). Average insecticide (material) cost per acre treated for the Central Valley Region is about $14.43.

Economic Model

The UC Berkeley agricultural economists developed an economic model that employs three parameters to summarize the production-related consequences of the cancellation of OP insecticides. These parameters are the per-acre yield changes and the per-acre cost changes as provided by the UC Cooperative Extension entomologists, and the fraction of total acres where OP insecticides were used. These parameters directly determine the production consequences to growers and, hence, indirectly affect the availability and the price of commodities for consumers. The fraction of acres using OP insecticides is important because use varies by region and crop—it would be a gross overestimation as to the importance of OP insecticides if yield and cost effects were assigned to all of the state's production acres.

The following table shows the estimates of cost and yield changes under the OP-free pest management scenario for moderate and severe (low and high) pest pressure.

Table 5. Yield and cost change estimates of UCCE entomologists

Crop	Yield Change		Cost Change*	
	low	high	low	high
Alfalfa	0%	0%	$27	$70
Almonds	0%	0%	$72	$206
Broccoli**	10%	30%	$65	$87
Carrots	0%	0%	$0.11	$0.69
Cotton	0%	0%	$56	$56
Grapes	0%	0%	$32	$163
Lettuce, Head	0%	0%	$64	$107
Lettuce, Leaf	0%	0%	$87	$129
Oranges	0%	0%	$119	$256
Peaches & Nectarines	0%	0%	$24	$82
Strawberries	0%	0%	$141	$189
Tomatoes, Fresh	0%	0%	$9	$44
Tomatoes, Processed	0%	0%	$16	$16
Walnuts	0%	0%	$56	$135

* Cost per acre

*** Yield changes in coastal region only*

Using these three parameters(cost and yield changes, plus percent of acreage treated with OPs), the economists' model predicted changes in total economic welfare in the economy, for both producers and consumers. Total economic welfare is defined as the sum of consumer welfare, which is a measure of the difference between the benefit derived from consumption and the cost of consumption, and producer surplus, which is a measure of producer profits. The economic impact of the cancellation of OP insecticide use was calculated as the difference between economic welfare with and without the use of OP insecticides. The model estimated welfare changes for a single year and was done only for the year immediately after the theoretical cancellation of all OP use. Owing to the complexities of predicting parameters four to five years in the future, no attempt was made to model the third scenario (which the entomologists called "IPM systems with emerging technology").

The two tables below (Tables 8 and 9 from the main report) show some of the output from the economists' simulation model. Table 10 show some of the regional effects the model predicted.

Table 8. Changes in Price and Quantity

Crop	Change in Price (percentage)	Change in Production* California	Change in Production* Rest of US	Change in Consumption*	Change in Net Exports*
Alfalfa	0.93	-184,845	48,743	-135,145	-957
Almond	0.48	-1,356	n/a	-1,311	-45
Broccoli	16.00	-111,285	2,083	-100,321	-8,881
Carrots	>0.01	-5	-3	-8	>-1
Cotton	1.69	-1,148	-19,214	-7,823	-12,540
Grapes	0.05	-999	-265	-1,231	-33
Lettuce, Head	0.36	-12,778	3,864	-8,641	-273
Lettuce, Leaf	0.46	-1,510	-148	-1,457	-200
Oranges	0.32	-40,517	-28,137	-67,848	-806
Peaches & Nectarines	0.32	-1,561	-2,016	-3,443	-133
Strawberries	0.26	-508	-743	-1,177	-74
Tomatoes, Fresh	0.03	-388	-223	-439	-172
Tomatoes, Processed	0.16	-10,849	114	-10,474	-261
Walnuts	0.58	-1,091	n/a	-956	-135

* Change in tons

*Changes in tons

Table 9. Changes in Producer and Consumer Welfare

Crop	Producers* (California)	Percentage of CA Value	Consumers**	Total Loss*
Alfalfa	-26,868	-3.4%	-6,059	-32,927
Almonds	-24,049	-2.3%	-5,797	-29,846
Broccoli	-13,621	-3.1%	-54,091	-67,712
Carrots	-3	>-0.01%	-1	-4
Cotton	-1,520	-0.1%	-10,573	-12,093
Grapes	-2,221	-0.1%	-1,091	-3,312
Lettuce, Head	-5,797	-0.9%	-2,809	-8,606
Lettuce, Leaf	-858	-0.5%	-925	-1,783
Oranges	-27,113	-3.0%	-1,096	-28,209
Peaches & Nectarines	-3,045	-0.6%	-1,545	-4,590
Strawberries	-643	-0.1%	-1,433	-2,076
Tomatoes, Fresh	-254	-0.1%	-137	-391
Tomatoes, Processed	-1,298	-0.2%	-1,037	-2,335
Walnuts	-8,092	-2.4%	-1,619	-9,711
Total	-115,382	-1.1%	-88,213	-203,595

*Change in thousands of dollars.

**Consumer loss due to change in California production.

Table 10. Regional Effects on California Producers

Crop	North Coast*	South Coast*	Sac. Valley*	Northern San Joaquin*	Southern San Joaquin*	Desert*
Alfalfa	-	-	-2,549	-7,991	-13,510	-
Almonds	-	-	-3,023	-4,861	-9,979	-9,004
Broccoli	-12,479	-17,698	-	1,310	5,832	9,414
Carrots	<-1	<-1	-	-	1	-3
Cotton	-	-	-42	315	-1,734	-59
Grapes	-23	-6	3	3	-2,066	-132
Lettuce, Head	-2,712	-435	-	-	-1,344	-1,303
Lettuce, Leaf	-791	-28	-	-	-59	21
Oranges	-	-619	-	-	-26,494	-
Peaches & Nectarines	-	-	-406	-363	-2,276	-
Strawberries	-396	-246	-	-	-	-
Tomatoes, Fresh	-62	-117	-10	-76	3	8
Tomatoes, Processed	-	-	-1,056	-459	217	-
Walnuts	-723	-128	-2,343	-2,421	-2,478	-
Total	-17,186	-19,277	-9,426	-14,543	-53,887	-1,058

* Change in thousands of dollars

- Not grown in significant quantities in region.

The OP-free management programs provided by UC specialists suggest that costs will increase but most non-OP pest management strategies can prevent yield losses. Results of the economic analysis suggest that the total value to society of OP use in California is significant at approximately $203 million, but hardly devastating when it is noted that the average California production value of these commodities totals over $10 billion. However, not all groups will share this burden equally. As expected, the losses are greatest in those instances where currently used OP pesticides have no close substitutes. For example, the largest reason for the pronounced losses to broccoli producers in the coastal region is lack of an alternative insecticide to control cabbage maggot. The crops most economically affected by OP cancellation are broccoli, oranges, almonds, and alfalfa, while carrots have the least to lose from a ban since very few OPs are currently being used in production. The total effects on producers of these crops are estimated as ranging from less than 0.01% of total 1999 crop value (carrots) to 3.4% of total 1999 crop value (alfalfa).

Literature Cited

Gray, G., and J. Hammitt. 1999. Risk/Risk Tradeoffs in Pesticide Regulation." Report for the American Farm Bureau. August, 1999.

Taylor, R. C., and H. A. Smith. 1999. Aggregate economic evaluation of the elimination of organophosphate and carbamate pesticides. AFPC Policy Research Report, Texas A&M University, April, 1999: 99-15.