UNIVERSITY OF CALIFORNIA GIANNINI FOUNDATION

UPDATE

Agricultural and Resource Economics

VOL. 5 NO. 2 FALL, 2001

Contractual Arrangements for Fresh Produce in California

by Ethan Ligon

Contracts may help shield growers from price risk, but some exposure to price risk may help align grower and marketer interests. Ê

Producers of fruits and vegetables, especially for the fresh market, operate in an unusually risky economic environment. While these farmers face the same sorts of production risk common to much of agriculture, they also produce a perishable commodity whose price is subject to unusually large fluctuations. While some of this variation in prices is predictable (e.g. seasonal variation), much of it is not, depending instead on unforeseeable shocks to both supply and demand. Indeed, price risk is particularly important for fruit and vegetable growers; dry beans, fresh pears, lettuce, fresh apples, grapefruit, potatoes and onions exhibit the greatest degree of price volatility of any agricultural commodities. Further, despite the great risk, no futures contracts or commodity insurance schemes exist for most fresh fruit and vegetable production.

Contracts

One important institution which does help to shield fruit and vegetable producers from both price and production risk are contracts, written between a producer and a "first handler," or intermediary who takes possession of fresh produce from the grower. Such contracts are of great importance for fresh produce. Roughly one third of total agricultural production (by value) in the U.S. is produced under contract, and of this third, fruit and vegetable production accounts for some 20 percent.

Contracts between growers and first handlers are part of the process enabling "vertical coordination" in the food production chain. Vertical coordination is a general term used to signify ways of harmonizing the vertical stages of production and marketing. While the role that contracts play in coordination is no doubt important, another important reason for the use of contracts is to reduce the degree of risk (in both price and production) that growers must bear, since an appropriately designed contract allows the first handler to share both sorts of risks with the grower.

A distinction is often drawn between marketing and production contracts; the idea being that with a marketing contract the grower assumes all risks of production but shares price risk with the first handler, while with a production contract the grower provides husbandry, but the first handler owns the commodity (and thus bears a greater share of the risk). If we employ this distinction we find that marketing contracts are of much greater importance for fresh produce than for

CONTRACTUAL ARRANGEMENTS-
Continued on page 2

Also in this issue..................

In the next issue....................

Changes in the North American Fresh-Market Tomato Industry Pose Challenges for California Tomato Growers
by Roberta Cook-Canela

other agricultural commodities; conversely, production contracts are little used. Of total contract production for all of U.S. agriculture (equal in value to some $60 billion in 1997), approximately $40 billion was produced under marketing contracts and $20 billion under production contracts. Of this total, only $1.1 billion (5.5 percent) worth of fruits and vegetables were produced under production contracts, while in contrast $10.6 billion worth of fruits and vegetables were produced under marketing contracts (26.5 percent).

The outsized importance of price risk to fruit and vegetable producers accounts for the particular importance of marketing contracts for this population. However, a close examination of the actual contracts typically employed for fresh produce reveals that although these contracts almost always reduce the risk producers face, they almost never eliminate it entirely. Furthermore, the amount of risk first-handlers are willing to shoulder depends importantly on the kind of commodity under contract.

At first glance, this may not seem surprising. After all, first-handlers presumably don't like risk either, and, as it is usually the first handler who designs the contract, they would seem to have no more interest in sharing the risks faced by the producer than they would in increasing the prices they pay for produce. Closer examination, however, shows this view to be simplistic. After all, a first-handler who is willing to share a grower's risk can charge for the service, since such a firm is implicitly offering not only marketing services to the producer, but also offering a measure of insurance. Furthermore, a first-handler who contracts with many different producers can reduce total risk by pooling, since years which are difficult for one producer may be offset by a particularly profitable year for another. An effective pooling scheme could eliminate any grower-specific risks, making the compensation received by the grower depend only on the risk collectively faced by all the growers under contract with a particular first-handler.

Unfortunately, by pooling all risks a first-handler might reduce a grower's incentives to produce both quantity and quality. This problem is particularly obvious in the case of production risk. If a first-handler were to make payments to the grower which depended only on acreage planted and not on harvest, the grower would have a powerful incentive to underinvest in costly inputs and labor. However, the case seems much less clear when we consider price risk. Why don't first-handlers make a payment which depends only on the quantity and quality of produce, observed at the farmgate?

It turns out that the main reason for price risk in contracts is that unobserved investments by the grower (e.g., labor effort, the application of fertilizers or pesticides) influence not only the quantity of the grower's output, but also its quality. By itself, this would not necessarily expose the grower to price risk. The first-handler may be able to simply condition payments on the quality of the produce, if he can observe it. If the first-handler is unable to observe quality directly, he may seek to infer it; objectively by measuring a variety of attributes of the produce, and perhaps also by more subjective means. However, if this inference is less than perfect, then the grower may well be exposed to price risk.

To see why poorly measured quality may expose the grower to price risk, consider the case of fresh, mature–green tomatoes. For tomatoes, the first-handler may care a great deal about the quality of the tomatoes he purchases as the quality of the tomatoes will effect the price eventually paid by the consumer. The grower has a fair amount of control over some of these qualities. For example, by modifying his irrigation or pest management practices, he may be able to affect shelf life. However, judging the eventual shelf-life may be extremely difficult to do at the farm gate, and may only become apparent when the tomatoes have actually become nearly unsaleable. Because the first-handler may be uncertain as to whether or not the tomatoes he has purchased do in fact have some of the qualities advertised, it may be optimal to ask the grower to pay some of the costs of short shelf life (or other qualities) by making his payment contingent on the prices eventually received by the firm.

Using data from a survey of the contracts offered by first handlers I conducted in 1999, we can get some handle on the relative importance of price risk and quality measurement in contracts. The sample frame was derived from the California Department of Food and Agriculture database of all firms licensed to purchase and broker agricultural products in California. The total size of this population is 4770.

Many of the firms licensed to buy wholesale agri-

CONTRACTUAL ARRANGEMENTS-
Continued on page 10

Plant Biotechnology in the Developing World: The Case of China

by

Scott Rozelle, Fangbin Qiao and Jikun Huang

A survey of China's plant biotechnologists shows that China is developing the largest plant biotechnology capacity outside of North America. This could affect trade with the United States, since it will increase China's supply and slow down imports.

Private life-science companies in the industrialized world perform most of the world's agricultural biotechnology research and technology development. Farmers in the United States have been the biggest beneficiaries of this work. More than 75 percent of area sown to genetically modified (GM) crops is in the US.

However, it is possible that the industrialized world's monopoly on plant biotechnology may no longer exist in the near future. In the past decade China has been accelerating its investments in agricultural biotechnology research and is making breakthroughs on commodities that have been mostly ignored in the laboratories of industrialized countries. Small farmers in China have begun to aggressively adopt GM crops. And this is happening at a time when, because of consumer resistance to GM products and the rising cost of commercializing new products, private research and development on plant biotechnology in the industrialized countries is declining.

This article utilizes data from a survey of 29 of China's plant biotechnology research institutes and interviews with the research directors of the major plant biotechnology programs. The overall goal is to answer the questions: What is China doing in agricultural biotechnology research? Is China's public-sector dominated investment strategy efficient? Can China be a source of plant biotechnology for its own farmers and for farmers in the rest of the world? Will this make China more competitive in the future and/or reduce its needs to import US agricultural commodities?

Plant Biotechnology Research and Achievements in China

Since the mid-1980s, scientists in China – mostly on their own, using technologies that they have developed themselves – have been applying advanced biotechnology tools to the field of plant science. The effort of the research community in China has generated an impressive array of new breakthroughs. From 353 applications between 1996 and 2000, China's Office of Genetic Engineering Safety Administration approved 251 cases of GM plants, animals, and recombined microorganisms for field trials, environmental releases, or commercialization (Table 1, rows 1 and 2). Of these approvals, regulators approved 45 applications for field trials of GM plant varieties, 65 for environmental release, and 31 for commercialization (rows 3 to 5).

Table 2 summarizes breakthroughs in China on food crops that have received little attention elsewhere. This commitment demonstrates the government of China's concern for food security. Transgenic rice resistant to three of China's major rice pests – stem borer (using Bt and CpTI genes),

Table 1. Agricultural Biotechnology Testing in China, 1997-2000

	1997	1998	1999	July 2000	Total
Total (plants, microorganisms and animals)					
Submitted	57	68	126	102	353
Approved	46	52	94	59	251
Approved for Plants					
Field Trials	29	8	28	na	45
Environmental release	6	9	30	na	65
Commercialization	4	2	24	1	31

Table 2. Genetically Modified Plants (commercialized and in trials) in China, 1999

Crop	Induced Trait
1. Cotton	Insect resistance [a] Disease resistance
2. Rice	Insect resistance Disease resistance Herbicide resistance Salt Tolerance BADH
3. Wheat	BYDV resistance and quality improvement
4. Maize	Insect resistance (Bt) & Quality improvement
5. Soybean	Herbicide resistance
6. Potato	Disease resistance
7. Rape Seed	Herbicide resistance
8. Peanut	Virus resistance
9. Tobacco	Insect resistance
10. Cabbage	Virus resistance
11. Tomato	Virus resistance [a] Shelf-life altered [a] Cold tolerance
12. Melon	Virus resistance
13. Sweet Pepper	Virus resistance [a]
14. Chili	Virus resistance
15. Petunia	Color altered [a]
16. Papaya	Virus resistance

Source: Authors' survey

[a] Approved for commercialization; all others waiting for commercialization or environmental release

planthopper, and bacterial leaf blight (using the Xa21 gene)–have already been through at least two years of successful environmental release trials. Researchers have moved GM wheat with BYDV resistance to field and environmental release trials. China's scientists also are experimenting with GM potatoes and peanuts. They also have begun experimenting with an array of horticultural and floral crops although work is still at a very early stage.

The nation's public-dominated research system has given China's researchers a strong incentive to produce GM crops that increase yields and prevent pest outbreaks. In industrialized countries, 45 percent of all field trials are for herbicide tolerance and improving product quality; only 19 percent are for insect resistance. In China, more than 90 percent of the field trials target insect and disease resistance.

Plant Biotechnology Research Resources

Unlike the rest of the world, in which most plant biotechnology research is financed privately, China's government funds almost all of the country's plant biotechnology research. The Ministry of Science and Technology has increased investment in plant biotechnology from 16 million yuan in 1986 to 92.8 million yuan in 1999. After a number of adjustments, China's total investment in plant biotechnology in 1999 was estimated to be US $112 million in Purchasing Price Parity (PPP) terms, more than 80 percent of which was directed at scientists in research academies.

Expenditures of this level, as well as future investment plans, demonstrate the seriousness of China's commitment to plant biotechnology, especially when compared to that of other developing countries. The two other large biotechnology programs in the developing world, in Brazil and India, fall short of China's. The Brazilian central agricultural research system, EMBRAPA, spends US $ 2 million annually on genetic engineering. The Indian government allocates US $ 15 million in PPP terms. Even after adding the investment of private firms (estimated to be US $10 million), plant biotechnology research expenditures in India are still only around 20 percent of China's. Given these levels of spending, China accounts for more than half of the developing world's expenditures on plant biotechnology

Compared to the industrialized world, including the U.S., China's spending has been relatively small, less than 5 percent of the $2 - 3 billion expended in industrialized countries. Such an assessment changes, however, when comparing China to the public research spending of other countries and when considering its future plans. Globally, the public sector makes about 45 percent of the research expenditures on plant biotechnology. China currently accounts for about 10 percent of this amount. In early 2001, however, China's officials announced that they plan to raise research budgets

Table 3. Yields, Costs and Pesticide Use by Cotton Varieties in the Sampled Households, 1999

Variety	Yield kg/ha	Total Production Costs per kg cotton (yuan/kg)	Pesticide use per Hectare No. of Applications	Quantity (kg)	Cost (yuan)
Bt cotton	3371	3.10	6.6	11.8	261
Non-bt	3186	4.28	19.8	60.7	1465

for plant biotechnology by 400 percent over the next 5 years. If this plan is carried out, China could account for nearly one-third of world's public spending on plant biotechnology. China's agricultural biotechnology research staff has become one of the largest in the developing world.

The Case of Bt Cotton

In response to rising pesticide use and the emergence of a pesticide resistant bollworm population in the late 1980s, China's scientists began research on GM cotton, launching the nation's most successful experience with GM crops. Embarking on their own method for genetically modifying crops, China's scientists started with a gene isolated from the bacteria, *Bacillus thuringiensis* (Bt) and modified the cotton plant using an artificially synthesized gene that was identified with sequencing techniques. Greenhouse and field testing began in the early 1990s. When cotton yields and sown area decreased due to pest losses in the mid-1990s, in 1997 China's Office of Genetic Engineering Safety Administration approved the commercial use of GM cotton. During the same year, Bt cotton varieties from publicly funded research institutes and from a Monsanto joint venture (with the U.S. seed company Delta and Pineland and the Hebei Provincial Seed company) became available to farmers. Although officials had previously approved the commercial release of tomatoes, sweet peppers and petunias into circumscribed regions around certain cities in China, the release of Bt cotton began China's first large-scale commercial experience with a product of the nation's biotechnology research program.

Response by China's poor cotton farmers to the introduction of Bt cotton eliminates any doubt that GM crops can play a positive role in poor countries. From only 2,000 hectares in 1997, the sown area of Bt cotton grew to around 700,000 hectares in 2000. By 2000, farmers planted Bt varieties on 20 percent of China's cotton acreage. The average cotton farm in the survey sample was less than 1 hectare. Currently, Bt cotton in China is the world's most widespread transgenic crop program for small farmers.

Farmers are receiving the greatest benefit from Bt cotton's reduced need for pesticides. According to our producer survey, Bt cotton farmers reduced their use of pesticides by an average of 13 sprayings, or 49.9 kg, per hectare per season (Table 3). This reduced costs by 1204 yuan per hectare per season. Farmers also significantly reduced labor for pest control.

The decrease in pesticide use has increased production efficiency. Although per hectare yields and the price of Bt and non-Bt varieties were the same, the costs savings and reduction in labor enjoyed by Bt cotton users reduced the cost of producing a kilogram of cotton by 28 percent from 4.28 yuan to 3.1 yuan (Table 4). If this case is generalizable to the case of farmers that plant other crops in China (and other developing countries), plant biotechnology will certainly have an impact on world production, consumption, nutrition, and trade.

Assessing the Impact of China's Plant Biotechnology Program

China's experience with Bt cotton demonstrates the direct and indirect benefits of its investment in plant biotechnology research and product development. According to our research, the total benefits from the adoption of Bt technology in 1999 were 650 million yuan. Ignoring the benefits created by foreign life science firms, the benefit from the varieties created and extended by the China's publicly funded research institutes were 375 million yuan. Farmers captured almost all of these benefits since government procurement prevented cotton prices from declining (which would have shifted some of the benefits to consumers). The social benefits from research on one crop, cotton, in only the second year of its adoption were enough to fund all of the government's crop biotechnology research in 1999. As Bt cotton spreads, the social benefits from this crop will easily pay for China's past biotech expenditures on *all* crops. Clearly, the high returns are one reason China is pushing ahead with plans to expand its biotechnology research agenda.

The survey also showed that farmers reduced the use of the most toxic pesticides, organophosphates and organochlorines, by more than 80 percent, and that this reduction appears to have improved farmer health. The survey asked farmers if they had suffered from headaches, nausea, skin pain, or digestive problems after applying pesticides. If the answer was "yes," it was registered as an incidence of "poisoning." Only 4.7 percent of the Bt cotton growers reported poisonings; 11 percent of the farmers who used both Bt and non-varieties reported poisonings; and 22 percent of those who used only non-Bt varieties reported poisonings.

China is still struggling with issues of consumer safety and acceptance, and it still has not approved the commercial use of GM varieties for a major food crop. Nonetheless, the needs of China's producers and consumers, the size of China's research investment in plant biotechnology, the rise of its research capacity, and its success in developing biotechnology tools and GM plants suggest that products from its plant biotechnology industry will one day become widespread inside China. If so, China's farmers will almost certainly become more productive. And the rise in productivity will directly affect China's production and will either directly or indirectly affect its trade in agricultural products. With China's accession to the World Trade Organization, the rest of the world (including farmers in the U.S.) expect to increase exports to China, and as new imports flow into the country, farm gate prices will certainly fall and reduce the income of some farm households. While we do not think that the increase in productivity will change China's long–run role as a major importer of the world's grains and other land intensive staple crops, aggressive adoption of cost reducing GM technology will slow down the flow of imports into China and reduce the decline in income that its grain farmers will experience.

China also could become an exporter of biotechnology research methods and commodities. Opportunities for contract research selling genes, markers and other tools, and exporting GM varieties are expanding in both industrialized and developing countries. China has the advantages of a large group of well-trained scientists, low cost research, and large collections of germplasm.

For further information on this subject, the author suggests the following resources:

C. James, Global Status of Commercialized Trangenic Crops, ISAAA Briefs 17, 65 (2000).

C. E. Pray, "Corporate Structure: Status of Research in a Chastened Agbiotech Sector," Paper Presented at the 2001 American Agricultural Economics Association Annual Meetings, Chicago (2001).

J. Huang, R. Hu, L. Zhang, S. Rozelle, *China's Agricultural Research Investment*, China Agricultural Press, p. 105 (2000).

Z. Xu, Biological Engineering Progress 20, 20 (2000).

R. L. Paarlberg, Governing the GM Crop Revolution: Policy Choices for Developing Countries, 2020 Vision Discussion Paper 16 (2001).

M. Qaim. The Situation of Agricultural Biotechnology in India, Center for Development Research (ZEF), University of Bonn (2001).

J. Huang, Q. Wang, Y. Zhang. "Agricultural Biotechnology Development and Research Capacity," Working Paper, Center for Chinese Agricultural Policy, Chinese Academy of Sciences (2001).

J. Huang, R. Hu, C. Pray, F. Qiao, S. Rozelle, "Biotechnology as an Alternative to Chemical Pesticides: A Case Study of Bt Cotton in China," Working Paper, Department of Agricultural Economics, University of California, Davis (2001).

Scott Rozelle is a professor in the Department of Agricultural and Resource Economics at UC Davis. His field of interest includes development economics and the economics of transition. He can be reached by telephone at (530)752-9897 or by e-mail at rozelle@primal.ucdavis.edu. Fangbin Qiao is a graduate student in ARE at Davis. Jikun Huang is the director of the Center for Chinese Agricultural Policy, Institute of Geographical Sciences and Natural Resource Research, at the Chinese Academy of Sciences in Beijing, China. Dr. Huang can be reached by e-mail at jikhuang@public.bta.net.cn.

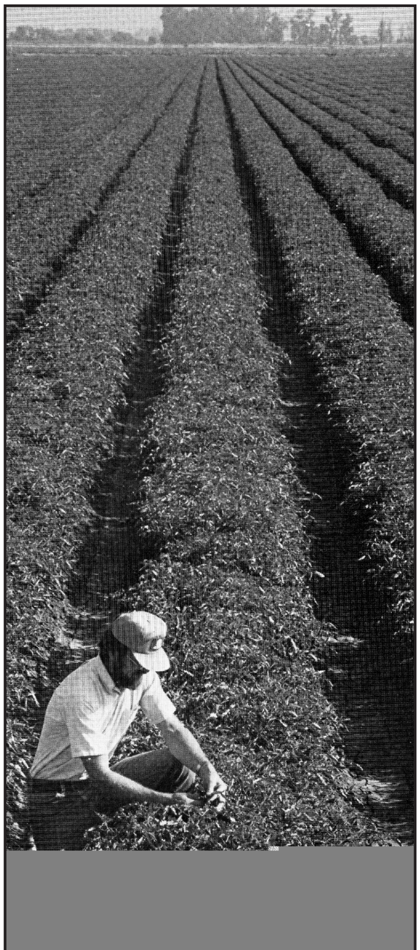
Pesticide Use, IPM and Pest Management Advice

by Mark Metcalfe

A survey of processing tomato growers reveals the more time growers spent monitoring their fields and the higher the quality of that monitoring, the less chemical pesticides that were used by the grower. Ê

A recent report by the National Research Council documents the fact that chemical pesticide use contributes to the value of U.S. agriculture, but it is also widely known that this pesticide use is responsible for generating undesirable environmental side effects. A long-standing objective of pesticide regulatory policy has been to reduce the occurrence of these undesirable effects, while simultaneously maintaining the effectiveness and value of pest management programs. Integrated Pest Management (IPM) strategies provide agricultural producers with the tools necessary to help achieve this regulatory objective, and therefore from a policy perspective it is important to have an understanding of the factors which influence chemical pesticide use and the adoption of IPM. To this end, a study of tomato growers in California was undertaken to examine the recommendations of pest control advisors, the use of IPM, and the factors influencing chemical use in the industry.

The availability of information is a particularly important factor that influences pesticide use in agriculture. Two important sources of information for growers are pest control advisors and Integrated Pest Management guidelines. The advice of pest control advisors and the implementation of IPM guidelines influence the use of chemical pesticides and the extent of this influence is dependent on the amount of effort devoted to the monitoring of field conditions, which is the process of information collection. Note that the use of IPM does not mean that no chemical pesticides are used. Instead, IPM guidelines provide standards for monitoring fields and call for the application of chemical pesticides when the monitoring of field conditions indicates that pesticides are necessary. The monitoring of pest populations and crop damage provides growers and advisors with the information necessary for more direct and efficient use of pesticides, both where and when they are needed.



Pest and disease monitoring provides growers and advisors with the information needed for more direct and efficient use of pesticides.
Photo courtesy of UC IPM Program

The use of IPM is not an all or nothing proposition; many different types of pest management programs utilize IPM practices to different degrees. Field monitoring and implementation of suggested guidelines are part of IPM, but the extent of monitoring and implementation of guidelines can differ substantially from farm to farm and also within the same farm depending on the nature of pest problems. That is, in cases where monitoring can be undertaken more easily, IPM is more readily adopted. Given this variability in IPM, it is difficult to determine to what degree IPM is used and the rate with which new practices are adopted. Nevertheless, it seems clear that IPM techniques have been successfully adopted by a significant number of California growers in cotton, almonds, stone fruits, walnuts and processing tomato production.

In the case of California processing tomatoes, a 1992 study surveyed 73 growers in six northern California counties to collect data on pest management from 130 fields of processing tomatoes with an

Table 1: Percentage Adoption of IPM Monitoring Techniques

	Adopter[1]	Non Adopter[1]
Insect Monitoring		
Monitoring of seedling pests	80	20
Monitoring of mid season pests	81	18
Monitoring of mid season predators	47	52
IPM fruit worm leaf sampling	20	80
Modified IPM fruit worm leaf sampling	16	83
IPM fruit sampling	9	90
Modified IPM fruit sampling	54	43
Consideration of fruit worm parasitization	23	76
IPM worm threshold	14	34
Disease Monitoring		
Scheduled mold control	56	38
Deep soil moisture probing	69	27
Shallow soil moisture probing	27	69
Routinely moisture probing	69	29
Irrigation water budgeting	14	83
Nematode Monitoring		
Routine nematode probing	23	76
Nematode lab tests	12	85
Nematode infestation records	18	80
Weed Monitoring		
Weed infestation records	16	80

[1] *Percentage of total sample. The difference between adopter plus non adopter and 100 percent represents non-respondents.*

Source: Wiebers, U., "Economic and Environmental Effects of Pest Management Information and Pesticides: The Case of Processing Tomatoes in California", Ph.D. Dissertation, Techniche Universitat Berlin, 1992.

acreage of 59,658 acres, which is 19.2 percent of California's total tomato acreage and 16.8 percent of total U.S. acreage. To identify the extent of IPM use, growers were asked whether or not they employed 18 different IPM guidelines for insect, disease, nematode, and weed management. Table 1 presents the percentage of adoption of IPM monitoring techniques by the growers surveyed.

The results of the survey reveal that adoption rates varied considerably across guidelines, but also show that many types of IPM strategies were in use. There was a high percentage of adoption of seedling and mid-season insect pest monitoring as well as deep soil and routine moisture probing for disease monitoring. While these quantitative measures are surely different today as compared with 1992, our research on this topic indicates that the qualitative factors influencing these numbers are similar and therefore identification of these factors and their implications is very important.

For example, the interaction between pest control advisors and growers is an important factor that influences the level of chemical pesticide use. The influence of pesticide use advice is becoming increasingly important as pesticide products and regulations become more complex and consequently, farmers become more dependent on the specialized knowledge and information provided by pest control advisors. All growers in the survey monitored their fields to some extent in order to obtain some pest information. The monitoring activities of growers are characterized by the time allocated to monitoring and the quality of that monitoring. The more growers are involved in quality monitoring, the more likely they are to be the first to identify pest problems and to identify them in the early stages when they can be controlled with fewer chemical inputs. Thus, individual growers have incentive to invest in monitoring activities in order to both reduce damage and also to reduce overall chemical pesticide costs.

A pest control advisor may not be aware of a grower's monitoring efforts but may be aware of the grower's knowledge of pest management. An advisor may expect that informed growers are more aware of their field situation and therefore may prescribe lower amounts of pesticides, expecting that more informed growers are better able to identify pest problems as well as better able to apply the chemicals effectively. Also, since some advisors employed by chemical companies earn commision on pesticide sales, it is often hypothesized that they may have incentive to sometimes over-prescribe the use of pesticides. If so, then they would be most likely to over-prescibe to those farmers considered to be less informed.

A parasitic wasp, Hyposoter exiguae, lays an egg in a young beet armyworm. Such natural enemies play an important role in the control of many tomato pests.
Photo Courtesy of UC IPM Program

Analysis of the results of this survey demonstrate the importance of the pest control advisor and grower relationship. Results reveal that growers of processing tomatoes depend heavily on the information obtained directly from monitoring their fields. That is, the more time growers spent monitoring and the higher the quality of that monitoring, the less chemical pesticides that were used by the grower. Chemical pesticide use was shown to be higher for use recommendations made by pest control advisors. The costs associated with these higher recommendations are calculated to be $26.40 per acre for advisors compared with $20.90 per acre for growers. Thus, advisors recommended, on average, pesticide use levels that were $5.50 per acre, or 26 percent higher than growers. This suggests that designing IPM monitoring programs that can be easily implemented, as well as training growers as to the use of these programs, would help to reduce the use of chemical pesticides.

The study also found that the pesticide use recommendations of advisors are dependent on the advisor's perception of grower's pest management knowledge. That is, more chemical pesticides were suggested for use on fields where growers were perceived to be less informed about pest management decisions. This fact once again suggests that increasing grower education through improved IPM training would help reduce the use of chemical pesticides both by pest control advisors and by growers adopting IPM techniques.

What can be done to increase the use of IPM practices in California agriculture? Improvements in the ease of monitoring and increased grower information would help increase IPM adoption and reduce chemical pesticide use through two channels: 1) improved grower involvement in pest management; and 2) improved perception of grower knowledge by pest control advisors. It is important to think of IPM as more than a technology that is available for farmers to either choose to adopt or to not adopt. Rather, it is a long term way of thinking about how to manage pests and how growers and pest control advisors can work together in a more effective and environmentally safe manner. Therefore to encourage the adoption of these long-run objectives, growers and pest control advisors need to be encouraged to build and continuously update their knowledge base, through education and training.

Our current research continues to examine these issues in order to update our understanding of the economic incentives of farmers and pest control advisors as well as the outside factors which influence pesticide use decisions. Only by understanding the incentives and factors that drive pesticide use can IPM programs be tailored to fit into the long–run pest management strategy of farmers and pest control advisors.

Mark Metcalfe is a research economist in the Department of Agricultural and Resource Economics at UC Berkeley. He can be reached by e-mail at metcalfe@are.berkeley.edu or by phone at (510) 642-0262

Table 1. Frequency with which Payment to Growers is Tied Directly to Downstream Prices

	Fresh Fruit	Fresh Veg	Processed Veg.	Winegrapes
Yes	67%	46%	24% Ê	8%
No	33%	54%	76% Ê	92%

cultural products did not deal in fresh produce, and others only held a license for tax purposes (this allows a farm which packs and ships its own produce to divide its operations into two, one side of which "sells" to the other). Through a telephone screening of a random draw of respondents, I identified a sample of firms engaged in contracting for fruits and vegetables with "outside" growers. Based on the population of interest, surveys were mailed to managers of 635 firms. Given that there is a great degree of diversity in the commodity chain, we simplified the survey by asking participants to focus on that commodity that was the most important in terms of their current activities in terms of fruit and vegetables.

Completed questionnaires were returned by 361 firms for a response rate of about 60 percent. To facilitate the analysis here I have divided the survey returns into the following groups: fresh fruit (30 percent), fresh vegetables (30 percent), processed commodities (14 percent) and wine grapes (26 percent).

For fresh growers the role of downstream prices is of clear importance, although there is a difference between fruit and vegetables. This difference is due, at least in part, to the fact that a considerable proportion of fresh vegetables is grown as part of a vertically integrated production and marketing chain.

One of the most important results established by the survey relates to the role of downstream prices in deciding the payment to the grower. If the grower's compensation does not depend on downstream prices, the grower bears no price risk.

Table 2 gives some sense of the importance of price risk for different categories of commodities. For fresh growers the role of downstream prices is of clear importance, although there is a difference between fruit and vegetables. In this connection, note that a significant proportion of fresh vegetables are grown as part of a vertical integrated production and marketing chain, which helps to account for the difference in the figures above. Equally important is that for wine grapes and processed commodities almost all growers receive payments that are not based on downstream prices.

To account for the fact that downstream price risk is of relatively small importance for processed commodities and wine grapes, note that for many of these commodities, the produce of many different growers is commingled. This often makes it difficult to assign responsibility for different outcomes to different growers. For example, contrast the case of processing tomatoes for paste to the mature green tomatoes discussed above. Although a processor may face quality problems which affect the value of the final product, in such cases it is likely to be difficult to assign blame to a particular grower. Accordingly, processors and vintners are much more likely to rely on careful quality measurement and condition grower compensation on the outcomes of these measurements rather than on downstream price realizations.

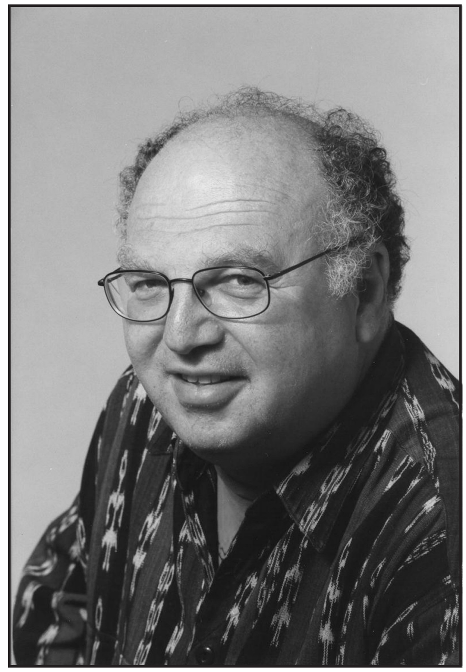
Conclusion

Contracts in agriculture play an important role in reducing the risk faced by producers. However, there is a trade-off between risk-reduction and the provision of incentives. A perfectly insured grower will have less incentive to make costly investments in inputs or effort than would a grower with no such insurance. On the other hand, if the risks associated with a particular commodity are too great, growers will choose to devote their time and resources to the production of safer alternatives.

Examination of contracts governing the production of fruits and vegetables in California are generally consistent with the predictions of theory. Further, variation in the kinds of risk in contracts across different commodities matches what we'd expect if these contracts are designed in such a way as to use risk to provide grower incentives.

Ethan Ligon is a professor in the agricultural and resource economics department at UC Berkeley. His interests include growth and development, agricultural contracts, applied econometrics, information and uncertainty. He can be reached by telephone at (510)643-5411 or by e-mail at: ligon@are.berkeley.edu. Ê

Faculty Profile



David Zilberman
George and Elsie Robinson Professor
Department of Agricultural and Resource Economics
University of California, Berkeley

David Zilberman is a Professor of Agricultural and Resource Economics and Co-Director of the Center for Sustainable Resource Development at UC Berkeley. David is a Fellow of the American Agricultural Economics Association and a current member of its Executive Board. David's broad research interests focus on the economics of production technology and risk in agriculture, agricultural and environmental policy, and marketing.

David was born in Israel and was introduced to agriculture while working for two years on the dairy farm and orchards of a kibbutz. He received his Ph.D. at UC Berkeley and joined its faculty in 1979. David's dissertation was on animal waste management in southern California where he searched for policies that enabled the industry to thrive while meeting environmental regulations. During the 1980s, he initiated several projects on the adoption of modern irrigation technology and computers in California agriculture. These studies demonstrated that farmers adopt new technologies when it makes economic sense and that extreme events, such as droughts or extremely good prices, trigger changes in farming practices. During the early 1990s, David's research on pesticide economics and policy made a case against radical policies that called to ban pesticides, and for smart policies that take advantage of the vast economic benefits that pesticides generate while using incentives to protect against side effects. These studies established that what matters is not what materials are used in farming but how they are used.

Some of David's research has been sponsored by government agencies such as United States Department of Agriculture, Environmental Protection Agency and California Department of Food and Agriculture. His work has emphasized that environmental and farm policies have to be integrated to be most effective and that market instruments and incentives are most effective in achieving social goals. Recently, David has been engaged in studies on the impacts of climate change, the Internet, and, in particular, biotechnology in agriculture. He is a co-founder of an international consortium of agricultural biotechnology, and his research and outreach efforts aim to better understand the economics of biotechnology in agriculture and to design policies that will enable developing and developed nations to benefit from these technologies.

David has taught classes on agricultural policy and environmental economics. He enjoys working closely with his students and has chaired many Ph.D. dissertation committees. David's wife, Leorah, teaches at Berkeley High. They enjoy going to movies, plays and Warriors games. They also enjoy visiting their three sons in Davis and walking their two dogs.

David Zilberman is the George and Elsie Robinson Professor in the agricultural and resource economics department at UC Berkeley. He can be reached by telephone at (510)642-6570 or by e-mail at: zilber@are.berkeley.edu.

Giannini Foundation of Agricultural and Resource Economics Update

Co-Editors: Steve Blank, Richard Sexton,
David Sunding and David Zilberman

Managing Editor and Desktop Publisher: Julie McNamara

ARE Update is published six times per year by the
University of California Giannini Foundation
of Agricultural Economics
Subscriptions are available free of charge
to interested parties.

Visit our Web site at: http://giannini.ucop.edu

To subscribe to **ARE Update** contact:
Julie McNamara, Outreach Coordinator
Department of Agricultural and Resource Economics
University of California
One Shields Avenue, Davis, CA 95616
E-mail: julie@primal.ucdavis.edu
Phone: 530-752-5346

ARE Update is available online at: www.agecon.ucdavis.edu/outreach/outreach.htm

One Shields Avenue
Davis, CA 95616