UNIVERSITY OF CALIFORNIA GIANNINI FOUNDATION

UPDATE

Agricultural and Resource Economics

VOL. 8 NO. 4 MAR/APR 2005

Pesticide Use and Air Quality in the San Joaquin Valley

by

Rachael E. Goodhue, Kiara Groves and Rick T. Roush

The California Department of Pesticide Regulation proposes to limit the maximum emission potential of pesticides formulated as emulsifiable concentrates to 20 percent. Many crops use pesticides that do not meet this requirement currently.

Air quality in the San Joaquin Valley is a significant concern for residents and policymakers alike. According to the California Air Resources Board (ARB), "The San Joaquin Valley experiences some of the worst ozone and particulate air pollution in the U.S., with both high levels and frequent episodes" (ARB, 2004, p.1). Sufficiently high concentrations of ozone in the troposphere, which begins at ground level, can be harmful to human health, causing respiratory sicknesses and irritation. Volatile organic compounds (VOCs) and nitrogen oxide combine with sunlight to form ozone. VOCs are emitted by a number of sources, including vehicles, livestock waste and pesticides.

The federal Clean Air Act requires each state to develop an implementation plan to improve air quality and meet air quality standards, including a standard for tropospheric ozone. The San Joaquin Valley Air Basin has failed to meet these standards, and is classified as an extreme nonattainment area. As part of efforts to bring it into compliance, the California Department of Pesticide Regulation (CDPR) will seek to reduce emissions of VOCs from pesticides through regulations, and through research and extension efforts regarding alternatives. At a February 23, 2005 meeting of its Pest Management Advisory Committee, CDPR announced that it intended to reduce VOC emissions from pesticides in the San Joaquin Valley by setting a maximum emission potential (EP) of 20 percent. This requirement mandates that all emulsifiable concentrate pesticides with an emission potential currently above this level must be reformulated in order to continue to be used in California.

The purpose of this analysis is to provide information that can aid in assessing the potential costs of the 20 percent maximum EP reformulation requirement, by providing information regarding the scope of the requirement's impact on agricultural production. Determining the net benefit would require information regarding the profit difference between growers' next best alternatives for each commodity-pest pair, given all the pesticide products affected by the requirement, and the effect of these alternatives on VOC emissions.

Background

A CDPR report (cited at the end of this article on page 5) regarding estimated VOC emissions from pesticides for 1990-2002 is a key summary document that is helpful for discussion of pesticides' contributions to VOCs. In the San Joaquin Valley, the major pesticide contributors are fumigants and products with emulsifiable concentrate (EC) formulations. Three fumigants, metam sodium (29.9 percent), 1,3-dichloropropene (14.2 percent), and

Table 1. Use of EC Pesticides with an Emission Potential Greater than 20 Percent

	Any Use	Intensive Use All EC[a]	Intensive Use Single Active Ingredient[b]	Intensive Use Single Product[c]
Number of Commodities	58	40	14	12
Value of Production ($1,000)	$14,326,571	$9,050,031	$3,351,680	$3,001,680
Share of 2002 CA Production	78.5%	49.6%	18.4%	16.5%

a. Total application-acres for all EC products are 50% or more of total harvested acres.
b. Application-acres are 50% or more of total harvested acres for EC active ingredient with greatest application-acres.
c. Application-acres are 50% or more of total harvested acres for EC product with greatest application-acres.

methyl bromide (6.4 percent) accounted for about 47.5 percent of all VOC emissions from pesticides during the May-October ozone season for 2002. Because fumigants are themselves VOCs, they have an emission potential of 100 percent. By nature, they cannot be reformulated, and are excluded from CDPR's proposed reformulation requirement.

For ECs, it is mostly the formulation ingredients (rather than the active ingredients) that collectively account for about 37 percent of VOC emissions. EC products with the active ingredient chlorpyrifos are the third largest contributor, accounting for 8.5 percent of all VOC emissions from pesticides during the May-October ozone season for 2002. The most important crops in generating emissions from ECs are cotton (estimated at 13 percent of the total VOCs), almonds (8 percent) and oranges (5 percent). However, these summaries overlook the complexities of the contributions from these crops. First, each crop uses multiple pesticides that emit VOCs. Second, eliminating currently available products by requiring reformulation may result in greater total pesticide use by growers, due to the need to use less effective alternatives for certain pests. Even if this increase in applications does not result in a net increase in VOC emissions, it may have other adverse environmental or human health effects. In cotton (for aphids) and citrus (for citricola scale), the EC formulation itself is currently believed to be critical to the effectiveness of chlorpyrifos at controlling specific pests. In these two cases, chlorpyrifos EC seems to be the safest and most effective way to control the pests, at least currently.

Research Approach

In order to evaluate the importance to California agriculture of EC pesticide products that would be affected by a maximum EP requirement, we linked data regarding pesticide use, pesticide formulations and emission potentials, value of production and harvested acreage. Our analysis was limited to a subset of agricultural crops for which it was possible to match information regarding pesticide use to information regarding acreage and the value of production.

It is difficult to quantify the importance of ECs for a large number of very diverse crops. Evaluating application acres at this aggregate level abstracts from other factors that are critical determinants of the economic value of ECs, such as the availability and efficacy of non-EC substitutes. Similarly, it is difficult to assess the extent to which two different ECs may be substitutes. If two products are substitutes for the control of a specific pest, then the sum of their use will provide a more accurate measure of their importance than will evaluating the two products individually. In contrast, if two products control two different pests, then their importance should be evaluated separately. There is also no direct information regarding the importance of ECs that are used on a small share of acreage to control a specific pest problem, and have no economically viable alternatives. This aggregate analysis can be used to identify commodities that require more detailed investigation, however, by identifying intensive users.

We report four measures of the importance of EC pesticides to California agriculture. Three measures compare harvested acres to the acres to which specified pesticides are applied for each crop for each commodity. First, we identify commodities that report EC application acres that sum to 50 percent or more of total harvested acreage, which we refer to as "intensive EC use" commodities. Second, commodities for which a single active ingredient is applied as an emulsifiable concentrate to 50 percent or more of harvested acreage, are referred to as "intensive single-active ingredient use" commodities. Third, commodities for which a single EC pesticide is applied to 50 percent or more of harvested acreage are referred to as "intensive single-product EC use" commodities. Finally, we report the number of EC formulation pesticides applied to each crop.

Clearly, these measures are only imperfect indicators of the importance of ECs to individual commodities. In particular, defining intensive use by comparing application acres to harvested acres does not differentiate between a product applied once to 50 percent of harvested acreage, and a product applied five times to 10 percent of harvested acreage. This limitation means that our calculation of the share of the value of production that relies on ECs may be too high. On the other hand, our measures do not reflect the value of a product that is the only effective control for a specific pest in a specific commodity, but that was not used on a substantial share of acreage in 2002. This limitation means that our calculations may understate the importance of ECs. It is also important to understand that these measures address the importance of pesticide use on an acreage basis and do not address the effect on VOC emissions. Depending on ECs and application rates, an intensively used product may account for a very small share of emissions, or a product that is not intensively used may account for a large share of emissions.

Our final summary measure of the importance of EC use to California agriculture is the number of EC products used by each commodity. The large number of products used by many commodities suggests that some EC products are likely to be substitutes. In turn, this suggests that the single-product use measure reported above underestimates the importance of ECs, although it is not feasible to determine to what extent this is the case, given our degree of aggregation.

Results: Twenty Percent Maximum Emission Potential

Table 1 summarizes our findings regarding the value of agricultural production that would be potentially affected by the maximum EP of 20 percent proposed by CDPR. Of the subset of commodities for which we could link pesticide use data and value of production and acreage data, 58 used one or more EC pesticides with an EP of more than 20 percent. These commodities accounted for about $14.3 billion of production, or 78.5 percent of California's total fruit and nut, vegetable, and field crop production in 2002 (henceforth referred to as California production). Figs are the only crop that uses pesticides affected by a maximum 20 percent emission potential requirement but does not use pesticides affected by a maximum 50 percent emission potential requirement.

Not all commodities that use ECs are intensive users of ECs. As shown in Table 2, of the 58 commodities that

Table 2. Use of EC Pesticides with an Emission Potential Greater than 20 Percent by Commodity

Commodity (Any EC Use)	Intensive Use, All EC[a]	Intensive Use, Single Active Ingredient	Intensive Use, Single Product[c]
Almond	x	x	x
Apple	x		
Apricot	x		
Asparagus	x		
Avocado			
Barley			
Bean, dried	x		
Bean, succulent	x	x	x
Boysenberry			
Broccoli	x	x	x
Cabbage	x		
Cantaloupe	x		
Carrot	x	x	x
Cauliflower	x	x	
Celery	x	x	x
Cherry	x		
Corn (forage fodder)			
Corn, human cons.	x	x	x
Cotton	x		
Cucumber	x		
Date			
Fig			
Forage hay/silage			
Garlic	x	x	x
Grapefruit			
Grapes			
Kiwi			
Lemon	x		
Melon	x	x	x
Mushroom			
Nectarine	x	x	
Oat	x		
Olive			
Onion, dry	x	x	x
Onion, green			
Orange	x		
Peach	x		
Pear	x		
Pecan	x		
Pepper	x		
Pistachio	x	x	x
Plum	x		
Potato	x		
Prune	x		
Pumpkin	x		
Raspberry			
Rice			
Sorghum			
Spinach	x		
Strawberry	x	x	x
Sugarbeet	x	x	x
Sweet potato			
Tangerine	x		
Tomato	x		
Tomato, processing	x		
Walnut	x		
Watermelon	x		
Wheat			

a. Total application-acres for all EC products are 50% or more of total harvested acres.
b. Application-acres are 50% or more of total harvested acres for EC active ingredient with greatest application-acres.
c. Application-acres are 50% or more of total harvested acres for EC product with greatest application-acres.

use any affected EC products, 40 are intensive users of all EC products, as indicated by an "X" in the second column of the table. These products have a value of production of $9.1 billion, or 49.6 percent of California production. Fourteen commodities are intensive users of EC products with a single active ingredient, as indicated by the third column of Table 2. These commodities accounted for 18.4 percent of California production or $3.4 billion. Twelve commodities are intensive users of a single EC product, and accounted for 16.5 percent of California production or $3.0 billion. These commodities are the same as the intensive users of a single active ingredient, excluding cauliflower and nectarines. Although it is not true for all of the commodities in our analysis, for the commodities that are intensive users of a single product the active ingredient in the most-used product is the same as the most-used active ingredient.

On average, each commodity within our set of 58 commodities that used any EC pesticides used 37.8 distinct EC products that would require reformulation under the 20 percent maximum EP requirement. The median number of affected products used by these commodities was 38.5. The maximum number of products used was 101, and the minimum was two. In total, there were 280 commodity-pesticide pairs in our sample that would be affected by a 20 percent maximum EP.

Results: Fifty Percent Maximum Emission Potential

Table 3 summarizes the value of agricultural production that would be potentially affected by a maximum EP of 50 percent for EC products. In California, 57 commodities use one or more EC pesticides with an EP of more than 50 percent. Together, these 57 commodities in our data account for about $14 billion, or 78.4 percent of California production. This is only one commodity fewer than the 58 that use one or more EC pesticides with an EP of more than 20 percent.

However, there is a substantial difference between the 20 percent maximum and the 50 percent maximum in terms of their effects on intensive users. Only 21 commodities are intensive users of pesticides affected by the 50 percent maximum, and these commodities account for 23.9 percent of California production, or about $4.4 billion. In contrast, recall that 40 commodities accounting for 49.6 percent of California production are intensive users of pesticides affected by the 20 percent maximum. Seven commodities, valued at $1.6 billion, are intensive users of a single active ingredient with an EP of more than 50 percent. The seven commodities are succulent beans, broccoli, cauliflower, celery, corn for human consumption, pistachios and strawberries. Six, valued at $1.4 billion, are intensive users of a single product (excludes cauliflower, relative to the previous list). While it is not the case for all commodities in our analysis, for the six single-product intensive use commodities, the most-used active ingredient is the same as the active ingredient in the most-used product.

Within our subset of 57 commodities, 51 used more than one affected EC product. The average number of products was 12.3, and the median was 12.0. The maximum number of products used by one commodity was 34. Relative to the 20 percent maximum EP requirement, many fewer product-commodity uses would be affected by a 50 percent maximum requirement. In total, there were 81 commodity-pesticide pairs in our sample that would be affected.

Reregistration and Minor Crops

A reformulated product will require reregistration. While in some cases reformulation may be achieved simply through changing formulation ingredients, and not the active ingredient or rate recommendation, in other cases reformulation will require registering a new pesticide product. Much of California's EC use is on so-called "minor crops." Registrants may conclude that the benefits of reformulating and reregistering a product for a minor use may be outweighed by the costs. Given the number of commodities that use ECs, and the complexity of the interactions among changes in EC formulations and product availability, it is difficult to estimate the potential effects of a reformulation requirement on product availability.

Implications and Further Research

In order for the San Joaquin Valley to achieve its VOC emission reduction objectives, VOC emissions from pesticides must be reduced. CDPR proposes to do so by imposing a 20 percent EP maximum on EC pesticides. EC pesticides are used by many California commodities, and either of the reformulation proposals we examined would affect pesticides used by a large majority of California's fruit and nut, vegetable, and field crops, as measured by the value of production. The intensive use of the affected products is more concentrated, but still accounts for a substantial share of the value of production. Our analysis suggests that the precise level of the maximum EP is a critical determinant of the scope of its potential effects on agriculture. A 20 percent EP limit affected roughly twice as many intensive users, accounting for twice the value of production, as a 50 percent EP limit.

Table 3. Use of EC Pesticides with an Emission Potential Greater than 50 Percent

	Any Use	Intensive Use, All EC[a]	Intensive Use, Single Active Ingredient[b]	Intensive Use, Single Product[c]
Number of Commodities	57	21	7	6
Value of Production ($1,000)	$14,308,484	$4,363,918	$1,588,890	$1,371,185
Share of 2002 Value of CA Production	78.4%	23.9%	8.7%	7.5%

a. Total application-acres for all EC products are 50% or more of total harvested acres.
b. Application-acres are 50% or more of total harvested acres for EC active ingredient with greatest application-acres.
c. Application-acres are 50% or more of total harvested acres for EC product with greatest application-acres.

Our aggregated analysis can only provide an approximation of the costs of a reformulation requirement. In addition to that information, it facilitates identification of commodities that have the greatest potential for incurring large losses due to reformulation, and hence require closer study. In some cases, these commodities would not be identified by an analysis done only on a per-active ingredient or per-product basis. For example, a commodity that intensively uses the group of impacted ECs as a whole, but does not intensively use any one active ingredient or product, should be examined more closely in order to determine if some ECs are substitutes.

Commodity-specific research can also serve as a means of identifying cases where there are relatively efficacious alternatives to using EC pesticides with high EPs. There are currently possible alternatives to some EC uses that could be promoted by training and permitting processes. However, due to the diversity of crops and pests for which EC pesticides are used, the necessary research and extension to reduce EC use will probably be complex and costly, and it will be necessary to prioritize research needs.

In this case, in order to maximize the expected net benefits of research, scarce research and extension resources should be directed to crop-pest cases where management alternatives to VOC-emitting pesticides will result in substantial declines in VOC emissions, and failing to obtain an effective alternative will result in a large potential value of production loss. For example, a high-value crop that accounts for relatively few production acres, but uses very high rates of a pesticide with a high EP would be a research priority, as would a lower-value crop with lower emissions per acre, but relatively many acres.

Translating this prioritization into practical terms, because of the relatively small contributions from so many other crops, the most cost-effective way to reduce the use of VOC-emitting ECs in the San Joaquin Valley will likely be to reduce the use of EC formulations of chlorpyrifos and other compounds in cotton, almonds and citrus. It also suggests that because fumigants are used at high rates on high-value crops such as carrots, potatoes and onions, and have a 100 percent emission potential, that any cost-effective approach to improving air quality in the San Joaquin Valley will likely include reductions in the use of fumigants, or in the VOC emissions per unit time. Alternatives to fumigant use should be another research priority.

For further information, the authors recommend the following sources:

Air Resources Board, State of California. 2004. “Proposed 2004 State Implementation Plan for Ozone in the San Joaquin Valley.” Staff Report. September 28. 42 pages. www.arb.ca.gov/planning/sip/sjv04/sjv_04_ozone_sip_staff_rpt.pdf.

California Department of Pesticide Regulation. 2004c. “Volatile Organic Compounds (VOC) Emissions from Pesticides.” 1 page. www.cdpr.ca.gov/docs/pur/vocproj/vocmenu.htm.

Spurlock, Frank. 2004. “2004 Update to the Pesticide VOC Inventory: Estimated Emissions 1990-2002.” California Department of Pesticide Regulation. Memo to John Sanders. May 17. 14 pages. www.cdpr.ca.gov/docs/pur/vocproj/060304em_inv.pdf.

Rachael Goodhue is an associate professor in the agricultural and resource economics department at UC Davis. She can be reached by e-mail at goodhue@primal.ucdavis.edu. Kiara Groves is a graduate student in ARE at UC Davis who can be contacted at groves@primal.ucdavis.edu. Rick T. Roush is the director and an entomologist in the University of California Statewide Integrated Pest Management Program who can be contacted by e-mail at rtroush@ucdavis.edu.