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Explaining Europe's Resistance to Agricultural Biotechnology

by

Gregory D. Graff and David Zilberman

European policies blocking genetically engineered crops are conventionally attributed to the concerns of European consumers, but they can be attributed to the self-interests of European industry and farmers as well. Biotech policies maintained in the name of consumer interests are helping European chemical firms to slow their losses in the global crop protection market and are helping European farmers differentiate their conventional crops on environmental and safety grounds, maintain their agricultural subsidies and win new non-tariff trade protections.

One of the major issues dividing the United States and the European Union (EU) and potentially determining the future of world agriculture is biotechnology. In 2003, 81 percent of soybean, 73 percent of cotton, and 40 percent of the corn grown in the United States were genetically engineered with crop protection traits. In Europe, only a negligible amount of biotech crops were grown, and the *de facto* moratorium on approving biotech products continued to block imports.

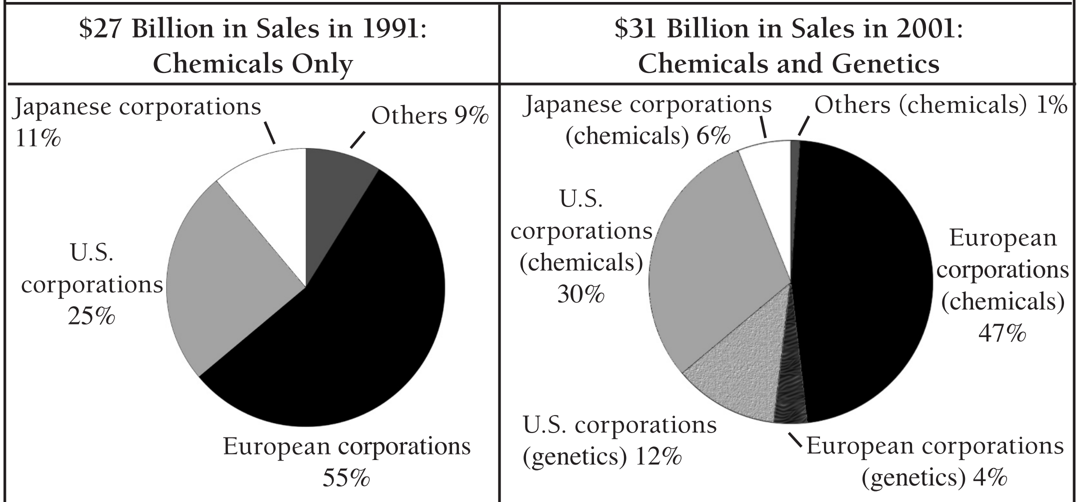
Preferences of European consumers are usually cited as the primary determinant for a whole range of European policies that effectively hinder research, patenting, product development, import and sale of genetically modified agricultural products. This conventional wisdom obscures, however, the preferences of other major forces in Europe, including the powerful European agrochemical and seed industries as well as the influential farm sector. It is often assumed that European industry and farmers have lost out on a potentially beneficial production technology due to a consumer-environmental backlash.

Further examination suggests that European industry and European farmers may actually have had incentives to hinder, at least in the short term, the introduction of genetic technologies into Europe. Historically, European industry has held a dominant position in the global market for agricultural chemicals, now worth over $30 billion annually, yet it has lagged in innovation and product development in biotechnologies, which have been consistently dominated by American firms. European farmers receive large amounts of government support, with the EU's Common Agricultural Policy (CAP) now spending over $40 billion annually, but these payments are coming under increasing international pressure in the World Trade Organization (WTO) and elsewhere. Both European industry and farmers are striving to maintain their eroding advantages.

The Political Economy of Agricultural Biotechnology Policy

The political economy approach views decisions and policies made by government as rational responses to the array of pressures and inducements—such as elections, campaign contributions, lobby efforts and popular movements—arising from across the various segments of society. The main interest groups that weigh in on agricultural and food policy are input suppliers, farmers, the food

Figure 1. Changes in the Global Crop Protection Market over 10 Years



Source: Wood Mackenzie and Phillips McDougal

industry, consumers and environmentalists. On innovation and new technologies, the scientific community weighs in as well.

Policies reflect power relations between groups, who can have different political weights depending upon the current political reality, such as who is in government. Some of the main findings of the political economy literature are that concentrated interests tend to have greater political weight than diffuse interests and, similarly, domestic interests tend to have greater influence than foreign interests. One upshot is that regulations tend to reflect the preferences of producers over those of consumers, as producers are usually more concentrated, creating a situation known as regulatory 'capture.' This is particularly true in rapidly developing areas of technology, where innovating companies often have better knowledge than governments. Thomas Bernauer, in a recent book *Genes, Trade, & Regulation*, asks why the situation with agbiotech in Europe seems to contradict the standard theory, with diffuse consumer interests prevailing over concentrated producer interests. Yet, this begs the more fundamental question of what actually are the interests of European producers in the first place.

How to Explain the European Position?

The assumption commonly made is that European producers would like to introduce genetically modified crops in Europe just as in the U.S. Indeed, firms like Syngenta, Bayer CropSciences, and their various predecessors in the industry are fully engaged in biotech research and development. Also, it is assumed that—were it not for consumer and environmentalist resistance—a similar percentage of European farmers would share the economic logic of American farmers and adopt biotech. Bernauer, and most other commentators, reason that the interests of consumers and environmentalists have dominated the political process. They have coalesced around an issue of 'public outrage,' exploited low levels of public trust in the authorities (following BSE, Foot-and-Mouth, etc.), educated the public and influenced retail markets. In addition, they have taken advantage of the complex web of EU and national regulatory bodies and its multiple entry points. As a result, in an apparent exception to the standard logic of political economy, diffuse concerns over environmental and food safety, European culture, bioethics and '*ordre public*' were able to prevail over concentrated business priorities.

Yet, perhaps there is no paradox. If restrictive biotech policies actually serve the economic interests of European industry and agriculture, they may not have sufficient incentives to seek liberalization. Several pieces of evidence suggest this may indeed be the case.

Examining Industry's Incentives

European industry has long held the upper hand in the incumbent crop protection technology of agricultural chemicals and has maintained it with a strong chemical R&D infrastructure. Starting in the 1970s, in the face of increasing stringency in pesticide regulations around the world, European firms invested their R&D dollars in a next generation of chemicals with better toxicological and environmental profiles. At the time, the U.S. already had a strong life sciences infrastructure in the public sector and was home to a new biotech industry. Facing similar regulatory pressures on pesticides, American firms chose to take advantage of the U.S. position in the life sciences and shifted significant R&D dollars into biotech programs. European industry only developed a limited capacity in the radical breakthrough technology of plant genetics and agbiotech.

Table 1. U.S. Patents Granted 1982-2002

	U.S. Patents on Agbiotechnologies and Crop Genetics	U.S. Patents on Agchemicals	Ratio of Biotech to Chemical Patents
European Inventors	774	3511	22%
N. American Inventors	3035	4449	68%

The historical *status quo* of European incumbency in agricultural chemicals is evidenced in market figures for 1991 (Figure 1). European-based corporations made 55 percent of sales in a $27 billion global crop protection market, which consisted entirely of pesticides. U.S. firms had a 25 percent share of the global market.

Since the introduction of seeds with crop-protecting genes in the mid-1990s, farmers have been shifting into this new technology, where it is available, at unprecedented rates. This is evidenced in 2001 (Figure 1) where genetics accounted for 34 percent of the $31 billion market. Comparisons between 1991 and 2001 show four crucial trends. First, sales for chemicals were basically flat over the decade. Second, chemical sales by U.S. firms grew to 30 percent (while chemical sales by European firms dropped to 47 percent), likely driven by a tie-in with genetics, especially the popular package of glyphosate with glyphosate-tolerant soybeans. Third, genetics have outstripped chemicals, providing virtually all of the growth in the global market. Finally, European firms have made a disproportionately small contribution to biotech sales, compared to U.S. firms.

Differences in Innovative Capacity

A key to these differences in sales of crop genetics is innovative capacity, and U.S. firms clearly have a significant advantage in the life sciences. One of the best ways to measure R&D strengths is to look at relative rates of patenting, and ideally we would like to compare U.S. and European inventors by looking at patents in both the U.S. and the E.U. over both biotech and chemicals for agriculture. However, under the restrictive European policies, patents are not granted in Europe over many of the inventions we wish to observe. U.S. patent registrations capture a much broader range of biotechnologies and crop genetics. Table 1 lists the number of U.S. patents granted between 1982 and 2002 on new agricultural biotechnologies and agricultural chemicals filed by European inventors versus North American inventors.

Despite the fact that European innovation is probably understated in these U.S. patent counts, there are still some telling observations. Over the 20 years, American and Canadian inventors have generated over two-thirds as many patentable inventions in biotech as they have in chemicals. In contrast, European inventors have generated only one-fifth as many patentable inventions in biotech as they have in chemicals. Analysis of citations to these patents show a large surge of highly cited early work in agbiotech in the early 1980s, virtually all by North American inventors, while citations to chemical patents were much more steady and equally distributed between European and North American inventors.

Together these results suggest that European firms are strong in the technology that is not selling, and weak in the technology that is. This goes a long way to explain foot-dragging on biotech policy; moreover, several behavioral and circumstantial indications concur.

Circumstantial Evidence

Unlike in the U.S., where firms conducted a strong campaign to counter early objections raised by environmentalists like Jeremy Rifkin, European companies were fairly passive about paving the way for the introduction of new biotech products in Europe. As a result, European firms ended up with a home market under a zero risk-tolerance regulatory regime based upon the 'precautionary principle,' while U.S. firms pushed for and got a regulatory approach based upon the 'substantive equivalence' of agricultural products, without special consideration to whether they were made using the tools of molecular biology.

The lack of European tolerance for food biotechnologies seems curious given their more liberal attitudes toward cloning and stem cell research. European regulation of chemical pesticides is at least as lenient as U.S. regulation, and European use of chemicals in agriculture is often higher. Cognitive dissonance among Europeans may allow for chemical regulations to be relatively more relaxed than biotech regulations: people tolerate risks with which they are more familiar and from which they know they derive clear benefits.

Similar trends can be seen in the lack of European champions in case law seeking to extend patents to cover DNA and genetically modified organisms. There is also a bias toward European firms in the biotech products approved before the *de facto* moratorium began.

What about Europe's Farmers?

Given the adoption rates observed in North America, Canada and Argentina, European farmers would be expected to embrace and profit from genetic technologies in much the same way. There has been some interest expressed by European farm groups, yet generally it remains muted. European farmers are perhaps just being sensitive to the sensibilities of their consumers.

While certainly some are, given the agricultural support and trade policies that govern the European farm sector, it is likely that consumer interests are not the whole story. Like industry, European farmers are not expected to push for the introduction of genetically modified crops if their deeper economic interests are being served by their restriction.

In the WTO, E.U. farmers are under immense pressure to reduce or even eliminate their direct agricultural subsidies under the CAP. Yet, support policies can be justified on the grounds of environment, food safety or 'public morality.' European growers are well aware that without current levels of support, many of them would go out of business and the value of land would plummet. The campaign to keep genetically engineered crops designated as potentially dangerous to the environment, public health and the European consumer's culinary sensibility, provides European farmers with an opportunity to differentiate their conventional crops while staying within WTO guidelines, maintaining a raft of subsidies and technical barriers to trade. This is, of course, at the heart of the debate in the WTO case filed against Europe. If Europeans win the case, it will establish a legal requirement for product differentiation on grounds of consumer preference, which should even allow them to capture a market premium at the expense of foreign farmers who use genetic crop protection.

Conclusions and Implications

The European rejection of agricultural biotechnologies cannot be explained as simply a case of consumer preferences; it also reflects the self-interests of the European agricultural inputs industry and farmers. European chemical firms have the comparative advantage in agricultural chemicals while U.S. firms have the advantage in biotech, but globally, biotech is growing much more rapidly. Had European policies allowed agbiotech products, U.S. firms were in a much better position to capture the gains. For their part, European farmers are exploiting the opportunity presented by biotech crops to bill their chemically protected crops as an alternative with desirable safety characteristics, in order to justify continued agricultural support and protections against imports, both before the WTO and before European consumers and taxpayers.

Will the current policy climate in Europe continue indefinitely? If agbiotech ends up developing products that significantly enhance consumer well-being while clearly helping the environment, then even European consumer attitudes will begin to reverse, and retailers like Carrefour and Nestle will develop that market. European seed and chemical firms will seek to acquire technologies from abroad while investing yet more of their own R&D in biotech. As European innovative capacity increases, European champions for biotech policy will emerge, and regulations will begin to adjust. European farmers will even start to grow the product. If, rather, there are no major product quality breakthroughs and agbiotech remains largely an agronomic technology, Europe can be expected to continue carving out a separate agricultural trading bloc, with higher standards and lower tolerances for biotech content. The large developing countries—China, India and Brazil—will continue to develop their own agricultural biotechnologies to feed their populations and export where they can. This would mean a continuation of the *status quo* in Europe, and it could persist for some time. Finally, if benefits of biotech continue not to be very apparent but risks become apparent through a preponderance of scientific evidence or an indisputable biosafety crisis, alternative technologies will evolve and overtake agbiotech as it is known today. In any case, the new knowledge and tools of molecular biology will continue to be decisive in the future of world agriculture.

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Agricultural Water Demand and the Gains from Precision Irrigation Technology

by

Karina Schoengold, David L. Sunding and Georgina Moreno

This paper estimates the parameters of agricultural water demand. Estimation results indicate that water use is responsive to changes in the price of water. The estimation results also find that the water savings from investment in precision irrigation technology vary widely by crop, but can be as high as 50 percent.

Allocation of scarce freshwater resources is an issue of great importance in dry regions of the world. Economists and other observers have argued that policies to improve the efficiency of water allocation can help alleviate conflicts among competing users and minimize water's role as a limit to growth. Efficiency-enhancing water management strategies can also help reconcile supply and demand imbalances without resorting to costly and environmentally damaging dams and other supply augmentation measures.

Water Use and Agriculture

Agriculture is the dominant user of water in the western United States and most other arid regions of the planet. Lacking adequate precipitation during the growing season, agriculture in these areas is dependent on large-scale diversion of surface water and groundwater pumping. In California, for example, even though large urban areas like Los Angeles, San Francisco and San Diego are almost entirely reliant on surface water diversion, agriculture in the state uses nearly 80 percent of developed surface water resources. In fact, considerably more water is used to grow hay in the state than is consumed by all the households and businesses in Los Angeles and San Francisco combined.

Using a unique panel data set from California's San Joaquin Valley, the results in this paper shed light on the short- and long-run responsiveness of farm water demand to changes in the marginal price of water.

One benefit of the estimation approach we employ is that it permits direct estimation of water conserved by the adoption of conservation technology. Our results show that there can be substantial savings from investment in precision irrigation technology, with reductions in water use per acre exceeding 40 percent in a few instances.

Due to the interest in using price reforms to manage water demand, a main objective of our analysis is to measure the responsiveness of farm water use to changes in the price of water. Our results allow us to distinguish between the changes in short- and long-run demand. Choices of outputs and production technologies are assumed to adjust over time, and thus a water price shock will have long-run effects through its influence on output and technology choice that will be distinct from the short-run effects that incorporate mainly management changes.

Data

Most of the data used in the estimation comes from Arvin Edison Water and Storage District (AEWSD). The data set includes an eight-year panel (1994-2001) in AEWSD. Annual data are collected at the field level on both the crop and irrigation system. Water price and delivery data are also provided by AEWSD. Combining records of technology and output choice by field with water delivery data, it is possible to piece together a fairly complete picture of water-use decisions at the micro level. Also important is the fact that in 1995, the District enacted a major water rate reform. By comparing water use before and after the rate reform, we can capture the effects of the price change, controlling for factors such as environmental conditions and changes in output prices.

Table 1 gives a summary of the land allocation over the sample period. The main citrus crop in the region is oranges; deciduous crops include mostly almonds, along with some peaches and apples. Truck crops include potatoes, carrots and onions, while field crops include cotton and some hay. Interestingly, perennial crop acreage has increased in recent years despite overarching concerns about agricultural water supply reliability. In 1994, perennial crops were planted on 49 percent of total acreage. By 1998, this had increased to 63 percent of total acreage.

Water Use and Capital Investment

In our analysis we explain water use at a particular location as a function of output and technology choices, relative prices and other factors such as environmental characteristics. Our estimation strategy assumes that the durability of physical capital fixes the input/output

Table 1. Land Allocation Over Time by Crop and Technology Type*

Crop	Irrigation	1994	1995	1996	1997	1998	1999	2000	2001
Citrus	*Drip*	16.9	16.8	16.4	20.9	22.0	22.4	22.0	22.3
	Gravity	1.9	2.0	2.2	2.3	2.4	0.9	1.4	1.3
	Sprinkler	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Grape	*Drip*	9.3	9.3	9.4	12.0	12.8	18.5	15.6	15.8
	Gravity	10.1	11.6	10.9	12.6	12.4	8.0	9.6	10.2
	Sprinkler	0.0	0.0	0.0	0.2	0.2	0.0	0.4	0.3
Deciduous	*Drip*	3.8	3.8	4.5	6.8	7.4	5.3	5.6	6.0
	Gravity	2.9	2.6	3.6	3.5	3.8	4.1	4.2	4.6
	Sprinkler	4.5	4.6	1.9	2.6	2.1	3.1	1.8	1.9
Truck	*Drip*	0.6	0.5	0.2	1.0	0.3	0.7	1.6	0.8
	Gravity	4.0	3.2	0.0	3.7	3.5	3.8	4.2	2.3
	Sprinkler	27.3	24.8	29.7	12.4	16.6	17.0	16.0	16.7
Field	*Drip*	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	Gravity	0.5	1.1	0.0	0.4	0.1	0.0	0.2	0.0
	Sprinkler	18.3	19.7	21.3	21.5	16.2	16.3	17.4	17.6
All Perennial Crops	*Drip*	30.0	29.9	30.3	39.7	42.2	46.2	43.2	44.2
	Gravity	14.9	16.2	16.7	18.4	18.6	12.9	15.2	16.2
	Sprinkler	4.5	4.6	1.9	2.9	2.4	3.1	2.2	2.2
All Annual Crops	*Drip*	0.6	0.6	0.2	1.0	0.3	0.7	1.6	0.8
	Gravity	4.4	4.2	0.0	4.1	3.6	3.8	4.4	2.3
	Sprinkler	45.5	44.5	51.0	33.9	32.8	33.3	33.4	34.3

** Land allocations are expressed in percentages, with the sum of citrus, grape, deciduous, truck and field crops in each year equal to 100.*

ratio in the short run, but that the choice of technology will adjust over time to changes in the relative prices of inputs and outputs. The choice of crop can also be viewed as a particular type of capital investment, as all crops require a significant investment in specialized farm equipment and human capital, while perennial crops also require capital investment in plant stock.

Water Savings from Precision Technology

An interesting and useful result of this analysis is that it allows measurement of the water savings resulting from investment in precision irrigation technology. To our knowledge, this is the first time such a benefit from investment in agricultural water conservation technology has been demonstrated and measured under field conditions. By comparing the coefficients of the same crop under different irrigation technologies in the water demand estimation, we can estimate the reduction in water application per acre from a change in technology. This analysis is done under the assumption that all other factors, such as slope, soil permeability and climate variables, are held constant. The results are presented in Table 2. With the exception of the comparison of water use by deciduous crops in gravity and in sprinkler irrigation, all of the coefficient pairs are found to be significantly different. In some cases, adoption of precision technology can cut water use per acre close to half.

Another important finding is that precision technology appears to result in different amounts of conservation when used on different crops. For example, drip irrigation uses only half the water of gravity irrigation with citrus crops. Therefore, the gain in moving from gravity to drip in citrus is very high. In grapes, drip irrigation also uses less water then gravity, but the difference is much smaller (a 30.2 percent reduction instead of a 46.4 percent reduction). The differential gains of the switch to efficient technology make sense from an agronomic or physical point of view as well. With citrus crops, the trees are widely spaced, leaving a lot of land between the trees where water is not used by the plant. Applying water directly to the root zone, as is the case with drip irrigation, will accordingly result in more water savings. Grapevines are planted much closer to each other, resulting in less wasted water from gravity-applied irrigation water.

Responses to Changes in Water Price

One benefit of our estimation approach is that the response to changes in water price can be decomposed into direct and indirect effects, where the indirect effects include changes in capital investment and land allocation.

We find that the indirect effect is unambiguously negative; implying that a change in the price of water induces water-conserving changes in crop and technology choices. It should also be noted that the indirect effects of water price changes are smaller than the direct effects. This pattern is explained by the fact that, while the price of water has been shown to be a significant determinant of adoption of conservation technology in agriculture, it is by no means the only determinant. Other factors such as weed control, a desire to save on labor costs, or a need to apply fertilizers precisely through the irrigation system can all spur investment in precision irrigation systems.

Our results show that agricultural water demand is somewhat more responsive to changes in the price of water than indicated by previous studies. Accordingly, one implication is that water rate changes can have a larger effect on water allocation than previously assumed. It is also worth noting that our panel only includes seven years of data after the major rate change. Given the durability of capital investments in irrigation systems, which can have a useful life of ten years or more, and plant stock, which can last up to forty years for some trees and vines, we would expect indirect effects to be larger when measured over a longer time period.

Some simple calculations help to illustrate the relative magnitudes of the direct and indirect effects. Table 3 summarizes our results, and shows how an increase in the marginal price of water reduces agricultural water use. For example, an increase of ten percent in the marginal price of water of $5.73 per acre-foot will reduce water use by 44.2 acre-feet per section, or 0.126 acre-feet per acre. Of this reduction, 83 percent is due to better management, and 17 percent is due to changes in crop or irrigation technology.

Table 2. Differences in Water Use Between Irrigation Technologies by Crop

	Irrigation Technologies Compared *		Percent Reduction in Water Use Coefficient **	
Type of Crop	Drip & Gravity	Gravity & Sprinkler	Drip & Gravity	Gravity & Sprinkler
Citrus	YES	n/a	46.4	n/a
Grape	YES	n/a	30.2	n/a
Deciduous	YES	NO	43.7	0.0
Truck	n/a	YES	n/a	41.9

** These columns answer the question "Is water use significantly different under the two compared irrigation technologies in the type of crop listed?" The tests that are not applicable (n/a) contain crop and technology combinations that are not observed in our data set.*

*** These columns show the percentage reduction in estimated water use from switching from gravity irrigation to a more efficient technology.*

Table 3. Effect of Changes in Marginal Water Price on Average Water Use

Percent Increase in Water Price	Water Price**	Avg. Water Use*	Direct Reduction	Indirect Reduction
		-----------Per Acre-------------		
0	57.3	3.034		
10	63.0	2.908	0.105	0.021
15	65.9	2.845	0.157	0.032
20	68.8	2.782	0.209	0.042
25	71.6	2.719	0.262	0.053
30	74.5	2.656	0.314	0.064

** Water use is measured in acre-feet*

*** Water price is the marginal cost per acre-foot in dollars*

Conclusions

Agriculture is the most important user of water in the western United States and in most arid regions of the world. As a result of rapid population growth and increasing concern about the environmental effects of surface water diversions, agricultural interests are under increasing pressure to conserve water. Our results indicate that an increase in the marginal price of agricultural water reduces demand for water. Of this reduction, the indirect effects of water price on output and technology choices account for roughly 17 percent of the total. This finding suggests that more active management has a large influence on water use. With larger price changes, indirect effects may be a larger fraction of the total.

Another important finding concerns the conservation benefits of adoption of precision irrigation technology. Comparing coefficients in the demand equation, the savings from switching from, say, gravity irrigation to drip is measured directly. For some crops, the water savings from investment in modern technology is large—close to 50 percent per acre. For others, the savings are not nearly as great. These findings provide a window on the performance of programs designed to stimulate investment in modern irrigation technologies and suggest that expectations of water savings should be conditioned on land allocation among crops.

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Faculty Profile

Shermain Hardesty is a Cooperative Extension Specialist in the Department of Agricultural and Resource Economics at UC Davis. She received her Ph.D. from the department in 1984. She returned to the campus in March 2002 to serve as Director of the Center for Cooperatives, a statewide special program, until its closure in January 2004 due to the severe budget cuts to the University's agricultural programs.

One of Shermain's strategies as director was to incorporate involvement of cooperative extension (CE) advisors in the Center's cooperative development projects. Her current projects include conducting feasibility studies with CE advisor Barbara Reed, for a cooperative cheese-aging facility in Glenn County, and a grass-fed beef marketing cooperative with CE advisor Roger Ingram, in Placer and Nevada Counties. She just initiated a similar beef project with Jay Norton, CE advisor/county director in Tuolumne County. Another of her current feasibility studies involves producers in Butte and Yuba counties who are interested in establishing a cooperative organic olive oil production facility. Dr. Hardesty is also completing research comparing the financial performance of cooperatives in specific agricultural sectors with investor-owned firms in similar sectors.

Shermain is establishing a center within the ARE department that will focus on rural cooperatives. Its mission will include assisting the development of new cooperatives and conducting research and outreach related to the issues of existing cooperatives. She is particularly interested in developing nontraditional structures and applications of the cooperative model to enable California's agricultural producers to compete effectively in a global environment. Potential structures include mergers to create international cooperatives, delivery rights to provide members with the potential for long-term capital gains from their equity investment, cooperatives designed to replace the generic promotion activities currently enabled by marketing orders, and equity financing programs involving nonmembers to expand cooperatives' access to capital.

In a recent discussion paper prepared for the California Agribusiness Executive Seminar, Dr. Hardesty assessed how the traditional structure of agricultural cooperatives has created weaknesses that can be overcome. These weaknesses include limited access to capital, difficulties in controlling members' delivery volumes, limited product diversification options and weak governance attributable to producer-members' lack of business expertise. She concluded that the future looks bright for California's supply and service cooperatives that remain focused on their core services. Bargaining associations could be displaced by marketing-agencies-in-common, and information-sharing cooperatives can effectively create countervailing power. Marketing cooperatives face considerable challenges, but the use of financing methods that are nontraditional for cooperatives, closed memberships and well-trained directors should greatly enhance their viability.

Shermain Hardesty
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To address cooperatives' education needs, Shermain is organizing a workshop for directors of California's agricultural cooperatives. Improved governance is the focus of the workshop, which will be held in Sacramento on July 13, 2004.

Shermain's second area of interest for research and outreach concerns the marketing issues of small producers. She is working closely with a group of producers from the Ferry Plaza Farmers Market who are organizing an association to increase the viability of farmers involved in direct marketing in the Bay Area. Shermain is also looking forward to collaborating with colleagues on a study of the marketing and distribution needs of California's organic producers.

In her spare time, Shermain enjoys cooking to appreciate California's seasonal bounties. She also cherishes getaways with her family at their cabin in Serene Lakes.

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Explaining Reduced Pesticide Use in Almonds

by
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Downward trends in dormant organophosphate (OP) use in almonds are explained by previous year's price, inventory, exports to Japan and educational programs. OP use varied significantly by region in California.

The California Department of Pesticide Regulation (DPR) began full-use reporting of all agricultural pesticides in 1990. The program requires monthly reporting of all agricultural pesticide use to the county agricultural commissioners, who transfer the information to DPR. The reports include the date and time of the application, commodity treated, acres planted, acres treated, pesticide product and quantity applied, application method and other grower identification information. Observation of downward trends in pesticide use led to questions as to the reasons for the decline. This study develops a methodology to determine the factors influencing levels of pesticide use for classes of materials and applies the methodology to a specific example—dormant organophosphate (OP) use in almonds.

Pesticide use can decrease in several ways. First, the number of growers using the pesticide can decrease; second, growers can continue to use a pesticide but on only a portion of their planted acreage; and third, growers can continue to use the pesticide but at lower rates than before. These three together give a complete picture of the changes in pesticide use over time.

Dormant Season OP Use in Almonds

OP dormant sprays control overwintering pests including navel orange worm (NOW), San Jose scale, peach twig borer (PTB) and early season mites. The use of OPs in California first came under scrutiny in the late 1980s when they began to show up in groundwater. Applications during the winter rainy season were identified as the major source of OP runoff into surface water. In response, alternatives have been developed and encouraged through private and public research and education programs. Spring application of pyrethroids is one alternative for control of NOW and PTB, although these materials increase the risk of high mite populations later in the season. *Bacillus thuringiensis* (Bt) is a second alternative control method for NOW and PTB, and is considered to have reduced risk of environmental harm.

DPR conducted an extensive statistical analysis of trends in dormant OP use in California from 1992 to 2000. The analysis confirmed a downward trend in OP use in California over the past ten years, measuring OP use as total pounds applied, percentage of total acreage treated and numbers of growers who applied dormant OPs.

Dormant OP Use Hypotheses

Hypotheses as to factors influencing the use of dormant OPs in almonds evolved from individual interviews with University of California Cooperative Extension farm advisors with almond responsibilities in Kern, Butte, Glenn and Fresno counties, and interviews with DPR researchers. In addition, hypotheses emerged from a focus group of private pest control advisers and growers active in the northern Sacramento Valley.

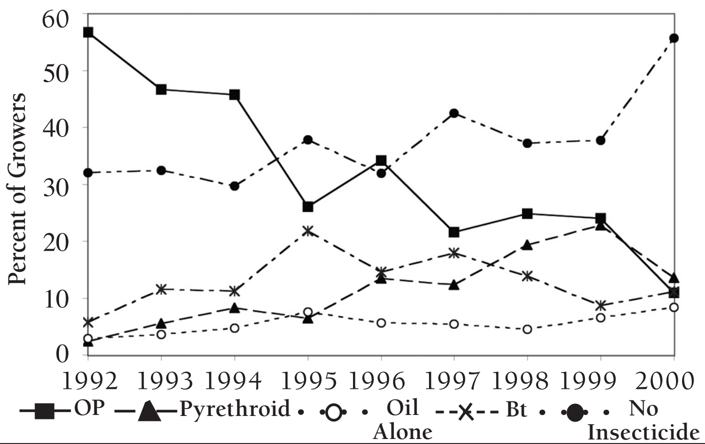
The hypotheses formed fall into the categories of weather, economics, physical, education and risk. Weather impacts OP spray decisions in several ways. In extremely wet years, it is difficult or impossible to get equipment into the orchard to apply a dormant spray in the winter. Consequently, we expected the number of acres treated with a dormant spray to increase the year following the high rain year.

Profitability was the number one reason given for skipping sprays. All almond handlers give bonuses for low reject levels. Growers are more likely to apply a dormant insecticide following a year of relatively high rejects and are more willing to take risks (skip sprays) in a low price/high crop year.

In the early 1990s, growers observed that they did not usually have a San Jose scale problem on almonds and that early season mites were not bad on almonds. They began to experiment with dropping OP sprays. Many growers adopted the strategy of letting populations of mites and scale build up over a few years before spraying, to reduce costs and resistance to pesticides by target pests. The overall consensus was that Kern County had more in-season insect problems than the other regions of the state, due to a longer growing season.

Growers adopted Bt after bloom, once Bt products were available, as an alternative to OP dormant sprays. However, the efficacy of Bt is now perceived by many

Figure 1. Percent of Growers Using Different Dormant Seaons Practices



to be too variable. In the mid 1990s, growers started to use pyrethroids plus oil for control of PTB. This treatment offered longer control than Bt products.

Growers expressed concern about the future availability of OPs due to pesticide regulations and have tried to find alternatives before losing the materials. Thus, over time, any given grower would be less likely to apply OPs for relatively routine pest problems that can be controlled using alternatives.

Data and Variables

We tested the hypotheses using data for the years 1992-2000. Pesticide use report (PUR) data was obtained from DPR. Each grower has a unique identification number for the PUR database, and reports the annual number of almond acres planted and the total acres treated with each specific pesticide, along with the date and location of each application.

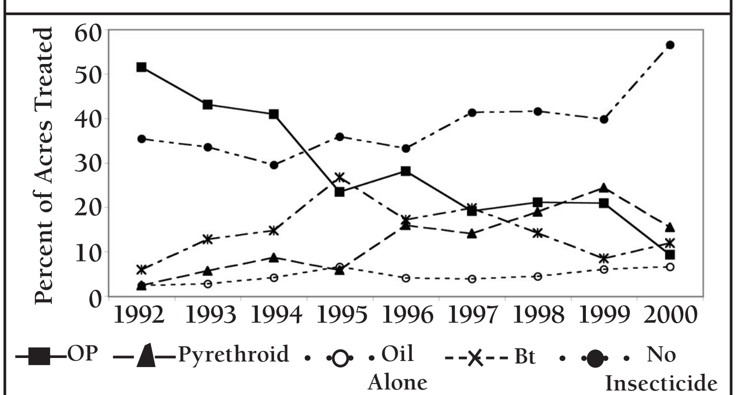
Weather variables for two time periods were included: the full dormant season (November 1 to March 20), and the critical dormant season (January 15 to February 15). Weather variables used data from the National Weather Service.

We aggregated counties into four growing regions to reflect differences in pest pressure, microclimate and other factors. Kern County was treated as its own region, Fresno and Tulare counties were aggregated into the south region, San Joaquin, Stanislaus, Yolo, Madera and Merced counties comprised the central region, and Butte, Colusa, Glenn, Sutter and Tehama counties comprised the north region.

We calculated an annual price measure for OPs, pyrethroids, carbamates, oils and Bt. Prices for individual products within each class were weighted by the recommended label application rate per acre. Almond price and quantity information was obtained from the Almond Board of California including the current and lagged price of almonds, carry-in from the previous year, carry-out to the next year, as well as the state aggregate pounds of almonds rejected for the current and previous year. Annual almond production was reported separately by county for the current and lagged year.

One specific objective was to test whether or not integrated pest management programs had a significant effect on pesticide use. Arguably, the most important research and educational effort directed at developing and promoting alternatives to dormant OP use is the Biologically Integrated Orchard Systems (BIOS), a program resulting from a collaboration among the Community Alliance with Family Farmers, growers, licensed pest control advisers, University of California Cooperative Extension researchers and DPR. The BIOS program was a focused outreach, education and demonstration program providing assistance to growers wishing to reduce synthetic pesticide use. The presence of a BIOS program in a county was expected to have an impact on OP use regardless of whether or not a grower actually enrolled in the program. The BIOS program was in effect in Merced, Stanislaus, Madera, San Joaquin and Colusa counties during some part of 1993 - 1999.

Figure 2. Percent of Almond Acres Treated with Various Dormant Season Insecticide Practices



Empirical Analysis

To test our hypotheses, we completed three sets of statistical analyses. The first set examined whether or not individual producers chose to use any OPs in a given year. The second set examined the acres to which individual producers applied OPs in a given year. The third set examined application rates.

Figure 3. Pounds of Active Ingredient per Almond Acres Planted

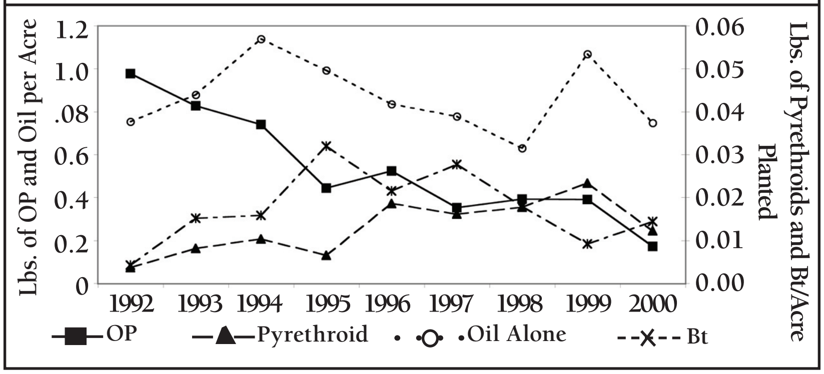


Figure 1 shows the trends in growers' decisions to use dormant control practices over the study period. The previous year's price of almonds was positively correlated with OP use, and was highly significant. This implies that growers expect a high price last year to translate into a higher price this year. As predicted, OP use increased with a higher reject level the previous year. Higher current year Japanese exports significantly increased OP use, as predicted, although the magnitude of the effect was quite small. However, higher current year total exports significantly decreased OP use.

The BIOS program consistently reduced the probability that a producer used OPs. The BIOS variable evaluates the effect that the program had when it was active. The "BIOSbeg" variable, which evaluates the effect the program had when it was active and after it ended, also reduced OP use, indicating that BIOS continued to impact OP use after the program officially ended.

The second analysis examined the determinants of the number of acres to which a grower applied OPs. Figure 2 shows the trend in acreage treated with various dormant season practices. Region was an important determinant of application acres, consistent with differences in farm sizes. Growers in the central region applied OPs to significantly fewer acres than growers in the northern region. Conversely, growers in Kern County applied OPs to significantly more acres than growers in the northern region. Also, growers in the south region applied OPs to more acres than growers in the northern region, although the difference was not always significant in this analysis.

We performed a third analysis to investigate the determinants of the application rate. Figure 3 shows the trends in pounds of active ingredient (AI) applied per acre for alternative dormant season materials. The mean application rate for OP was 1.82 pounds per acre, or approximately half the recommended label rate of four pounds per acre. The time trend variable was significant and positive in these specifications. Farms with more total almond acres used significantly lower application rates than those with fewer acres, although the effect is small in magnitude.

Growers in the south region and Kern County used significantly higher application rates than growers in the north region. Growers in the central region had application rates that were not significantly different than in the north region.

This analysis provided evidence that the BIOS program reduced OP use. The rate of OP application decreased in counties and years when the BIOS program was active and remained lower in the years following the end of the formal program.

Conclusion

This study shows that over time, growers are less likely to use environmentally unfriendly pesticides, especially when effective alternatives are available. Growers are more likely to use harmful pesticides in years when they expect yields to be low and more likely to use them when price expectations are high. Educational and demonstration programs are effective in reducing the use of targeted pesticides. Growers are more likely to reduce the use of pesticides by avoiding use altogether than using pesticides on only part of their acreage. Interestingly, application rates for those using pesticides may be increasing over time even though the percentage of growers using that pesticide is decreasing. This is consistent with education measures encouraging growers to limit pesticide use to serious pest problems. The results make the case for increased public/private partnerships to develop and execute education and demonstration programs related to pesticide use.

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