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Agricultural Impact of the Sudden Elimination of Key Pesticides under the Food Quality Protection Act

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Note to the Reader

At the time this document was written, the joint Environmental Protection Agency (EPA)-U.S. Department of Agriculture (USDA) Tolerance Reassessment Advisory Committee (TRAC) was convened for the first time. The TRAC is an advisory committee under the Federal Advisory Committee Act (FACA) authorized by Vice President Gore in response to broad concerns about implementation of the Food Quality Protection Act (FQPA). The TRAC's guiding principles are to advise and comment on FQPA implementation in the following areas: (1) using sound science in the protection of public health; (2) transparency—translating sound science into sound and fair regulations; (3) making reasonable transitions for agriculture to FQPA implementation; and (4) establishing an effective means of consultation with pesticide user groups and others concerned with FQPA implementation.

Since this document was written, four formal meetings and several TRAC subcommittee meetings have occurred. Two additional TRAC meetings are scheduled in early 1999. We presume that a formal report from the TRAC will be sent to the USDA-EPA at the termination of the FACA.

Several of the concerns raised by this document may be assuaged through the TRAC process. For instance, the TRAC Subcommittee on Risk Mitigation has begun to define what "alternative" pesticide controls are and how their registration may be accelerated by the EPA. In addition, the USDA has initiated a process of developing "crop profiles" to identify specific uses of FQPA targeted pesticides, how their loss may impact production, and how effective current alternatives may or may not be. Presumably the crop, pesticide, and pest research implementation needs identified by the profiles will be addressed in future USDA research and improvement efforts. These efforts could profoundly affect long-term FQPA impacts on integrated pest management (IPM) programs. However, risk mitigation and other refinements in policy are yet to be fully addressed by the TRAC or either agency.

The Risk Assessment Subcommittee of TRAC has identified a framework for refining nine science issues critical to FQPA implementation. They include (1) applying the FQPA 10-fold safety factor; (2) dietary exposure assessment—whether and how to use Monte Carlo analyses and the 99.9 percentile issue; (3) exposure assessment—interpreting "no residues detected"; (4) dietary exposure estimates; (5) drinking water exposure; (6) assessing residential exposure; (7) aggregating exposures from all nonoccupational sources; (8) how to conduct a cumulative risk assessment for organophosphate or other pesticides with a common mechanism of toxicity; and (9) selection of appropriate toxicity endpoints (or critical effects) for risk assessments of organophosphates. In addition, the TRAC process has provided a review of how the EPA could be more transparent in its tolerance setting and reregistration processes under the FQPA. More clarification is needed of emerging policies like the "threshold of regulation" concept recently released for public comment by the EPA.

In our judgment, the TRAC has improved FQPA implementation by providing a more transparent regulatory process. Yet, many FQPA implementation concerns have surfaced through the TRAC process. Much uncertainty remains about how the law will be implemented. Particularly challenging are the EPA's actual implementation of the common mode of action and the cumulative risk analysis of key classes of pesticides. Therefore, our comments should be taken in the spirit in which they were first written, namely in terms of the impact of sudden loss of key pesticides. The authors hope that the guidelines emerging from the TRAC process will help to shape EPA implementation of the FQPA so that it will avoid the drastic impacts that could ensue from the kind of sudden pesticide losses discussed in this report.

Summary

The Food Quality Protection Act of 1996 (FQPA) charges the Environmental Protection Agency (EPA) with developing and implementing regulations to enhance protection of the U.S. food supply from pesticide risks. A key provision of the Act calls on the EPA to evaluate pesticide residue risks based on aggregate exposure to all pesticides that share a common toxicological effect on humans. Initial moves by the EPA raised concerns in the agricultural community that FQPA implementation might result in sudden bans on broad classes of pesticides that have been key to U.S. farm productivity. This report analyzes the potential impact on agricultural producers from sudden elimination of key pesticides under careless implementation of the FQPA.

The EPA's Office of Pesticide Programs has identified three groups of pesticides as being higher risk and, therefore, first priority in their implementation plans for the FQPA. They include the organophosphate (OP) and carbamate (CB) insecticides and the group of broad spectrum chemicals (known as B-2 chemicals) classified as potential carcinogens that are used largely on minor crops (Table 1). This group of potential carcinogens are the most commonly used fungicides. Almost all of these pesticides are used in Integrated Pest Management (IPM) programs. For agronomic crops like corn, cotton, and soybeans, there are, with a few exceptions, effective alternatives for these pesticides.

Unlike pest management in the large-acreage agronomic crops, current pest management in fruits, vegetables, and both human and animal health programs offers fewer alternatives to these pesticides. There may be no immediate alternatives to the use of OPs, CBs, or B-2 fungicides or nematicides for some minor crops, or for mosquito and cockroach control programs. For other crops, the cost of the alternatives or the operational dynamics and/or adoption complexities may pose a significant local or regional threat to the survival of an industry (see Appendix A). Under the FQPA, the viability of many minor crops will depend on the available alternatives for each site-specific IPM program. In another region, a rotational strategy may be possible because a local market exists for the rotational crop.

In the case of perennial fruit crops, growers might be able to adopt a range of OP, CB, and B-2 fungicide mitigation processes including extended preharvest application intervals and postharvest residue removal processes. Other less reliable and more complex alternatives

like pest species-specific pheromones to disrupt insect mating, insect growth regulators, synthetic pyrethroid insecticide substitutes, new fungicides, and pathogen-resistant varieties may provide some relief. Yet, established plantings cannot be changed quickly without high costs, market dislocation, and new variety acceptance on the part of consumers. Even where some alternatives are available, many producers may not be able to adapt quickly enough to service these sudden changes.

Many existing IPM programs have natural and/or augmentative biological control organisms that have evolved resistance to the OP and/or CB insecticides. Therefore, the OP or CB insecticides, after many years of use, have a selective advantage because they do not disrupt biological control organisms for damaging secondary pests like mites, aphids, and leafhoppers. Rapid change from an OP-based IPM program to synthetic pyrethroids may provide an alternative for some pests, but will likely result in secondary pest outbreaks and the use of more insecticides and miticides. Each pest-crop and local/regional crop situation will present a different challenge for IPM managers. Clearly, alternatives for one

Table 1. Priority list of pesticides: pesticides that will be first to undergo review of tolerances by U.S. Environmental Protection Agency, as required the Food Quality Protection Act of 1996

Organophosphates	Carbamates	Potential Carcinogens (B2)
Acephate - I	2EEEBC - F	1,3-Dichloropropene - N
Azinphos-methyl - I	Aldicarb - I, N	Captan - F
Bensulide - H	Asulam - H	Chloropicrin - O
Chlorethoxyfos - I	Bendiocarb - I	Copper hydroxide + mancoz - F
Chlorpyrifos - I	Benomyl - F	Folpet - F
Chlorpyrifos methyl - I	Carbaryl - I	Fosetyl-al + maneb - F
Coumaphos - I	Carbendazim - F	Iprodione - F
DEF - Defoliant	Carbofuran - I, N	Lindane - I
Diazinon - I	Chlorpropham - H	Mancozeb - F
Dichlorvos - I	Desmidipham - H	Maneb - F
Dicrotophos - I	Fenoxycarb - I	Mefenoxam + mancozeb - F
Dimethoate - I	Formetanate HC - I	Metam sodium - F, I, H, N, soil fumigant
Disulfoton - I	Methiocarb - I	Metiram - F
Ethion - I	Methomyl - I	Oxythioquinox - I
Ethoprop -I, N	Oxamyl - I, N	Pronamide - H
Ethyl parathion - I	Phenmedipham - H	Propargite - I
Fenamiphos - I, N	Propamocarb hydrochloride - F	Thiodicarb - I
Fenitrothion - I	Propoxur-I	Triphenyltin hydrox. - F
Fenthion - I	Thiodicarb - I	Vinclozolin - F
Fonofos - I	Thiophanate methyl - F	
Isofenphos - I	Troysan KK - AM, F	
Malathion - I		
Methamidophos - I		
Methidathion - I		
Methyl parathion - I		
Naled - I		
Oxydemeton methyl - I		
Phorate - I		
Phosmet - I		
Phostebupirim - I		
Pirimiphos methyl - I		
Profenofos - I		
Propetamphos - I		
Sulfotepp - I		
Sulprofos - I		
Temephos - I		
Terbufos - I		
Tetrachlorvinphos - I		
Trichlorfon - I		

Abbreviations: AM = antimicrobial, I = insecticide, F = fungicide, H = herbicide, N = nematicide, O = other pesticide.

pest-crop situation may not be suitable for another pest, crop, local area, or region.

Included in the list of higher risk pesticides are several widely used, relatively low cost fungicides including captan, chlorothalonil, triphenyltin hydroxide, maneb, and mancozeb that are critical to IPM programs in which they are used for fungicide resistance management strategies. These broad-spectrum, contact-protective fungicides are critical to the continued use of non-B-2 systemic fungicides in the benzimidazole, ergosterol biosynthesis inhibitor, phenylamide, morpholine, and strobilurin classes. In addition, these fungicides are often crucial to minor crop IPM programs that use weather monitoring to predict infection periods. Because the ergosterol biosynthesis inhibitors, phenylamides, and other fungicides have some curative action, growers can control diseases, such as late blight of potato/tomato and apple scab, after the infective periods have occurred. Loss of the broad spectrum fungicides mentioned above could mean the loss of efficacy for the systemic fungicides and could result in increased preventive spraying with less effective fungicides. Thus, IPM programs that have integrated two different fungicide disease control strategies could be lost.

The broad-spectrum fungicides are the only materials registered for many minor crops and often are the only fungicides registered for crops with intermediate acreage such as potatoes and sugar beets. To prevent crises, the EPA should communicate with Interregional Research Project No. 4 (IR-4) program personnel and U.S. Department of Agriculture (USDA)/Cooperative State Research, Education, and Extension Service (CSREES) IPM coordinators located in most states before a specific pesticide action is implemented. Where key pesticides are unlikely to be reregistered under the FQPA and where cancellation is imminent, both the USDA and the EPA should work cooperatively, as mandated, to ameliorate any short- or long-term dislocation in local crop production and rural economic stability. This situation will mean a new local-area, alternative IPM program requiring significant additional public sector support for development and implementation of replacement IPM programs. The EPA should continue to work with USDA's new Pest Management Alternatives Program (PMAP) to identify locations with critical needs for development of alternatives for farmers to use in IPM programs. The most critical focus in the new PMAP program is linkage to local needs, but this requires additional appropriations to meet these FQPA-induced dislocations. Unfortunately, even if the USDA administration's funding request for this program is supported, only the most critical crop issues will be addressed over the next 2 to 3 years.

One other group of USDA programs that will be critical in a successful FQPA transition is the land grant university-based IPM programs. Each state-based IPM program was provided with an additional $25,000 to identify annually, together with stakeholders, critical IPM issues. These funds were provided prior to the FQPA and are insufficient in states with many minor crops like California, Michigan, Florida, Washington, Oregon, New York, North Carolina, and Texas. Integrating this "needs assessment process" with the new USDA PMAP, IR-4, the USDA IPM Initiative, IPM Regional Research, and the EPA's alternative pesticide and biological control registrations will be a complex, regionalized process that will take years to effectively replace the pesticide groups targeted by the FQPA.

The potential loss of several nematicides under the FQPA will leave few options, other than rotation, for nematode control in some crops. Severe economic losses or production dislocation could occur because of inadequate controls for root knot nematodes on many crops and cyst nematode on sugar beets. The potential loss of the broad spectrum fumigant metam-sodium (Vapam) will cause significant problems for potato growers who will lose a critical control for both nematodes (root lesion and root knot) and *Verticillium* wilt. Loss of this fumigant will result in large acreages of irrigated land being abandoned for potato production in the Columbia Basin and in the Midwest. At the present time, there are no alternatives for these nematicides with similar economy and efficacy.

In general, the sudden elimination of key broad-spectrum pesticides that share a similar toxicological effect on humans could cause serious economic hardship to U.S. fruit and vegetable farmers. Especially where few alternatives exist to the OP, CB, and B-2 fungicides, elimination of one or more of these pesticide groups could cause production of certain crops to shift away from certain traditional production regions, including shifts to imported foods.

The effects would be much less severe from a gradual phasing in of more flexible regulations designed to attain the same risk reduction goal. Gradualism with supplementary research funds would permit time to develop alternative pest management practices. More flexible regulations might include cosmetic and microbiological standards that allowed safe, trace levels of certain pests or pest-parts, permitting pesticide reduction in foods that currently have zero tolerances for impurities. Likewise, research into consumer willingness to pay for foods labeled as safer could trigger the development of standards that in turn create markets offering growers higher prices for foods produced with decreased pesticide risk.

Introduction

The purpose of this document is to provide a scientific perspective on the possible consequences of sudden elimination of major groups of pesticides under careless implementation of the FQPA. The FQPA amends both the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and the Federal Food, Drug and Cosmetic Act (FFDCA), which together regulate pesticide registration and use. The FQPA provides several major additions to FIFRA and FFDCA including application of an additional safety factor to protect infants and children. The FQPA also directs the EPA to reassess tolerances considering aggregate exposure (1) to pesticides in the diet, drinking water, and the environment, and (2) to pesticides exhibiting a common mode of action as a group.

The authors of this document recognize and agree in principle with the goal of this statute, which is to provide a reasonable assurance of no harm from pesticides in our diet and environment. We are concerned, however, about the consequences that may arise from the careless implementation of this statute by the EPA. Our concerns specifically focus on unintended negative impacts on IPM programs, resistance management, minor crops, and the competitiveness and profitability of American agriculture. Additional resources will need to be allocated to facilitate implementation of pesticide alternatives for FQPA-induced changes in agriculture, and in human and animal health protection. To communicate these concerns, the task force has selected a question and answer format.

1 What impact could a sudden decrease or elimination of key pesticides or classes of pesticides under the FQPA have on IPM programs?

Integrated pest management programs are knowledge and information intensive and site- specific management systems. Integrated pest management is a philosophy of pest management that integrates many different strategies, tactics, and tools to hold pest damage below economically injurious levels while minimizing impacts on society and the environment. These programs use pest monitoring, forecasting, and damage thresholds to predict pest severity, and to assess effectiveness of controls as the season progresses and the crop develops. Integrated pest management programs avoid unwarranted use of pesticides but vary greatly in complexity.

No IPM program with which we are familiar has consistently avoided all use of pesticides for suppression of pest populations. For example, many IPM programs use biological control of natural pests integrated with selective, short-lived (in the environment) pesticides. Some of these pesticides include OP and CB insecticides, some herbicides, and B-2 fungicides. Over 60% of the minor crops (most of the fruit and vegetable crops) grown in the United States currently depend on the use of some pesticide. Ultimately, change in agriculture production systems is dependent on the complex interactions of the social, economic, ecological, climatic, and infrastructural conditions under which the production system and its IPM program(s) function. Therefore, prediction of the impact of the FQPA on IPM programs is not a simple, straightforward process, but varies across production systems within a region and especially between regions.

Under the FQPA, both the EPA and the USDA are required to promote IPM programs and to consider a pesticide's use within an IPM program. Along with the EPA's responsibility to reassess existing pesticide registrations using the new FQPA guidelines, it is directed to accelerate registration of decreased risk pesticides, particularly for use in IPM programs, and to provide for minor crop pesticide registrations to ensure that these essential dietary foods are plentiful. The overall intent of the legislation is to review potentially hazardous pesticides while replacing them with pesticides that pose lower risks to human health and are more environmentally friendly.

One of the principal risks from sudden and careless implementation of the FQPA is that it would remove potentially hazardous, yet critical, pesticides like the OP, CB, and B-2s before replacement chemical alternatives are available to IPM programs. Thus, an unintentional consequence of this legislation could be the broad scale collapse of IPM systems. Therefore, the final rules that the EPA develops to implement the FQPA could have profoundly negative, and largely unintentional, impacts on IPM programs.

The transition time and conditions imposed on IPM systems by EPA rules under the FQPA may be critical to the survival of these systems. Under the FQPA, the EPA has many policy tools to limit unintentional effects. These policy tools include (1) appropriate time-limited tolerances for key pest controls where satisfactory alternatives are not available; (2) data call-ins where use and residue data are inadequate for good decision making; (3) emergency exemptions for delivering key new compounds where no alternatives would exist if the EPA cancelled a current pesticide; (4) several incentives to foster registration of alternative pest controls; (5) relative risk analysis that examines the risk of the use of a key pesticide as compared with the risk of loss of that pesticide, including the impairment of a particular IPM system, and the resulting socioeconomic and health costs; and (6) evaluation of potential negative environmental effects.

For agronomic crops like corn, cotton, and soybeans, there may be reasonable alternatives for the targeted pesticides. For minor crops, and human and animal health protection, the situation is dramatically different. For some minor crop, and some mosquito and cockroach control programs, there are no effective alternatives to the OP, CB, or B-2 compounds for certain pest infestations. In other pest management systems, the cost of the alternative or the operational dynamics and/or adoption complexities pose a significant local or regional threat to the survival of an industry. Whether the replacement(s) for these targeted chemicals will be viable depends on the complexities of each site-specific IPM program. For example, producers in one local area or region might have a disease-resistant cultivar to use in place of a lost B-2 fungicide, but this germ plasm might not be adapted to the agroecological conditions in other regions. In another region, a rotational strategy may be possible because a local market exists for the rotational crop; yet, a comparable local market for the rotational crop is not available in all locations. Thus, transition is possible in one region but not in another.

In the case of perennial fruit crops, growers might be able to adopt a range of OP and CB mitigation processes including alternate row application of the pesticide, lower rates of application, extended preharvest intervals between applications, and postharvest residue removal processes. Other less reliable and more complex alternatives like species-specific pheromone disruption of a pest, sterile male release, insect growth regulators, synthetic pyrethroid insecticide substitutes, and disease-resistant varieties may provide some relief from FQPA-induced changes. Yet, established perennial plantings cannot be changed quickly without high costs, market dislocation, and new variety acceptance on the part of consumers.

2 What Impact Could a Sudden Decrease or Elimination of Key Pesticides or Classes of Pesticides under the FQPA Have on Resistance Management?

Resistance management (RM) is a strategy within IPM that seeks to delay or prevent the evolution of resistance to pesticides in pest populations. Resistance management seeks to decrease selection pressure operationally by implementing three pest management principles (1) to diversify effective pest control mechanisms, (2) to perpetuate susceptible genes in pest populations, and (3) to monitor and predict resistance development in time to avert or mitigate its effects.

Under the FQPA, the loss of the broad spectrum, B-2 protective fungicides like captan, chlorothalonil, mancozeb, or maneb may leave no alternatives for controlling plant pathogens other than the resistance-prone systemic fungicides that include the benzimidazoles, ergosterol biosynthesis inhibitors, phenylamides, morpholine, and the soon-to-be registered new fungicides in the strobilurin class. Many of these latter fungicides, including the strobilurins, fit the EPA definition of a "safer pesticide." Fungicide resistance, without the availability of broad spectrum, protective fungicides, may place highly effective, widely used IPM programs for potato, tomato, apple, peach and other stone fruits, peanut, sugar beet, celery, strawberry, floral, turf, and many other minor crops at high risk because the other classes of fungicides available are resistance prone and because true biological controls for these pests are either not very effective or are unavailable. In addition, the loss of certain fungicides may place the predictive weather-based IPM programs that have decreased pesticide inputs to minor crops at high risk.

One of the key insect and mite resistance management strategies is to utilize diverse pest controls including OPs and CBs to control resistance-prone pest populations. Thus, their loss will decrease the potential to manage pest resistance in crop, and human and animal health protection programs. As these compounds are lost, more reliance will be placed on fewer and newer alternatives, creating more selection pressure from these compounds that, in turn, could accelerate resistance development in pest populations. The range of effects one could expect in resistance development is dependent on the EPA's rules for implementing the FQPA. If many different pesticides are lost before new alternative chemicals are available, resistance will likely develop quickly especially in minor crops. If the EPA implements the FQPA with an array of effective alternatives in each major and minor crop such that pest managers have the pest control tools and the time to develop IPM programs with effective RM strategies, then resistance development can be prevented or at least delayed.

3 What impact could a sudden decrease or elimination of key pesticides or classes of pesticides under the FQPA have on the distribution of food production within the United States? Internationally?

Significant adverse consequences likely may result from a sudden major decrease or elimination of key pesticides or classes of pesticides. The potential for shifts in agricultural production and processing clearly exists. The beneficiaries of such changes will be regions where pest and insect pressures are less, such as the semi-arid western United States and certain foreign countries. (Foreign countries are discussed in Question 4.) The extent of such shifts will depend on (1) availability and effectiveness of alternative pest management methods, (2) rate of pest development of resistance to remaining control methods, (3) willingness of processors and consumers to accept produce that is blemished or infested with pests, (4) occurrence of changes in related U.S. trade and food quality regulations, and (5) availability elsewhere of sufficient land and water to accommodate a geographical shift in production.

Although there may be alternatives for FQPA-targeted pesticides in field crops, e.g., corn, cotton, and soybeans, there are far fewer alternatives for fruits and vegetables, collectively referred to as minor use crops, each of which covers fairly small acreages. Many of these minor crops rely on a very small number of registered pesticides but are attacked by an array of insect and disease pests. Those few alternatives would be used heavily if any of the OPs, CBs, or B-2s were banned. In some cases, the alternatives are ineffective or, at best, only partially effective. The result could be an accelerating of the evolution of pest resistance to the remaining legal pesticides as noted before. This, in turn, would restrict further the pest control options available to producers. This impact will likely be greatest in those regions where pest pressure is greatest, notably the humid regions of the eastern and north central United States. Crops that are at serious risk to be displaced from those regions include apples, cherries, peaches, other perennial fruits, potatoes, tomatoes, and other processing vegetables (see Appendix A).

Two factors could mitigate U.S., regional, and international displacement of fruit and vegetable production resulting from proscribing, or prohibiting, groups of pesticides under the FQPA. The first factor is the development of alternative pest controls. This will require considerable additional research and delivery resources to discover and implement alternatives that are effective against the array of pests. A key improvement would be to decrease use of risky pesticides gradually, rather than precipitously, accompanied by a major research effort to develop alternative pest controls for current pests and production conditions. Developing a full spectrum of viable pest control alternatives would be a very substantial undertaking because many of the pesticides being reviewed are broad spectrum in nature, whereas newer chemical and nonchemical methods of pest control are much more narrowly targeted, including some that are limited to individual pest species. At present, certain pests are susceptible to only a handful of promising replacement pesticides or nonchemical controls in the EPA registration queue. However, even these alternatives may present profitability risks to growers. Because the new products typically control a narrower range of pests, they require growers to use several different products to achieve results similar to those obtained with more broad spectrum compounds. This could increase costs so that some producers are no longer competitive. The problem is compounded for minor use crops, because registrants will first pursue registrations that provide them with the greatest economic benefit. While the FQPA does create incentives for registrants to register minor uses, some low acreage minor crops will likely face a time lag between when products are lost and when replacements can be developed and delivered.

The second mitigating factor focuses on postharvest processing and consumer behavior. In some cases, processors currently must reject a whole load of produce or all of a grower's production if insect larvae are detected in a single item. The vegetable and fruit processing industries might be aided by low-cost, effective methods to screen incoming produce for internal insects and external blemishes. This screening might allow removal of unacceptable items from loads that must be rejected at present. But better screening will only help if accompanied by a change in food quality norms. The FDA should review restrictions on insect parts and other foreign matter in processing fruits and vegetables, with particular attention to whether nonzero tolerances can safely be permitted where they are not currently. For fresh fruits and vegetables, market research is needed to determine consumer willingness to tolerate minor flaws in produce that is locally raised and low in pesticide risk.

Unfortunately, the Administration's 1998 Food Safety Initiative, intended to decrease microbiological food safety risks, may increase reliance on pesticides. In support of the Initiative, the FDA published guidelines that may eventually prevent growers from shipping pest-flawed or damaged produce. These guidelines could aggravate the cost to growers of complying with any sudden major decrease in available pesticides that might occur under the FQPA.

Without the impact-mitigating changes suggested above, it is likely that the sudden decrease or elimination of key pesticides or classes of pesticides would cause major regional shifts of food production, especially fruits and vegetables, out of the humid eastern United States to western states or abroad (see Appendix A).

4 What Impact Could a Sudden Decrease or Elimination of Key Pesticides or Classes of Pesticides under the FQPA Have on the Competitiveness of U.S. Food Production?

The elimination of key pesticides or classes of pesticides could affect the competitiveness of U.S.-grown food in the U.S. market. Again, the effect would be greatest for fruits and vegetables. Following the devaluation of the peso in Mexico, fresh fruit and vegetable exports to the United States increased. There remains excess capacity in Mexico for further increases in production. If pesticide restrictions were to substantially increase the cost of food production in the United States, then Mexico and other countries could boost exports to the United States, bound only by U.S. residue tolerance standards. Under the World Trade Organization (WTO) agreements, the United States may not restrict imports based on the method of production; it may only discriminate based on measurable characteristics of the traded product. Hence, foreign producers could continue to use pesticides banned in the United States, so long as they removed all residues by increasing the time between the last spraying and harvest, using chemical washes, and other protective practices.

These drastic impacts on U.S. competitiveness could be mitigated by the same factors that could mitigate regional shifts in production within the United States. Again, a crucial question is whether efficacious and cost-effective alternative pest controls become available. If replacements become available, but achieve effective pest control only at a higher per unit cost than those of global competitors, then production will shift to lower cost regions of the United States and the world. If replacement pest controls and postharvest pest removal methods are not developed in time, the eastern United States is likely to see its fruit and vegetable industries shrink to serving only small niche markets for consumers willing to tolerate imperfect produce for the sake of locally grown food (see Appendix A).

5 What are the criteria necessary to properly evaluate viable alternatives for pesticides that might be in jeopardy under the FQPA's tolerance reassessment process?

To answer this question, one must first have a firm grasp of what is meant by "viable alternatives." Essentially, there are two somewhat disparate views of what alternatives are. In the first, alternatives are essentially products that can be directly substituted for OPs, CBs, herbicides, and B-2s that are likely to be curtailed by the FQPA. For a simple definition, we will call these the "plug-in and spray" direct substitutes for OPs, CBs, herbicides, and B-2s (potential carcinogens). A second alternative includes other approaches to pest control such as parabiological, augmentative, or classical biological control options.

Existing or Pipeline "Plug-in and Spray" Alternatives

The synthetic pyrethroids are very effective on many insect pests and will provide some direct substitution solutions in some agricultural production, and in animal and human health protection systems. In addition, these compounds have been given time-limited tolerances under the FQPA by the EPA. However, many of the pyrethroids have relatively narrow spectrums of activity (they do not control all the important pests) and some have nontarget impacts or secondary pest induction problems just as the OPs, CBs, and B-2s have. Insecticide resistance and cross-resistance also are a significant and rising problem with this class of compounds. Therefore, in most cases, the pyrethroids are not really a direct plug-in and spray substitution for the FQPA-affected pesticides.

Included in the list of higher risk pesticides are several widely used fungicides including captan, chlorothalonil, triphenyltin hydroxide, maneb, and mancozeb that are critical to IPM programs in that they are used in fungicide-resistance management strategies. These broad-spectrum, contact-protective fungicides are essential for the ability to continue to effectively use the non-B-2 systemic fungicides in the benzimidazole, ergosterol biosynthesis inhibitor, phenylamide, morpholine, and strobilurin classes. These fungicides often are critical to minor crop IPM programs that use weather monitoring to predict infection periods to lessen the frequency of application and quantities of pesticides used. Because some of the newer fungicides have some curative action, growers can control diseases, e.g., late blight of potato/tomato and apple scab, after the infections have occurred. Loss of the broad spectrum fungicides mentioned above will mean the loss of the efficacy of the systemic fungicides and will result in increased preventative spraying with less effective fungicides. The highly effective IPM programs that are robust and long lasting because they have integrated two different disease control strategies will be lost. An example of this problem would be the loss of the highly effective late blight control programs based on predictive IPM systems when new strains of the late blight fungus resistant to metalaxyl (a phenylamide fungicide) became widespread.

Most new compounds that are suggested as plug-in and spray alternatives usually are less broad spectrum, more expensive, and/or require altered spray timing or new monitoring to make them effective. Therefore, the idea that there are direct substitutes for many of the FQPA-targeted tools is somewhat fallacious because there are no direct substitutes for these compounds in the agrochemical production pipeline (compounds in EPA's registration queue). In most cases, compounds such as the spinosads, nicotinile, fipronil-like compounds, sterol inhibitors, strobilurins, azadiractin, and insect growth regulators are synthetic or fermentation compounds that have or will have their place in IPM programs. However, sufficient time and transitional resources will be needed to ensure complete implementation, and in some production systems they will not individually or collectively substitute for the OP and CB controls targeted by the FQPA.

Potential loss of several OPs and CBs along with B-2 nematicides such as Telone and metam-sodium will leave few options, other than rotation, for nematode control. Severe economic losses or production dislocation will occur without adequate controls for root knot nematodes on many crops and cyst nematode on beans and sugar beets. The potential loss of the broad spectrum fumigant metam-sodium will cause significant problems for potato growers who lose a critical control for both nematodes (root lesion and root knot) and *Verticillium* wilt. Loss of this fumigant will result in large amounts of irrigated land being abandoned for potato production in the Columbia Basin and in the Midwest. At the present time there are no alternatives for these compounds that have similar cost and efficacy. The scheduled loss of methyl bromide also will create a critical situation for tomato and strawberry producers in the southeastern states and California.

Parabiological, Augmentative, and Classical Biological Control

The development of fermentation products (e.g., *Bacillus thuringiensis* [Bt] and spinosads) and emergence of genetically engineered crops, repellents and attractants, other technologies (e.g., pheromone disruption, sterile male release), and natural product chemicals (e.g., the spinosads or strobilurins) are exciting and potentially effective substitutes for the OPs, CBs, and B-2s. These management tools have great promise and, given time, will likely be the first wave of integrated replacement programs for OP and CB insecticides and B-2 fungicides. In some cases, pest management systems will be able to transition rapidly (3 to 5 years) to these relatively more complex, information-intensive alternatives. In no case that we are familiar with at this time is there a direct, easily implemented, parabiological system that is as simple or straight-forward informationally as the OP and CB insecticides and the B-2 fungicides. Therefore, parabiological tools will require much more information for adoption and management.

There has been a steady increase in augmentative biological control, or annual or more frequent release of natural enemies, in the public and private sector since the early 1970s. In some instances, highly effective disease, predator, and parasite controls are available. However, the whole field suffers from the lack of a consistent quality product, demonstrated efficacy, and sound economic analysis. In addition, this industry has significant public sector education challenges as it promotes the release of viruses, bacteria, fungi, parasitoids, and predators because these terms are often viewed rather negatively.

Classical biological control also had successful, largely public-sector, programs that generally go unnoticed by U.S. consumers and legislators. Yet many forest, agronomic, and human and animal pests have been dramatically decreased through foreign exploration, importation, quarantine, and colonization programs.

In the past 20 years, the USDA Cooperative Extension Service—the traditional public information delivery system for dissemination of pest management information—has been steadily downsized without the concomitant growth of private sector information delivery systems. Although some private sector developments have been excellent, timely, and effective, pest management information delivery is still largely a publicly supported activity. Certainly, electronic communication developments will aid this process. What organization(s), public or private, will provide the information necessary to implement parabiological, augmentative, and classical biological control as well as other alternatives at a time when the USDA Extension Service has been eroded?

In general, we believe that funding of public sector parabiological, augmentation, and classical biological control programs to the extent needed to provide economic, socially adoptable, and effective broad spectrum controls using these pest management approaches has not been a high priority in the United States. The private sector, particularly the agrochemical industry, has not invested heavily in augmentation or classical biological control because these public-good technologies threaten pesticide sales without offering compensating benefits that can be privately appropriated.

6 What other federal and state programs might be affected by a sudden decrease or elimination of key pesticides or classes of pesticides under the FQPA?

Implementation of the FQPA and loss of the pesticides identified by the EPA (Table 1) will create the need to identify new IPM alternatives through the state land-grant university IPM programs, IR-4, USDA's Pest Management Alternatives Program (PMAP), and regional IPM competitive grant programs. In addition, FQPA-directed changes may result in increased need to develop the data necessary for new minor crop registrations through the IR-4 program and to register more alternative compounds through EPA's Section 18 emergency registration process and the Biopesticides and Pollution Prevention Division. While funding for the IR-4 program has been increased in recent years to an amount approaching actual need, the amount of funding for PMAP and IPM programs is insufficient to address the transition needs of the FQPA implementation. In our view, IPM has been underfunded since the early 1980s.

Obviously, better detection and more frequent pesticide residue monitoring could result from the FQPA as regulators seek to make informed decisions and society demands pesticide residue information. Therefore, the USDA Pesticide Data Program and other public and private residue detection programs will likely increase. There is a significant need for more information on pesticide use and usage information under the FQPA. Therefore, the National Agricultural Statistics Service (NASS) will especially need to expand its data collection on minor crops.

Over 60% of the insect pests and 40% of the plant diseases plaguing agriculture and human and animal health are imported from other areas of the globe largely through trade. Therefore, increased funding will be needed in international programs to identify new biological controls for imported pests (USDA/Animal and Plant Health Inspection Service [APHIS], USDA/Agricultural Research Service [ARS], and USDA/CSREES). Also, the EPA's registration activities for biologically based pest controls and replacements for human and animal health vector controls will need to be bolstered.

In addition, U.S. agricultural producers, processors, retailers, consumers, and environmentalists will likely call for similar removal of OPs, CBs, and B-2s from the production of competitively imported produce and products. Because competitors may be able to deliver no-residue products, many uses will not be detectable through conventional monitoring technologies. Therefore, these groups may demand a form of "production audit" system guaranteeing that these chemicals have not been used on imported produce. European Integrated Fruit Programs (IFP) and organic production already require a degree of this type of audit system. This process will present a range of significant challenges for harmonization of international regulations, NAFTA, and WTO negotiations. It also could result in increased monitoring and pesticide residue scrutiny of imports by USDA/APHIS and other related public and private import monitoring services. Decreases in cosmetic standards for fruits, vegetables, and contaminants (like insect parts and mold spores) by the USDA and the FDA could significantly decrease the need to control pests at or near zero levels.

7 What is the Impact of Using Default Assumptions under the FQPA?

With the new requirements of the FQPA, pesticide residue data are generally in short supply, especially for minor crops. Table 2 summarizes the USDA Pesticide Data Program (PDP) residue monitoring system's results for the last several years. The program falls short of the FQPA's requirements in several ways. First, the PDP has neither addressed all of the important crops nor all of the pesticides used. In fact, less than 50% of all minor food crops have ever been monitored. Second, not all pesticides are monitored. For example many of the organic insecticides and fungicides that have known human toxicity end points are not monitored at all. Third, residue detection is a sampling challenge. Most chemicals used in the production of a crop, protection of humans or animals, or in the environment can be detected if a sufficiently large sample can be collected, extracted, and analyzed. Today's analytical technology can detect pesticides at the parts per trillion concentration level. However, no one is certain what one molecule in a trillion means biologically.

An additional source of pesticide residue data exists in the private sector. For example, baby food manufacturers and other processors routinely monitor their products. In fact, many baby food processors have had Hazard Analysis and Critical Control Point (HACCP) programs for residue detection and mitigation for many years. This source of residue data probably dwarfs the public sector's, but the data will not be available publically if they can be used in a way that threatens the food processor's reputation. Residue data also are available from both land grant universities and private retail residue monitoring services, but those data may not meet EPA's stringent good laboratory practices (GLP) requirements.

The EPA has a policy that is particularly troubling under the new FQPA legislation. First, in the absence of appropriate usage and residue data, the EPA may use default assumptions for risk assessment. The EPA's default assumption has been that each pesticide or group of pesticides will be used at the maximal rate, at the maximal allowable frequency, and up to the legally defined last day of treatment (preharvest interval). Obviously, the lack of actual usage and residue data could result in a significant overestimation of pesticide residues in the EPA's risk estimation processes.

Table 2. U.S. Department of Agriculture Agricultural Marketing Service Pesticide Data Program residue monitoring: Commodities sampled by year

		Sample Year								
Commodity	Type	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apple juice	Processed						+	+	+	+
Apples	Fresh	+	+	+	+	+	+			
Bananas	Fresh	+	+	+	+	+				
Broccoli	Fresh		+	+	+					
Cantaloupes	Fresh									
Carrots	Fresh		+	+	+	+	+			
Celery	Fresh		+	+	+					
Corn	Syrup–HF55									
Grapefruit	Fresh	+	+	+						
Grapes	Fresh	+	+	+	+	+	+			
Grapes	Juice									
Green beans	Canned/frozen						+	+	+	+
Green beans	Fresh		+	+	+	+				
Lettuce	Fresh	+	+	+	+					
Milk	Dairy						+	+	+	+
Orange juice	Processed							+	+	+
Oranges	Fresh	+	+	+	+	+	+			
Peaches	Canned						+	+		
Peaches	Fresh		+	+	+	+	+			
Pears	Fresh							+	+	+
Potatoes	Fresh	+	+	+	+	+				
Soy beans	Grain						+	+	+	+
Spinach	Canned							+		
Spinach	Fresh					+	+	+		
Strawberries	Fresh/frozen									
Sweet corn	Canned/frozen				+	+	+			
Sweet peas	Canned/frozen				+	+	+			
Sweet potatoes	Fresh						+	+		
Tomatoes	Fresh						+	+		
Wheat	Grain					+	+	+		
Winter squash	Fresh							+	+	+
Winter squash	Frozen							+	+	+

Appendix A: Illustration of Potential Grower Impacts

The authors were asked to write a brief response to the following questions: What impact could a sudden decrease or elimination of key pesticides or classes of pesticides under the FQPA have on the distribution of food production within the United States and internationally? What impact could a sudden decrease or elimination of key pesticides or classes of pesticides under the FQPA have on the competitiveness of U.S. food production? Any phased decrease of key pesticides that allowed time for producers to adjust would presumably have less impact than a "sudden decrease or elimination."

The impact of a sudden decrease or elimination of a key class of pesticides under the FQPA on food production could vary considerably from crop to crop. The impacts for a specific crop will depend upon a number of key factors.

Illustration: The Case of Apples and Tart Cherries in the Eastern United States

1. The number of pests, the type of damage, the typical extent of damage, and the interrelationships within the pest complex.
2. The availability and effectiveness of the next-best pest control materials or techniques.
3. The extent and type of pest damage likely with the next-best control alternative.
4. The state of research on alternative pest controls including effectiveness, time before availability, and interrelationships with different pest, economic, and market factors.
5. The feasibility of sorting out pest-damaged fruit depending on the type and extent of insect damage

that is likely with the next-best pest control materials or methods.

6. The above factors emphasize the importance of technological knowledge to accurately predict these aspects if certain pesticides are banned.
7. The degree to which market customers, including consumers, require products free from pest damage versus their acceptance of some pest damage.
8. The legal quality requirements related to the marketing of fresh and processed products with regard to acceptable pest damage or insect infestation in the products both nationally and internationally.
9. The likely reactions of market customers, including food manufacturers, retailers, and consumers, if they cannot obtain pest damage-free products from the affected supplying regions.
10. The competitive position of alternative U.S. production regions and their relative ability to produce and market acceptable quality products without the class of pesticides in question.
11. The ability and likely response of foreign suppliers if some U.S. growers no longer can supply market-acceptable quality products.

In the eastern United States, and to a lesser extent, the Pacific Northwest, apples and tart cherries are two industries that could be substantially impacted by a loss of OPs and CBs. This impact is especially true because of the current state of available technologies for the control of key pests. For these two industries, the following is a brief summary of the impact of FQPA implementation.

According to IPM technology experts, the availability of OPs is extremely important for the biological control component of IPM systems and for the decrease of insect-resistance problems in these crops. These experts also indicate that the currently available alternatives to OPs and CBs are only partially effective in controlling cherry fruit fly, plum curculio, apple maggot, and codling moth.

Therefore, if OPs were banned or severely curtailed, the cherry industry would likely be unable to keep the larvae of cherry fruit fly (maggots) and plum curculio (worms) out of the fruit—especially after the first few years of less use because pest populations would likely increase to high densities. Because most of these maggots and worms cannot be seen from the outside of the fruit, the larval-infested fruit cannot be sorted with currently available technology.

Similarly for apples, if OPs were banned, or dramatically curtailed, the alternative control materials and methods would only be partially effective against apple maggots and plum curculio. Therefore, the industry could not keep larvae, especially apple maggot, out of the fruit. Much of this larval infestation could not be seen externally.

It is currently illegal under state and federal statutes for processors to process and market cherries or apples containing any larvae (maggots or worms). Even if it were legal, processors report that consumers, food manufacturers, grocery retailers, and food service firms will not accept either cherries or apples with any larvae or larval parts present. Thus, if growers do not have effective pest control methods and have insect larvae in their cherries and apples, the processors, and hence the growers, will not be able to market any of the infested fruit.

A substantial decrease in the percentage of marketable cherries and apples that are larvae-free and hence acceptable to buyers is likely during the first 1 to 3 years after being forced to change to partially effective pest control alternatives for OPs. However, some larval-free fruit may be available for 1 to 3 years because of currently low insect populations and the availability of partially effective alternative control including some synthetic pyrethroids. After just a few years, larval infestations from cherry maggot, apple maggot, and plum curculio are expected to increase and buyers would increasingly decline to buy the fruit after experiencing larvae in their products.

Buyers could either drop cherries and apples from their product offerings, shelves, or menus, or they could shift to alternative available sources of larvae-free fruit—in some cases from imports. Thus, the large U.S. tart cherry industry and the eastern U.S. apple industry would be unable to produce and market larvae-free, and hence market-acceptable quality fruit within a few years. Likely impacts on future quality, market acceptability, and hence sustainability vary somewhat by major market segment, which includes pitted cherries, cherry juice, fresh apples, applesauce, apple slices, and apple juice.

The overall result of FQPA implementation may be a rapid and substantial demise of these industries in the eastern United States because of the inability to produce market-acceptable, larvae-free fruit. For tart cherries, the impacts will likely include (1) a decrease in pitted cherry products in food manufacturers' product lines, retail grocery stores, and food service menus; (2) an increase in imported cherry juice; (3) a possible small volume of imported pitted cherries; and (4) gradual development of large volume tart cherry industries in certain countries where tart cherries presently are not grown. Countries that either lack these pests or that allow growers to use pesticides banned in the United States are the likely beneficieries.

For the eastern U.S. apple industry, the impacts will likely include (1) expansion of U.S. apple production and fresh sales to western U.S. regions having less pest pressure; (2) an immediate and large increase in imported fresh apples and apple juice concentrate; (3) substantial decrease in applesauce availability for U.S. consumers, followed in 2 to 5 years by development of substantial foreign capacity for apple sauce and apple slice processing and importation; and (4) some increase in production of apple sauce and slices in western U.S. apple-producing regions. If researchers can develop new IPM systems or materials to effectively control these key pests, the FQPA impacts on the cherry and apple industries could be decreased substantially. Development of effective new technologies, however, will require several years and considerable financial investment.

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