Staff Paper

FQPA Implementation to Reduce
Pesticide Residue Risks:
Part I: Agricultural Producer Concerns

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Acronyms

Bt	*Bacillus thuringiensis*
EPA	U.S. Environmental Protection Agency
FFDCA	Federal Food, Drug and Cosmetics Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FQPA	Food Quality Protection Act
GAO	General Accounting Office
IPM	Integrated pest management
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development
TRAC	Tolerance Reassessment Advisory Committee
USDA	U.S. Department of Agriculture
WTO	World Trade Organization

FQPA Implementation to Reduce Pesticide Residue Risks:

Part I: Agricultural Producer Concerns

Executive Summary

The Food Quality Protection Act: Implementation challenge

The Food Quality Protection Act of 1996 (FQPA) transforms the regulation of pesticide residues on food in the United States. Three changes are prominent. First, the Act replaces a two-tiered system which prohibited the presence of any carcinogenic pesticide residues in processed foods but tolerated the same residues on fresh-market foods. Under the FQPA, the U.S. Environmental Protection Agency (EPA) is authorized to develop uniform pesticide residue tolerances for both fresh and processed foods. These tolerances must be based on a conservative standard appropriate for infants and children, rather than the adult-based tolerances that prevailed previously for fresh-market produce. Second, the previous system of pesticide registration was based upon risk associated with specific uses of each compound. Under the FQPA, pesticide registration will be based upon aggregate risk to the most susceptible consumers from all pesticides sharing a common biochemical mode of action in humans. Third, the previous system based all risk assessment decisions on a chemical's potential to cause cancers in animals or humans. The FQPA expands the scope of health effects included in risk assessment decisions to include potential endocrine and reproductive effects of pesticidal chemicals.

As the EPA has moved to develop implementation guidelines for the FQPA, agricultural producers and input suppliers have become particularly concerned about the impact of the aggregate risk standards on regulatory decision making. These standards are sometimes referred to by analogy as a "risk cup" whose limited capacity can be filled with certain pesticide uses to the point where there remains no room for other uses. Particular concerns have centered on whether a small risk cup, combined with conservative risk assessments, might cause whole families of pesticides to become unavailable, especially to producers of minor crops. Supporters of the FQPA counter that loss of whole groups of pesticides is not a likely outcome.

Agricultural producer concerns

Even if the FQPA's implementation results only in a restriction of the pesticides used on some crops producers still have four major concerns. The foremost concern is about the potential loss of farm profitability, especially for farms specializing in fruit and vegetable production. Specifically, producers point to economic impact studies which predict crop yield losses and the need to switch to more costly pest control methods which could undermine farm profits. Michigan fruit and vegetable producers are a case in point. Unfortunately, the validity of most impact studies is seriously limited by their assumptions. History suggests that the actual impacts of known pesticide cancellations have tended to be less than predicted. As a practical matter, the magnitude and incidence of the FQPA impacts will depend on how the Act is implemented. Given the FQPA's mandate to minimize health risks without regard to the foregone benefits of pesticide use, the most pressing policy research need is to examine alternative means for implementing this mandate rather than more impact studies.

The impact on farm profitability of the FQPA will depend on its implementation details. In general, the more major the changes needed to be made in existing farming practices and the shorter period of time to make the adjustments, the higher the potential impacts on farmer profitability. Furthermore, as more producers move to a reduced chemical system of production, the more they will need to acquire new knowledge and management skills.

The loss of various uses of pesticides will have uneven impacts across the country. In Michigan, for example, the apple maggot is controlled by azinophos-methyl (Guthion), an organophosphate for which there do not appear to be effective, profitable substitutes. Eastern Washington apple growers, on the other hand, do not have to contend with the apple maggot as a pest.

The second major concern of the agricultural community is that the FQPA implementation could result in unfair competition if foreign competitors can use pesticides forbidden to domestic producers. This issue is complex. While residue standards enforced at the border are current policy, little imported produce is actually tested. At the same time, because some fresh produce arrives when little domestic output is on the market, some imports do not directly compete with U.S. production. And because pests vary among regions, the same crop produced abroad may not need the same pesticides required in the United States.

The trade impacts of the FQPA, therefore, are not easily determined and are dependent on the way that the FQPA is implemented. Any definitive research to resolve this issue would require comprehensive data bases on chemical uses by crop across countries. It does appear that some fresh product imports which compete directly with domestic products–such as Michigan potatoes competing with Canadian potatoes–could be negatively impacted if the FQPA conferred a production cost advantage to Canadian imports. If the FQPA uses strict residue standards by crop, regardless of country of origin, however, and if such standards are strictly enforced, there should be no competitive disadvantages posed to U.S. products by the FQPA since all production would be required to meet the same standards. The adequacy of import inspections becomes a key policy concern then, for an FQPA strategy that relies on residue standards. Also, there will still be situations where other countries' grades and standards which require use of certain pesticides on imports might need to be renegotiated to assure market access for U.S. products.

The third area of producers' concern is the impact of the FQPA on consumer purchases. If reduced pesticide use results in more blemishes or lower quality product, will consumers refuse to purchase the product? Many consumers are willing to pay more for reduced pesticide use, but price and other product quality attributes are important. Some studies suggest that there is consumer resistance to price increases above 10 percent. Consumer preferences are dynamic and could easily change with more information, however. Even though there is a growing and profitable markets for pesticide-free foods, and there are many case studies of profitable farm enterprises with organic or low pesticide practices, such markets for these products represent only about two percent of sales. And, while the food system is evolving to provide attributes that consumers desire, and lower pesticide risk is clearly one such attribute, there is a lack of research to undergird pursuit of these markets by large numbers of producers. We know little about: 1) those final product attributes for which the consumers are willing to pay, including specifically 2) whether they are really willing to pay more for products, perhaps imperfect, produced with lower pesticide use. Such consumer research should be conducted and should also address the impact of public education on consumer preferences. Indeed, as food production increasingly is consumer-focused, understanding consumer demands and then communicating those demands from the table all the way to the farmer and farm input suppliers, will become crucial for business success.

The fourth major concern of producers is that reduced availability of pesticides may translate into excessive reliance on a few remaining pest control weapons, resulting in accelerated development of genetic pest resistance. This vicious cycle of fewer pest control options hastening the reduced effectiveness of those pest controls that remain can be broken by 1) undertaking considerably more research into non-pesticide methods of pest control, 2) implementing the FQPA in a manner that does not prohibit all uses of broad classes of pesticides, or 3) developing new classes of pesticides that are lower risk.

Implications

There are many uncertainties with respect to the impacts related to alternative FQPA implementation strategies. Because these uncertainties potentially impact producers' livelihoods, many argue for a go-slow, long transition for any major changes in the way they farm or the pest control products they use.

Competing with these agricultural concerns, however, are a parallel set of concerns, expressed by consumer and environmental groups, that the FQPA's promise to protect infants and children from pesticide risks will be sabotaged by lax implementation. Research as to how much, if any, of these problems relate to agricultural's use of pesticides is fragmentary and inconclusive. Nevertheless, the existing evidence is such that many experts, including a National Academy of Sciences panel, have advocated that the United States adopt a conservative approach to protect sensitive sub-populations from cumulative exposures.

Learning from producer concerns and moving ahead with the FQPA implementation

The common element that emerges from this review of producer concerns reviewed is: Impacts on producers will depend on *how* the FQPA is implemented. Having established a ban on the use of broad categories of pesticides would be economically damaging, little value will be gained from additional research measuring just how damaging those impacts would be. The current imperative is *how* to implement the Act in a way that meets its food safety mandate while minimizing the likely adjustment costs to producers. In “Part II: FQPA Implementation Alternatives and Strategies,” the authors assess alternative ways to establish pesticide use priorities and to complete the transition to agricultural production that meets FQPA standards.

FQPA Implementation to Reduce Pesticide Residue Risks:

Part I: Agricultural Producer Concerns

The Food Quality Protection Act (FQPA) is comprehensive legislation intended to protect human health from the hazards of pesticides in our food supply. Because the FQPA represents a major break from the established methods of managing pesticide risk, farmers, agribusinesses, environmentalists, policymakers, and consumers all have concerns about the implementation of the FQPA. This paper reviews the legislative history of FQPA and examines in detail the concerns of agricultural producers for how the Act might be implemented. In a following paper, "Part II: FQPA Implementation Alternatives and Strategies," the authors examine strategies for accommodating producers' concerns while meeting the legislative mandate of FQPA to protect the U.S. food supply from pesticide risks.

What Is FQPA?

The FQPA changed the manner in which pesticide risks are to be managed in the United States. In particular, the FQPA replaces the "zero cancer-risk" standard for pesticide residues in processed food contained in the Delaney Clause with a single health based standard for both raw and processed foods. The new standard requires that pesticide tolerances are set to assure with "a reasonable certainty, that no harm will result from aggregate exposure" to the pesticide. If there is insufficient data to establish the levels at which there is "reasonable certainty that no harm" will occur to infants, children, and other sensitive individuals, an additional tenfold safety margin is to be added. One reason for the addition of this safety factor is that pesticides may be harmful to the nervous system and reproductive organs–particularly of infants, toddlers and small children. Besides being smaller than adults, children's bodies are still developing, and they tend to consume–proportionally–many more fruits and vegetables than the average adult (Kuchler, Ralston, Unnevehr, and Chandran, 1996).

Because of these concerns, the FQPA requires that the U.S. Environmental Protection Agency (EPA) treat those pesticides which have a common toxic mechanism as a single hazard, and obligates EPA to consider dietary and non-dietary exposures in an aggregated manner. Thus, attention is focused on exposures stemming from food consumption, drinking water, and residential uses.[1] The Act requires that EPA review all existing tolerances to ensure that they meet the new safety standard by the year 2006. The Act directs EPA to focus first on pesticide uses posing greatest health risks, bringing those tolerances into compliance with the new safety standard of the Act. This last requirement is sometimes referred to as the "worst first" criterion.

FQPA represents a major break with previous pesticide policy–as found in the Federal Insecticide, Fungicide, and Rodenticide Act of 1947 (FIFRA)--which gave considerable weight to the benefits of pesticide use (Cropper and Oates, 1992). The FQPA applies a "precautionary principle" to pesticide risks. The "precautionary principle" is firmly embedded in European environmental policy and requires that regulatory action be taken before uncertainty about possible environmental or health damages is resolved (Hanley, Shogren, and White, 1997). For food safety, this principle rejects the assertion that absence of evidence of harm necessarily equates with safe food (Wargo, 1996). Thus, the FQPA strictly limits the nature and influence of benefits considered in establishing pesticide tolerances. Regulators are to consider only health

[1]While occupational exposure to farm workers is not included in the FQPA, there is currently a petition to the EPA administrator to include farm children as a major subgroup to be included within the FQPA (Natural Resources Defense Council, United Farm Workers of America, Farm Workers Justice Fund, American Public Health Association Petition, 1999; http://www.ecologic-ipm.com/farmkids.PDF).

risks and benefits that accrue to consumers (Schierow, 1998). That is, a policy of the minimization of risk to human health replaces the previous test of balancing costs and benefits (including producer benefits) of chemical uses.[2]

The rationale for this "precautionary principle" approach is that researchers cannot accurately predict the social costs of new pesticides; that is, they cannot predict whether new pesticide will ultimately cause health problems. Advocates of the precautionary principle point to a history of chemical uses that, while initially thought safe, ultimately proved to have negative health impacts (Wargo, 1996).[3]

Legislative History

The FQPA was passed with the support of many farm organizations, consumer groups and environmentalists, in part because it eliminated the distinction between raw and processed food tolerances. When passed in 1958, the Federal Food, Drug, and Cosmetics Act (FFDCA) prohibited the establishment of any processed-food tolerances for food additives classified as oncogenic (capable of inducing tumors) in animals or humans regardless of whether the additive

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[2]The EPA, under FQPA can consider pesticide benefits only if either (a) "the pesticide protects consumers against adverse health impacts that are greater than the health risks posed by the pesticide itself" or (b) "the pesticide is needed to prevent a 'significant disruption in [the] domestic production of an adequate, wholesome, and economical food supply.'"

[3]The proverbial version of the "precautionary principle" is "better to be safe than sorry." Accompanying food safety risks, however, is the possibility of taking costly preventive actions that ultimately are found to be unwarranted. Both types of risks impose potential social costs–albeit on different stakeholders. Economic theory provides a less demanding principle–that of the "safe minimum standard." The safe minimum standard also demands protection of human health and environmental quality before uncertainty about impacts are resolved. However, it includes a caveat–action should be taken unless the societal costs (e.g., the lost benefits from withdrawn pesticide uses) of so doing are deemed unacceptably high. What is unacceptably high is a social decision, not a scientific one.

was deemed to be a health hazard (National Research Council, 1987). This provision of FFDCA, called the Delaney Clause, meant that no residue was allowed in any processed product if the responsible chemical had ever produced tumors in test animals. With advances in chemical toxicology over the succeeding decades, it became possible to detect infinitesimal levels of oncogenic compounds that would have passed undetected during the 1950's. As a result, the Delaney Clause "zero-risk" standard came to be viewed as extreme by many.

To further complicated the issue, pesticide residues found on fresh or raw foods (but not processed foods) were regulated under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Under FIFRA Section 408, pesticide registrations were established by balancing the benefits and costs from using the chemicals. The inherent contradiction between the pesticide usage provisions of FFDCA and FIFRA was a source of frustration to many in the agricultural industry and led, in part, to their support of FQPA.

In discussions leading to passage of FQPA, environmentalists and consumer advocacy groups were willing to eliminate the Delaney "zero-risk" provision in processed foods [4] in exchange for (1) an elimination of criteria which called for the balancing of benefits and costs of pesticide use on fresh foods, (2) shifting from a focus on individual pesticide uses to a focus on aggregate exposure from all pesticides sharing a common biochemical mode of action in humans, (3) introduction of more conservative thresholds to reflect risks based on children's diets, and (4) broadening the health risk criteria beyond cancer to include the possible risk of endocrine-related reproduction damage and neurological damages. These last two concerns gained visibility

[4]The FQPA did not repeal FFDCA Section 409, which contains the Delaney Clause. Section 409 remains in effect for food additives in processed foods that are not pesticide residues. (Schierow, 1998).

following the release of a 1993 National Academy of Science study on pesticides in children's diets (National Research Council, 1993) and a book entitled *Our Stolen Future* which promoted the hypothesis that chemicals, including pesticides, could cause birth defects and fertility problems in humans and other animals (Colborn et al., 1996).

The implementation of FQPA has focused initially on those families of pesticides deemed to pose the greatest threats to human health. The first groups of chemicals being examined are the organophosphate and carbamate insecticides, which are nerve poisons, plus those fungicides classified by EPA as B2 carcinogens.[5] These groups of chemicals are currently used on many crops.

The diverse nature of the many stakeholders and their interests complicate the implementation of FQPA. Relations among many of the stakeholders are marked by distrust and suspicion about underlying motivations and values. Moreover, most agricultural stakeholders tend to originate from a history and culture that emphasizes protection of agricultural profitability, voluntary and community-based programs, and public subsidies to obtain public goals. By contrast, many other stakeholders come from a culture that emphasizes public safety and the pursuit of public goals through more regulatory, top-down programs accompanied by fines and penalties as incentives to obtain public goals (Batie, 1987). Given the many and differing perspectives on these fundamental issues, it is of little surprise that the implementation of the FQPA is exceptionally controversial.

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[5]The U.S. Environmental Protection Agency classifies carcinogens into five groups, A - E. A substance in group B1 or B2 is a Probable Human Carcinogen.

The FQPA Implementation Planning Process

While initially supportive of FQPA, many producers are now concerned about how the Act will be implemented. Producers have protested that there are potential negative impacts on their livelihoods if many of the uses of these chemicals were to be banned or their use were to be seriously curtailed. In response to these concerns, Vice President Gore called for the establishment of an advisory committee, and in May 1998, the joint EPA-USDA Tolerance Reassessment Advisory Committee (TRAC) was established to try to obtain the smooth implementation of the FQPA. The TRAC is charged with providing policy guidance on sound science, ways to increase transparency in decision making, and strategies for a reasonable transition for agriculture.

The TRAC process has been contentious. By May, 1999, eight environmental and consumer organizations, including the Environmental Working Group, World Wildlife Fund, Natural Resource Defense Council, the Consumers Union, had resigned from the TRAC, protesting that the process consumes too much EPA staff time and serves as a political tool of the FQPA opponents to delay implementation of FQPA. The TRAC supporters counter that TRAC has forced the EPA to be more open about their decision processes and has forced rationalization of its decisions to others. Despite the TRAC process, producers' concerns with respect to the implementation of FQPA remain.[6]

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[6]In late April 1999, a bill was introduced by Representative Pombo in the House of Representatives (HR 1592, "Regulatory Fairness and Openness Act of 1999") that addresses some producers' concerns. The bill would postpone tolerance setting until there is more data, require comprehensive transition analyses before implementation of tolerances, and monitor the competitive strength of major U.S. agricultural commodity sectors in the international market place. If it passes as written, the bill will substantially delay implementation of FQPA. HR 1592 provisions would change the FQPA mandate of minimizing human health risks from pesticide use

Key Implementation Issues

Most of the key implementation issues of the FQPA revolve around EPA's answer to three major questions:

(1) What is the maximum allowable exposure to particular chemical-family for an individual consumers?

(2) How do current uses, including both domestic and imported agricultural uses, contribute to that exposure?, and

(3) How does the EPA allocate the maximum allowable exposure per individual among competing uses?

The EPA has had to develop, in a very short time, procedures and processes for answering these questions. Despite the enormous difficulties associated with this task, the EPA has been making significant progress in refining and answering many significant science policy issues, particularly with respect to the first two questions.

The first of the three major questions addresses exposure to risks. Under the FQPA, exposure (defined as the estimate of the human population at risk from cumulative[7] exposure to a particular chemical family) is based on an aggregate[8] of all possible sources. These sources are not only dietary exposure from both domestic and imported foods, but also drinking water and

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to prohibiting the cancellation or modification of a tolerance base on uncertain data.

[7]Cumulative assessments combine exposures to two or more chemicals that share a common mechanism.

[8]Aggregate assessments account for multiple sources and routes of exposure for a single chemical. For a good overview of this estimation procedure see EPA Staff Paper #25 (September 14, 1998), "EPA's Assessment Process for Tolerance Reassessment."

non-food sources in the air, households, schools, lawns, and gardens. The total exposure for an individual permitted under the FQPA has been termed "the risk cup." The "risk cup" is a pesticide-exposure performance standard for chemicals sharing a common mechanism based on an individual's exposure stemming from all food and non-food sources.

The second major question requires an estimation of the contribution of various pesticide uses to individual exposure – a complex task. Estimates of dietary risks from pesticide residues require adequate information on (1) the combined acute and chronic toxicity of the pesticide and (2) the cumulative, aggregate exposure to pesticide residues on food. The latter, requires (3) information on pesticide use patterns over time, and (4) consumption patterns by age, sex, ethnicity, and location (Archibald and Winter, 1989). The science and data collection underlying such estimates is evolving and incomplete, and there are many sources of uncertainty (Wargo, 1996). Scientists compensate for this uncertainty with estimates of use patterns and cumulative exposures based on established, but frequently controversial, protocols and estimation procedures.

Once there has been a cumulative and aggregate assessment of risks from pesticide uses, the size of the "risk cup" that can be allowed for a class of chemicals is determined. The size of the risk cup equates with the legislative requirement that there is a "reasonable certainty that no harm" will occur to infants, children and other sensitive individuals.

The next challenge, then is the third question--how to prioritize those uses in each "risk cup." That is, within the acceptable exposure risk to a particular class of chemicals, which potential uses are to be allowed within the cup and which are to be excluded? Addressing this thorny problem is a challenge and a great concern to chemical registrants, retailers, agricultural producers and other chemical users.

Potential Impacts of the FQPA: Producer Concerns

The concerns of many stakeholders associated with agriculture about the implementation of the FQPA can be characterized as fear that (1) the risk cup will be too small, (2) the calculations of the current contributions of agricultural and other uses of pesticides to the risk cup will be too large and (3) that important domestic agricultural uses will not have priority in the final allocation of pesticide uses.

Many producers are concerned that, just as there are potential risks from implementing the FQPA too slowly and not adequately protecting human health, there are also potential risks of proceeding too rapidly and/or with “too small” a risk cup or too conservative an allocation of uses. Many fear that the science underlying the calculation of various pesticide uses relies too heavily on overly conservative usage estimates rather than actual use data (Implementation Working Group, 1998). If this is true, the translation of uses into exposures and therefore into tolerances will be overly conservative. They fear that multiple conservative safety factors in the calculation of contributions to the risk cup will impose costs on agricultural producers that are disproportionate to the safety benefits garnered. Furthermore, they are frustrated that, within FQPA, these costs cannot be counted unless they impact human health. In addition, they fear that non-agricultural uses such as home lawn care or pet care will take precedence over agricultural uses.

Many producers worry that too small a risk cup could have unforeseen and unintended consequences on their livelihoods. They are also concerned that they will be forced into making investments or transitioning into new systems of production or processing that either will be too expensive or ineffective in achieving the twin goals of profitability and exposure safety. They worry as well that the FQPA may become a constraint that is tightened over time; that is, they may be subject to further regulatory requirements without the necessary research investments to provide the technological alternatives they need to make profitable transitions to reduced chemical use. There is also the concern that foreign producers might obtain an enduring competitive advantage over domestic producers if the FQPA imposes stricter regulations on domestic production practices than those faced by foreign producers. In addition, producers fear consumer rejection of fruits and vegetables if FQPA limits pesticides that provide improved quality attributes–such as absence of blemishes. Finally, they worry that fewer available chemicals may translate into accelerated genetic resistance of pest to those pesticides that remain available under the FQPA.

For many of these concerns, research is fragmentary and, while suggestive, certainly not conclusive. Actual impacts, and thus the validity of producer concerns, will depend on how the FQPA is implemented. Nevertheless, it is worthwhile to examine these concerns in greater detail, to catalog the pertinent research available, to assess what future research needs exist, and to explore implications for the implementation of the FQPA.

Farm Profitability

The first producer concern surrounding the implementation of the FQPA is farm profitability. This issue is defined in the context of producers' concerns. The state of knowledge surrounding these concerns is presented. Finally, implications of the FQPA for farm profitability are summarized.

Defining the Issue: Farm Profitability Concerns

Most of producers' concerns with the FQPA understandably revolve around impacts on sector profitability and viability. These economic impacts manifest themselves through direct profitability changes or indirectly through limited choice of alternatives, through import competition, changes in consumer behavior, and pest resistance accompanied by loss of pesticide-based technologies.

Producers are concerned that the FQPA implementation will directly and significantly impact their profitability if the FQPA removes pesticides from the producers' choice set. At least for the first phase of the FQPA, the main producer concern is for the profitability of fruits and vegetables, which have fewer substitute pesticides and higher residues than other crops. The potential impact of the FQPA on the welfare of fruit and vegetable producers becomes more severe as (1) the risk cup becomes smaller, (2) the contributions of fruit and vegetable chemical use to the risk cup become larger, and (3)"minor crop" pesticide uses are given less protection.

Fruit and vegetable producers in the state of Michigan are a case in point. As illustrated by Table 1, Michigan producers use a large number of "high-profile" organophosphate and carbamate insecticides. Their location in a humid region makes insect and plant disease attacks endemic. For example, Michigan growers, which produce 45 million dollars of fresh apples and 55 million of processed products per year currently use eleven organophosphates or carbamates pesticides that are "at risk" in the FQPA process. "At risk" pesticides are those most likely to be impacted by the FQPA.[9] One organophosphate of particular concern to Michigan growers is

[9]This "at risk" determination was assigned by the authors based on whether an organophosphate and/or carbamate pesticide used on a Michigan grown crop has been identified as being potentially affected by the FQPA in one or more of the following sources: U.S.

azinphos-methyl, (Guthion), which is viewed by producers as essential for control of the apple maggot. According to National Agricultural Statistics Service, 83 percent of Michigan apple acres are treated with azinphos-methyl three to four times a season.

Appendix A lists "at risk" chemicals by various Michigan fruit and vegetable crops and by chemical trade name. The reliance on many of these pesticides by Michigan producers means they are concerned about whether affordable, effective alternatives can be substituted if these "at risk" pesticides are lost (Whalon et al., 1999).

Although most producers recognize the need to meet consumer demands for enhanced food safety, many are worried about consequences if whole classes of pesticides become unavailable. If whole classes of pesticides were banned, short-term producer profitability risks could loom large (Whalon et al., 1999). To begin with, the most convenient substitutes for compounds that are banned tend to be close chemical relatives. Previous studies have shown that producer profitability suffers more from losing whole families of related compounds than from losing access to individual compounds when similar substitutes remain (e.g., Swinton et al. 1995).

However, it is doubtful that whole classes of pesticides are actually at risk with the implementation of the FQPA. While some agricultural publications have asserted that a complete cancellation of two classes of pesticides--organophosphates and carbamates--is planned as part of the implementation of the FQPA; the EPA has labeled such rumors as "scare tactics" and assure

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Environmental Protection Agency, Office of Pesticide Programs, Organophosphate Use and Usage Information (http://www.epa.gov/oppbead1/matrices); Consumers Union 1998 study "Worst First: High-Risk Insecticide Uses, Children's Foods and Safer Alternatives; Consumers Union 1999 study "Do You Know What You're Eating? An Analysis Of U.S. Government Data On Pesticide Residues In Foods"; Michigan State University Pesticide Loss Prediction Database (http://www.cips.msu.edu/par).

critics that complete chemical class bans will not be forthcoming. The EPA also has indicated that rather than bans *per se*, they may require very low or even zero residues on products for particular chemicals for particular crops. Because residue requirements focus on a residue outcome rather than on the use of an input, they would leave growers the option of how to use restricted chemicals so long as the result met the residue standards. For example, in some cases, producers could use a chemical but leave a long enough post harvest interval so that residue standards would be met. It is possible that EPA might also allow some mitigation of pesticide residues on the crop at harvest via processing, that is, washing, peeling, or cooking the crop may reduce residues to acceptable levels.

Another producer concern is that, in certain small acreage fruit and vegetable crops, there may be few registered pesticide substitutes to begin with, simply because manufacturers found the pesticide market for those crops to be too small to warrant the investment in toxicology testing required in order to obtain registration with the U.S. Environmental Protection Agency (EPA). For these "minor use crops," which include virtually all fruits and vegetables grown in the United States, the lack of substitute pesticides is largely responsible for the dramatic decline in profitability found in studies that have attempted to predict short-term impacts of complete pesticide bans[10] (Swinton and Scorsone 1997; Knutson et al. 1993). Because the residues found

[10]Profitability impacts from restricting the use of pesticides would be expected to be most severe where pest pressure is greatest. In the United States, the climate of the humid East tends to favor pest insects and diseases more than the arid West, making pesticide bans potentially more damaging to grower profitability in the Eastern states. For example, the apple maggot is a severe problem in Michigan orchards, but they are not a pest in Eastern Washington orchards (Gut, Personal Communication, 1999).

on these products are high while the profitability of these uses to chemical suppliers may be low, producers are concerned that minor crop uses will be omitted in the final allocation.

Another producer concern involves new technology products. Severe restrictions of various pesticide chemistries may imperil future technological innovations that depend upon the availability of those pesticides. Examples include low-rate sprayers, bait traps, and other innovations that may sharply reduce pesticide residue risks, but that rely nonetheless on the availability of pesticides. The validity of this concern depends on whether the EPA regulates with reduced residue requirements or with bans. A residue performance standard would impact fewer technologies than a categorical ban.

State of Knowledge: Farm Profitability

There have been both profitability impact studies of reduced pesticide use as well as studies addressing the problems of transition from conventional to lower chemical pest management systems.

Impact Studies of Reductions in Pesticide Use

There have been many impact studies of varying quality during the past decade of both the economic benefits provided by pesticides and the impacts of their removal (see Textbox 1). Few of these studies address the issue of whether manufacturers would abandon investments in development of new or re-registration of existing “minor use” pesticides. However, one study found that a 10 percent increase in “regulatory costs” leads to about a 20 percent decline in the number of new pesticide registration (Ollinger and Fernandez-Cornejo, 1998). It also found that regulation encouraged firms to focus research on large crop markets such as corn and soybeans to the detriment of horticultural crops. On the other hand, this same study found that a 10 percent increase in regulatory costs also was found to lead to a 5 percent increase in registrations of less toxic pesticides.

Textbox 1: Examples of Economic Impact Analyses of Pesticide Loss

The economic impact analyses have come in two general forms. One set has examined the impact of across-the-board reductions or bans in entire categories of pesticides (e.g., insecticides, herbicides, or fungicides). These analyses include the Knutson *et. al*. studies on U.S. field crops (1990) and on U.S. fruits and vegetables (1993), and the Pimentel *et. al*. (1991) study of 40 major U.S. crops. They also include the Deloitte & Touche analysis of fungicide benefits to fruits and vegetables in Canada (Deloitte & Touche Management Consultants, 1992).

The second set of economic impact studies have focused on specific pesticides or narrow groups of related compounds. The triazine herbicides (National Agricultural Pesticide Impact Assessment Program (NAPIAP), 1992; Carlson, 1998; Swinton *et al*., 1995; Nowak *et al*., 1993; Ribaudo and Bouzaher, 1994; Osteen and Kuchler, 1986) and methyl bromide soil sterilant (Ferguson and Padula, 1994; Deepak et al., 1999) have received the greatest share of attention, although a few other compounds have also received attention (e.g., Gianessi and Kopp, 1989, on 2,4-D herbicide; Cox and Easter, 1990, on alachlor herbicide).

While some of the impact analyses have been national in scope, many have taken a regional or even local perspective. Among those directly relevant to Michigan agriculture are several that have focused on pesticide loss in so-called "minor use"crops. These include comprehensive state-wide assessment efforts (Vergot III, 1994), as well as more focused, detailed studies of pesticide loss in specific Michigan fruits (Ricks *et al*., 1993; Swinton and Scorsone, 1997). Other potentially relevant regional studies from the Upper Midwest focus on field crop production in the absence of alachlor herbicide (Cox and Easter, 1990) and the triazine herbicides (Swinton *et al*., 1995).

There have been enough studies of economic benefits to spawn a growing set of review articles comparing previous impact studies. Jaenicke (1997) reviews 17 studies on economic impacts of pesticide reduction. Carlson (1998) reviews ten national studies of benefits provided by atrazine and the triazine herbicides. Fernandez-Cornejo, Jans and Smith (1998) provide an excellent review and critique of economic studies of pesticide use.

Unfortunately, existing studies of possible profitability or broader economic impacts of reductions of pesticides are not very informative for a variety of reasons. Most of these studies suffer from severe limitations that limit the drawing of conclusions on profitability. These limitations stem, in part, from the complicated nature of economic impact analysis (see Textbox 2).

Textbox 2: Complicated Nature of Economic Impact Analysis

The complicated nature of economic impacts from changes in pesticide regulations makes careful impact analysis a major challenge. Consider the steps:

1. Choose a set of plausible, politically realistic regulatory scenarios
2. Predict short-term effects on alternative pest management methods, pest control costs, pest pressure, and crop yields.
3. Predict long-term effects on pest management, costs, pest pressure, crop yields, crop prices, and prices. Include price effects due to international trade and products for which crop products are inputs (e.g., livestock).
4. Predict effects on consumers, producers, and taxpayers.
5. Include nonmarket benefits and costs, such as increased soil erosion if herbicide loss causes more tillage or reduced cancer rates from banning a carcinogenic fungicide.

While many economic impact studies have done step (2) reasonably well, most have fallen short on the other points. The difficulty of forecasting technological change and farming system adjustments (including not just alternative pest management, but also alternative crop and livestock enterprises) makes long-term prediction of costs and yields especially difficult (Ayer and Conklin, 1990; Jaenicke, 1997; Moore and Villarejo, 1996). Accurate prediction of these yield and cost effects is a prerequisite for accurate forecasts of price changes and the supply response they trigger (both domestically and for imports), making those "second-round" effects even less

Many studies of the economic consequences of pesticide reduction mislead in one or more of three ways. First, many focus strictly on private costs incurred, neglecting or sharply underestimating the benefits that could accrue from reducing the use of pesticides (Jaenicke, 1997). Since laws and regulations that reduce pesticide use are motivated by expected benefits, to omit those benefits from an impact assessment can be misleading, depending on how the research is portrayed (Bromley, 1994).

Second, most pesticide reduction impact studies seriously underestimate both farmers' ability to adapt and industry's ability to develop alternative technologies (Jaenicke, 1997; Moore and Villarejo, 1996).

Because of this omission, actual impacts of known pesticide cancellations have frequently turned out to be less than many of the impact study predictions (Moore and Villarejo, 1996).

A related shortcoming is that in some impact studies, only a narrow range of alternative pest management tools is evaluated. Choosing a single pesticide alternative may simplify the analysis, but if the more plausible management alternative is a complicated mix of integrated pest management methods or the substitution of crop insurance for pesticides, then those more complicated and imaginative alternatives should also be evaluated if reliable estimates of actual costs are to emerge from the research.

As Porter and van der Linde (1995a and 1995b) have shown, well-designed regulations in some cases can succeed in inducing innovations that actually create new benefits to the regulated industries. Looking beyond agriculture, one of the most striking examples of regulation-induced innovation is the manufacturing industry's response to the phase-out of chlorofluorocarbons (CFCs). Instead of relying on the environmentally damaging CFCs, affected firms re-examined and redesigned production processes and found many alternatives that were more cost-effective than the CFCs they replaced. The literature on corporate environmental management is peppered with similar stories of how companies faced with a legal requirement to prevent pollution found cost-reducing innovations in their production processes (Batie, Ervin, and Schulz, 1998; Hoffman, 1997). Such technological innovation may be particularly important in efforts to reduce pesticide use.

A third shortcoming of many pesticide policy impact studies is that they address an inappropriate policy scenario. One approach has been to examine extreme, politically infeasible scenarios. This drawback is one of the main criticisms brought against the Knutson *et al.* studies

(1990 and 1993) by Ayer and Conklin (1990) and by Smith (1994). Given the likelihood that EPA will continue to allow some uses of organophosphate and carbamate insecticides, the criticism appears to remain valid for Knutson and Smith's latest effort (1999). Clearly the cost of more restrictions is greater than the cost of few restrictions. But costs rise disproportionately at the margin as fewer alternative pest controls remain. Generally, the further a policy scenario moves from the status quo, the greater the costs (Gianessi, 1993). The magnitude of complete bans of pesticides tends to be very different from those of moderate pesticide reduction plans or residue limitations. Although not politically viable, the cost of a plan that eliminates pesticides entirely will be considerably more than double the cost of a plan that reduces pesticide use by half.

An important caveat with respect to the applicability of many of these impact studies to the FQPA is that the FQPA targets broad groups of pesticides that have similar mode of action in human subjects, whereas previous studies focused on the impact of reducing the use of a single compound, or a narrow group (e.g., triazine herbicides). Thus, generalizations from many impact studies to the FQPA are inappropriate.

Studies on the transition to low-chemical pest management

The difficulty of estimating the impact of reductions in pesticide use on producers' profits is further complicated by difficulties in determining the financial implications of widespread transition to bio-based IPM or organic production. Many producers, both here and abroad, have already substantially reduced their use of pesticides. If agricultural producers are to change from chemical intensive production practices to practices less reliant on chemical intensive systems, their capacity to adjust to a loss of chemical alternatives will depend, not only on the extent of chemical loss, but also, on the availability of reduced chemical alternatives.

Thus, the size of the commitment and the length of the transition depends on what alternatives are available to replace chemical-intensive production methods. If only a few high risk pesticide uses are removed from the farmers' portfolio, and if reduced risk pesticide alternatives are available, then the transition period will be short. If, on the other hand, all farmers are to move to all bio-based integrated pest management alternatives or to organic production, the transition period could be lengthy. Despite numerous private farm success stories using these practices, this alternative path is quite challenging for many producers (see Textbox 3). The reason lies, in part, on the need for producers to learn whole new management systems, for ecosystems to adjust to fewer chemicals, and for the development of markets and consumer acceptance.

Textbox 3. Examples of Reduced Chemical Pest Management Practices and Systems

Some lower-chemical and organic policy experiments are on-going to better understand the barriers to such transitions as well as to speed the transition process. For example, Denmark and Sweden pay its producers to use organic techniques (Lohr and Salomonsson, 1998). Some European experiences have been successful in profitably substituting bio-based practices for chemical-based ones (Resis, et al., 1994). White and Wetzstein (1995) calculated that the benefits to cost ratio to U.S. farmers of using integrated pest management (IPM) practices in cotton was 6.5 to 1. A Consumer Union Study (1999) showed a steep decrease in pesticide residues on U.S. grapes from 1994 to 1996 a decline attributed to the broad adoption of integrated pest management strategies. A similar conclusion was reached by another study (Fernandez-Cornego, 1998). The Natural Resources Defense Council publication showcases 22 farm operations throughout the U.S. who have reduced chemical use through a variety of alternative pest management techniques including scouting and monitoring for pests, using precision pesticide application equipment, rotating crops, switching to biological-based pest control strategy, and adopting better management and soil-building practices (Curtis, 1998).

On a pilot basis, the U.S. government is also paying some American farmers to experiment with organic production. The Environmental Quality Incentives Program (EQIP) in Iowa provided funds to supplement organic production practices. The Wisconsin Potato and Vegetable Growers, in cooperation with the University of Wisconsin and the World Wildlife Fund, hope to reduce pesticide reliance. Several of the pesticides involved are organophosphates or carbamates (Lynch, 1999 personal communication). Gerber® has collaborated with its growers in Michigan, California and elsewhere to grow peaches for baby food that are free of organophosphates. Gerber® selected growing areas where there are fewer difficult pest problems and, they used pheromones to disrupt mating by harmful insects and found that, after a transition period, such production was "significantly less costly for growers" (World Regulation Review, November, 1998). Similarly, through Campbell Soup Company's efforts to reduce input use, growers reduced their use of synthetic insecticides and fungicides for tomatoes by 30 percent, synthetic pesticides for celery by 40-90 percent, and soil fumigation for carrots by 60 percent (Bolkan and Reinert, 1994). Other food companies are engaging in similar efforts through environmental stewardship programs with growers to address environmental issues and protect product quality (Kashmanian and Holtorf, 1998).

There is evidence that, in some circumstances, chemical-free production systems can be profitable (Welsh, 1999). For example, a recent study of organic farming systems in the Northern Great Plains of grain and oilseed production found certain organic systems had net returns to land and management equal to or greater than the conventional and reduced till farming systems in the study area (Dobbs, 1994). Although, a transition period of a few years maybe required before the switch from conventional to organic becomes profitable (Smolik and Dobbs, 1991). A comparative analysis of an organic apple production system in coastal California found that the organic production system yielded a greater net return per hectare (using grower-received farm gate premiums of 38 percent (1990) and 33 percent (1991) for unsorted, certified organic apples) than the conventional management system. The organic production system required higher material and labor inputs in all years (Swezey et al., 1998). Welsh (1999) reviewed six land-grant university studies comparing organic and conventional grain cropping systems in the Midwestern United States. Results of three of the studies indicate that, without price premiums, the organic cropping systems were more profitable than the most common conventional system, generally a corn-soybean system in three studies; and, they were less profitable than the most common conventional system in three studies. Furthermore, each of the organic systems were always more profitable than the continuous corn systems, even without price premiums.

It must be noted, however, that any comparative study must be interpreted carefully since profitability will be influenced by existing institutions, available technology, demand and supply factors, as well as land characteristics (Batie, 1998). In addition, there are, in many cases, price premiums which offset any potential yield decreases (Dobbs, 1998). Such price premiums would most likely dissipate in the long run with increased volumes of organic production, unless consumer demand grows proportionally to the increase in production. However, there is at least anecdotal evidence that the cost of growing and marketing organic food are falling as the industry expands (Welsh,1999). Nevertheless, although “going organic” may be promising in some cases, and, despite the growing market share of organic products, the organic production, if measured in terms of percentage of total food production is still in its infancy.[11]

Policy research needs

As indicated earlier, most policy research on farm profitability related to reduced pesticide use has taken the form of economic impact analyses. Though most of the studies have important limitations, the value of additional impact studies is highly questionable. Not only are such studies costly and subject to criticism, they are unlikely to make a productive contribution to the FQPA debate. As passed into law, the FQPA explicitly excludes farm income impacts from consideration in pesticide review decisions. These decisions are to be made entirely on the basis of attendant health risks and benefits to consumers. Health risks take priority, unless there is a "significant-disruption" in the food supply comparable to the one that occurred when aflatoxin contaminated U.S. feed corn in the late 1980's (Phillips and Gianessi, 1998).

A more productive approach to policy research on farm profitability is to examine the consequences of alternative ways of implementing the FQPA. Each alternative should be evaluated based on its ability to meet its goal of reducing human health risks in a manner that (a) leaves agricultural producers the greatest possible flexibility and (b) leads to investments in research and development to assist producers to make profitable transition production systems that result in lower food dietary risks. There is a real need for policy analysis that focuses on regulatory alternatives (means) rather than regulatory ends (Bromley, 1994).

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[11]A similar statement applies for biotechnology products that reduce chemical residues (Zilberman and Millock, 1997).

One such policy analysis need is to examine alternative means to meet FQPA pesticide residue standards on various food products. These needs are discussed in greater detail in an accompanying paper ("Part II: FQPA Implementation Alternatives and Strategies")[12]. Another policy analysis need is to estimate the crop production loss threshold that would qualify as a "significant-disruption" in the food supply so that the EPA would have clear guidance on when it is legitimate to consider pesticide benefits in implementing FQPA (Phillips and Gianessi, 1998).

Implications: Farm Profitability

The impact on farm profitability of the FQPA will depend on its implementation details. In general, the more major the changes needed to be made in existing farming practices, and the shorter period of time to make the adjustments, the higher the potential impacts on farmer profitability. It is doubtful that there will be price premiums offered for reduced use of higher risk pesticides except for a few speciality markets. Also, the more producers move to a reduced chemical system of production, the more they will need to acquire new knowledge and management skills.

Because of the variability of agriculture across the country, the loss of certain uses of pesticides will have uneven impacts. In Michigan, for example, the apple-azinphos-methyl (apple-Guthion), crop-pesticide combination is particularly vulnerable. Should this use be eliminated by the FQPA, many apple growers question whether other profitable alternative pesticides or practices exist. Because other regions' apple growers may not have the same pests as Michigan,

[12]For example, in Part II we explore possible policy vehicles–such as transition insurance and educational assistance that could reduce negative impacts on farm profitability form the implementation of the FQPA.

Michigan growers also fear they would become the high cost producers, even if they found other effective, but more expensive apple maggot pest control methods.

Import Competition Concerns

The second producer concern surrounding the implementation of the FQPA is import competition. This issue is defined in terms of potential impacts to U.S. producers' competitiveness with foreign producers due to FQPA. The state of knowledge surrounding this concern is presented. Finally, implications for international competitiveness are developed.

Defining the Issue: Import Competition Concerns

Apart from worries about farm profitability impacts, producers are also concerned that the FQPA might undermine the competitive position of U.S. food products in world markets, including domestic markets. This concern involves how the EPA will include chemical uses from imported sources in the risk cup: that is, will imported foods reduce the size of the risk cup available for domestic producers? Such concerns are understandable given the heavy reliance of U.S. agriculture on chemicals and the increasing share of imported foods.

One way to better understand this concern is to assume that FQPA implementation will reduce crop yields. However, such reduced domestic food production need not imply reduced farm incomes. Studies on the domestic impact of pesticide bans have shown that in many cases, due to inelastic consumer demand, farm income actually increases as the quantity supplied is diminished. For example, Knutson et al (1990) projected significant field crop yield losses from an (unrealistic) complete pesticide ban coupled with rising crop prices, and predicted,

> "These crop price increases would convert to sharp increases in gross receipts to crop producers. Under the no chemical option, for example, producers' gross income in 1994 for the eight crops studied would increase by 18 percent from the $58.6 billion baseline to $69 billion under no pesticides and by 34 percent from the baseline to $78.6 billion with no chemicals. Despite cost increases associated with each chemical use reduction scenario, crop producers would experience a sharp increase in average real net farm income from $13.3 billion under the baseline to $20.6 billion with no pesticides and $29.3 billion with no chemicals during the 1995-98 period. Again, this increase in income would assume perfect producer knowledge; instant adjustments in crop mix; specified changes in cropping patterns; and a willingness on behalf of producers to endure a greater intensity of farm management, labor supervision, and labor input."

However, such conclusions of improved farm income would be invalidated if either (1) aggregate U.S. yields did not decline with reductions in certain pesticide uses, or if (2) direct import competition significantly increased. Another way this concern is expressed is that, even if yields do not decrease, foreign competitors might have a lower cost of production advantage if they have access to chemicals unavailable to Americans.

The United States currently imports about 15 to 20 percent of its total domestic consumption of agricultural products. Imported fresh fruit is now about one-third of total domestic consumption (GAO, 1998). This amounts to over 5.6 billion pounds of imported fruit and 8.4 billion pounds of vegetables (USDA, ERS, 1999). Of course, pesticides are used in the production and storage of these imports. While the Federal Food, Drug, and Cosmetic Act (FFDCA) prohibits the importation of food with pesticide residues greater than the tolerances permitted within the United States, the monitoring and testing of imported products may be insufficient to ensure that such tolerances are universally enforced (Schierow, 1998; GAO, 1998;

Wargo, 1996).[13] Wargo (1996), for example, notes that only 8,000 samples are taken from imported fruit and vegetables yearly. This amount is the equivalent of only one residue test for each 2 million pounds of imported foods.[14] Some claim that this level of enforcement can lead to unfair competition with U.S. food products and/or unsafe foods in the domestic supply. However, other analysts do not agree that the FQPA compliance would endanger the competitiveness of U.S. food products nor that enforcement is inadequate (Textbox 4 offers several such counter arguments.)

Textbox 4. Views on Why FQPA May Not Hurt U.S. Trade Competitiveness

Despite the common notion that compliance with the FQPA will damage the competitiveness of U.S. producers, research on this issue is not definitive.

FQPA supporters note that for many foods, a higher percentage of imported foods is tested for chemical residues than is tested domestically. A recent Consumer Union study (1999) found no noteworthy difference in the detection of illegal residues and imported products with samples of each having violation rates of less than 5 percent. There are also considerable incentives for foreign exporters to voluntarily comply with U.S. standards. These incentives include severe penalties for violations, exporters' desire to maintain good reputations as reliable suppliers, as well as joint foreign-domestic ownership arrangements (Cook, personal communication, December 21, 1998; Marchant and Ballenger, 1994). Indeed, there is an argument that, because of the size of the U.S. market, the U.S., in some sense, sets "the standards that other countries adopt" (Ervin, personal communication, February 12, 1999).

An additional complicating factor is the difficulty of assessing the comparability of residue standards in the United States and other countries. While there is often an assumption that major differences exist between the standards of the United States and its trading partners, evidence on this issue is mixed. For example, the United States maintains regular communication with major food trade partners like Mexico to provide greater "health protection for both the American and Mexican consumers by eliminating the use of non-registered pesticides, standardizing pesticide residue analyses, and improving communication" (GAO, 1992, p. 43). Also, some countries, like Japan, have stricter residue requirements on many chemicals than does the United States (Marchant and Ballenger, 1994). Indeed, the Consumer Union study (1999) concluded that much imported produce had lower or less toxic residues than does domestic produce. Furthermore, not all imports directly compete with U.S. production due to differences in seasonal availability.

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[13]For example, over a two year period the FDA tested only 72 samples of bananas for benomyl. During the same period nearly 25 billion bananas were imported into the U.S. (Wargo, 1996).

[14]There is also a concern over foreign use of compounds that are neither registered in the U.S. nor tested for their toxicity.

If more pesticide uses are restricted under FQPA, an additional trade question will arise: If U.S. farmers are denied a chemical input that is legal to use in other countries, and if such use does not leave a detectable residue, will U.S. farmers be placed at a competitive disadvantage relative to foreign producers? The question assumes that the EPA will implement bans on certain pesticide uses as opposed to residue limits.

The answer depends only in part, on how much the use of the chemical would lower production costs relative to other costs in the production and transportation of the product. There are many factors to consider in making this comparison, including other non-chemical costs of production, whether a chemical is actually used and its actual impact on yields, and whether the imported products are in direct competition with domestic production. Therefore, while competitive disadvantages could result from the implementation of the FQPA, each case would need to be examined individually.

Michigan producers are particularly sensitive to this concern. Table 2 illustrates the vulnerability of Michigan producers to foreign competition, based on the level of domestic U.S. consumption of imported fruit and vegetable products that are also grown in Michigan. For example, 5.3 percent of fresh potatoes and 4.6 percent of processed potatoes are imported to the U.S.–almost entirely from Canada. Potato producers clearly want to remain competitive with Canadian producers and are concerned if they lose important uses of pesticides such as Monitor (methamidophos), an organophosphate. Much of this competition is direct competition and is of more concern to Michigan producers than, say, the importation of fresh asparagus from Mexico which is seasonally available at a time when Michigan producers are not producing fresh asparagus.

A related concern is when other countries' grades and standards forbid the importation of U.S. products unless they have been treated with pesticides. For example, in order to be imported to Brazil, Michigan apples must be sprayed with azinphos-methyl (Guthion) to assure there are no apple maggots. Loss of Guthion might therefore equate with the loss of the Brazilian market for Michigan apple producers, unless some substitute treatment is acceptable to Brazilian importers.

State of Knowledge: International Competitiveness Under Reduced Pesticide Use

Empirical studies to resolve these international competitiveness issues are fragmentary and inconclusive, for a variety of complex reasons. There are few studies which address the competitiveness question. Some studies have shown that U.S. pesticide regulation has not caused significant economic loss to the farm sector (Osteen and Szmedra, 1989). One analysis of whether Canadian environmental laws have disadvantaged Canadian farmers relative to their American counterparts, found that the actual effects on competitiveness were not large (Deen and Fox, 1991; McEwen and Deen, 1997). A similar conclusion for U.S. southern crops was reached by Marchant and Ballenger (1994). A common thread in these studies is that any change in the costs of production due to environmental compliance are insignificant relative to other factors such as exchange rates, and costs of transportation, processing, and retailing. Such conclusions are reinforced by studies of nonagricultural industries. These studies have found remarkably little evidence that either trade or industrial locations has been a result of various environmental regulations. Ervin and Fox (1998) summarizes the evidence to date:

> "Comprehensive reviews conclude that compliance costs have caused insignificant output reductions on average, and show little if any evidence of any significant trade impacts (Dean, 1992). The lack of significant effects may reflect a host of offsetting influences, e.g., similar environmental programs across competing exporters, exchange rate forces, and management and technology innovations." (p. 10).

While these studies reach similar conclusions, their applicability to understanding the impact of the FQPA is limited as they were conducted before any implementation of the FQPA.

Studies on competitive relationships are also hampered by lack of information about which countries allow which chemicals for which agricultural uses. Furthermore, there is a lack of data on actual rates of use. Mexico, for example, accounts for 55 percent all fresh and frozen fruits and vegetables exported to the United States (USDA, 1997). The Mexican climate, soil and pest conditions are quite different from most of the United States' conditions. Pesticides that have efficacy in the United States may not perform as well in Mexico, and vice versa. For example, a 1992 GAO study found 17 pesticides used in Mexico that do not have U.S. pesticide residue tolerances, five of which are used on foods imported into the United States. The toxicity of these pesticides may be of concern, but sampling and testing is quite limited. Furthermore, not all tolerances apply to the same crops in the United States and Mexico. Thus, it may be that limiting a chemical use on a crop in the United States may have little to no impact on production practices for the same crop in Mexico, where the chemical is not be used on that crop. Even when comparisons are made for a pesticide crop on domestic versus imported foods, the results are inconclusive. In one such comparison, fungicide residues and several insecticides were higher on imported grapes than domestic, but, dicloran fungicide residues and insecticides (parathion-methyl) were higher on domestic peaches (Kuchler, et al., 1996; Consumers Union, 1999). The issue of imported versus domestic residues must be resolved on a case by case basis; unfortunately the necessary information to do so is not readily available.

Also due to seasonal differences, many fresh market crops that are grown in other countries do not compete directly with the same crops in the United States. For example, many

Latin American fruits and vegetables may capture the winter U.S. markets, but their production diminishes by the time of the first spring Californian harvest. Still later, the Washington and Michigan fresh products enter the market. In such a case, differences in pesticide compliance requirements may not have a major affect on competitive relationships in these cases.

For certain other cases, however, there may be significant competitive disadvantages for U.S. growers. Processed products which can be stored will face direct competition from foreign producers. Likewise, certain regions of the United States compete directly with fresh product imports for selected commodities during certain seasons. For example, in the U.S. winter market for fresh tomatoes and strawberries, Florida produce competes head-to-head with Mexican produce for significant periods. In the case of methyl bromide, a soil and post-harvest fumigant, analysis suggests that Mexico would gain market share from Florida farmers for tomatoes, eggplants, bellpeppers, cucumbers and strawberries following a proposed unilateral U.S. ban on the use of methyl bromide (Deepak, Spreen and Van Sickle,1999). Studies of competitiveness must carefully analyze the nature of the competition as well as the pesticide rates of use on a case-by-case basis.

Policy research needs

Any research to determine whether reduced availability of chemicals in the United States would have a significant impact on the competitiveness of U.S. crop products will require comprehensive, accessible data bases on chemical use across countries by crop, actual chemical use by country by crop, and residue detection capabilities by crop. Without such data, it is difficult for EPA to determine the role of imports in allocating uses for the “risk cup.” On the other hand, if the FQPA is implemented using a residue limit, and if detection and enforcement of residues at borders is adequate, then less data and research on the impact of differential access would be required to allocate imports to the risk cup.

Implications: International Competitiveness

The trade impacts of the implementation of the FQPA are dependent on implementation details. Any definitive research to resolve this issue would require comprehensive data bases on chemical uses by crop across countries. It does appear that some fresh product imports which compete directly with domestic products–such as, Michigan potatoes competing with Canadian potatoes–could be negatively impacted if the FQPA conferred a production cost advantage to Canadian imports. If the FQPA uses strict residue standards by crop, regardless of country of origin, however, and if such standards are strictly enforced, there should be no competitive disadvantages posed to U.S. products by the FQPA since all production would be required to meet the same standards. For example, with this implementation strategy, U.S. imports of Chinese apple juice would have to meet the same residue requirements as domestic apple juice. The adequacy of import inspections, then, becomes a key policy concern then, for an FQPA strategy that relies on residue standards. There still would remain situations where other countries' grades and standards would need to be renegotiated to assure market access for U.S. products.

Consumer Resistance Concerns

The third producer concern surrounding the implementation of the FQPA involves consumer resistance to U.S. grown fruits and vegetables. This consumer resistance is defined in terms of consumer resistance to purchase fruits and vegetables due to increased blemishes from pest damage, and/or potentially higher consumer prices. The state of knowledge surrounding this concern is presented. Finally, implications for consumer resistance are developed.

Defining the Issue: Consumer Resistance Concerns

A third major concern of producers is that the benefits of reduced pesticide residue risk on food could carry unrecognized costs for consumers. These costs take two forms. First, if the risk cup excludes certain pesticide uses, the quality of fruits and vegetables may suffer due to increased blemishes from pest damage, leading consumers to reject these products as inferior. Second, if reduced pesticide access causes higher unit costs for producers, these higher costs could trigger a decline in quantity supplied. Such a reduction could in turn lead to increases in price that meet with consumer resistance.[15]

Also, some argue that, if fungal diseases were to result from reduced fungicide use, these diseases could conceivably pose food-borne health risks that offset some of the health protections gained by reduced fungicide use. A collateral point is that the FQPA and the FIFRA do not govern older non-synthetic pesticides, so they do not cover human health risks from such "organic" pesticides such as nicotine sulfate. If banning certain chemicals meant a return to such older non-synthetic pesticides, then risks to human health could actually increase. However, since the FQPA explicitly allows for consideration of the impacts of any regulatory decision on human

[15]There is an accompanying argument–not related to producers livelihood--that if consumers (particularly lower income consumers) must sacrifice other purchases for the sake of maintaining their accustomed diets, then they may not be better off than they were with pesticide residues on cheaper, better quality food.

health, these last concerns translate into a need for research to better identify and quantify the health risks associated with reduced access to pesticides or various mitigation strategies.[16]

There are potential opportunities for producers that emerge from consumer concerns with food safety. Increasingly, U.S. agriculture is dividing into two types of markets–one is the low cost production of commodities; the other is the value-added, consumer-focused production of consumer desired food attributes (Drabenstott, 1999). This second type of market does not require low cost production *per se*, rather it demands high value consumer benefits per consumer dollar spent.

One such attribute desired by consumers could be reduced food risks due to reduced pesticide residues–provided to both domestic and export markets. Capturing these markets requires that consumers be aware, through labeling or other communication methods, of the reduced risk attributes when making purchases (Wargo, 1996). Gerber®, for example, pursues a strategy of achieving no detectable residues on their final product. To achieve this result, Gerber® provides very strict pesticide use requirements within their grower contracts.

However, many producers are wary of depending on the consumers' willingness to pay for organic or reduced residue foods until it is determined whether such markets emerge and are robust and profitable. They also express concern about the wisdom, the feasibility and the profitability of labeling these food attributes of reduced pesticide in the grocery. They fear such

[16]There is a strong argument here for careful consideration of all health risks within the FQPA mandate–including, for example, the risks of eating organic versus conventional diets or transported versus local production.

labeling will stigmatize non-labeled foods. Furthermore, they question whether the accuracy of ecolabels[17] will be enforced as well as whether they will receive adequate prices for their efforts.

State of Knowledge: Consumer Resistance Concerns

The validity of many of the farmers' concerns about consumer demand for reduced pesticide foods depends on the validity of three assumptions: (a) that pesticide bans or reductions lead to increased producer costs, (b) that increased producer costs lead to increased consumer prices, (c) that the quality of fresh products will worsen, and (d) that consumers will reduce their purchases in response to increased prices or decrease quality. There is little research to resolve these issues but, given the low price elasticity of food, the low amount of disposable income spent on food by most customers, and the small additional cost of pesticides in most production budgets, there is reason to suspect that the conclusion of increased consumer expenditures on food following the FQPA implementation would, at best, apply to only very poor consumers. Knutson et al. (1990) found $18 billion in aggregate consumer food expenditure increases likely to result from whole-scale, all-pesticide bans. For many consumers, however, such an (unlikely) wholesale ban would translate into only a few dollars per month (about 3 percent increase in aggregate food expenditures and less than $12 extra per month for each member of the civilian labor force).

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[17]Ecolabel programs are being developed in many countries to differentiate and enhance revenues for products produced under environmentally preferable conditions. An ecolabel identifies environmentally preferable products based on an environmental impact assessment of the product compared to other products in the same category or by country-of-origin environmental requirements. Ecolabels are much like a seal of approval. When developed by governments, they are awarded by a public or private nonprofit organization that establishes environmental standards for product categories and certifies that products meet those standards (van Ravenswaay and Blend, 1998). Though ecolabels are more prevalent in European markets, the most notable example of an ecolabel in the United States is the "dolphin-safe" label on tuna.

With respect to reduced-pesticide product markets, there is limited research on both consumers' perceptions of pesticides and on how these perceptions translate into purchases (CAST, 1995). The findings of various recent studies strongly indicate that many consumers are interested in food health and safety and about the methods used to grow food (Richman, 1999). A study by the Food Marketing Institute (1997) found that 74 percent of surveyed American consumers perceived pesticide residues as a "serious hazard." A 1990 study of 1,860 North Carolina shoppers found that 60 percent believe that chemicals in the food supply are a matter of high concern (Eom, 1992).

While the growing level of media coverage chronicling public exposure to pesticides and their related health and food safety impacts suggests that public concern about exposure to pesticides will continue (Office of Technology Assessment, 1995), there are differences between consumers. For example, the Food Marketing Institute's 1997 study found that 37 percent of consumers in the East purchase organic produce versus 29 percent in the West (Thompson, 1998). Van Ravenswaay and Hoehn (1991a) have conducted extensive research in the area of consumer perspectives on chemical residues in food; they have found that perceptions of risk from pesticide residues differ greatly among consumers. One implication is that there are major differences in information needs, policy preferences, and market niches among the public.

According to The Hartman Report (1996), a majority of American consumers are willing to buy environmentally friendly products. It appears that a growing number of consumers are seeking food grown without pesticides, or under "environmentally friendly" production systems. For example, a study by the American Farm Bureau Federation of a small group of suburban consumers in Rosemont, Illinois, found an average willingness to spend $21 per week more to "ensure a safer food supply" (Lipton and Fields, 1999).

Following the Alar episode, van Ravenswaay and Hoehn (1991a and 1991b) found that U.S. consumers would pay on average $0.24 more per pound for apples that were "pesticide-free" at a time that apples normally cost $0.79 per pound. A 1990 survey of 600 Michigan households found that 38 percent would pay more than a 10 percent increase for food products grown without the use of chemicals (Atkin, 1990). Various recent studies and surveys on consumer attitudes toward natural foods have found that 30 to 40 percent of consumers would buy reduced-pesticide foods at slightly higher prices, such as a 10 percent price premium for organic produce (Richman, 1999).

In one of the few studies of consumers' response to reduced food quality, U.S. consumers were asked to evaluate color photographs of apples with varying levels of pest damage and varying prices (van Ravenswaay and Hoehn study, 1991a & 1991b). They estimated that consumers would accept damage of about 7.5 percent of the visible area in return for guarantees that residues were below federal limits and if prices did not change. These findings are consistent with other studies that show that some customers will accept mild damage from pests in exchange for reduced pesticide residue (CAST, 1995).

However, whether consumers would actually pay such increases in a real world setting is questionable. A survey of Georgia consumers concluded that, despite strong consumer preferences for certified pesticide free produce, most would not pay a price premium of more than 10 percent for the product (Misra, Huang and Ott, 1991). One implication drawn by the authors was that consumers may expect the government to assure that fresh produce is free of pesticide residues. Eom (1992) also found consumer resistance to higher prices in his study of North Carolina shoppers. When consumers' responsiveness to price increases was tested in hypothetical questioning, each 1 percent increase in the price of a less risky produce reduced the likelihood consumers would purchase it by 0.57 percent.

Policy research needs

The markets for organic foods and other foods produced by using methods that are "environmentally-friendly" are growing by 20 percent per year, yet, they still represent less than 2 percent of overall food sales (Welsh, 1999). This percentage translates into a United States and European Union market for organic food of about $6 billion in total sales (Welsh, 1999). Food companies are responding to consumers' desire for pesticide-free foods, by introducing new "green" brands, yet surprisingly little is known about consumer reaction to these brands or about the impact of public education on consumer preferences. Indeed, as food production increasingly is consumer-focused, understanding consumer demands and then communicating those demands from the table all the way to the farmer and farm input suppliers, will become crucial for business success.

Implications: Consumer Resistance Concerns

While research suggests nearly three-fourths of Americans are concerned about pesticide residues, research is inconclusive about whether consumers will pay premiums for large volumes of reduced pesticide residue foods. Some studies suggest that there is consumer resistance to price increases above 10 percent. Consumer preferences are dynamic and could easily change with more information, however. Even though there is a growing and profitable markets for pesticide-free foods, and there are many case studies of profitable farm enterprises with organic or low pesticide practices, such markets for these products represent only about two percent of sales. And, while the food system is evolving to provide attributes that consumers desire, and lower pesticide risk is clearly one such attribute, there is a lack of research to undergird pursuit of these markets by large numbers of producers. We know little about: (1) those final product attributes for which the consumers are willing to pay, including specifically (2) whether they are really willing to pay more for products produced with lower pesticide use. As a result, there is no certainty that if many farmers pursued organic markets, there would be price premiums over and above prices paid for conventional production. Economics suggests, however, that the production and marketing costs for organic production should decrease overtime as more research and development is directed toward this method of production.

Pest Resistance

The fourth producer concern surrounding the implementation of the FQPA is pest resistance. Pest resistance is first defined and then the state of knowledge surrounding this concern is presented. Finally, implications for pest resistance are developed.

Defining the Issue: Pest Resistance

A longer term concern by producers is that the loss of certain pesticides or pesticide uses could hasten pest resistance to the remaining pesticides. Geneticists have long observed that heavy reliance on just one or two means of pest control creates strong “selection pressure” for the survival of those individuals with resistance traits. A reduction in the number of pesticides available in farmers’ pest management portfolio could result in greater reliance on those that remain, raising the odds that pests become resistant to the legal tools remaining. Hence, producers fear losing – by means of biological resistance – those safer pesticides not lost by regulatory means.

A supporting argument holds that access to pesticides may be a key to maintaining a safe food supply during the next few years. After fifty years of synthetic pesticide research and development, American agriculture is highly dependent on pesticides. In recent decades, we have refined our farming systems so that integrated pest management (IPM) techniques and more specialized chemistries have reduced the number of pesticide sprays and the application rates. But many IPM tools follow Teddy Roosevelt's maxim to "talk softly but carry a big stick,"relying on the presence of efficacious pesticide weapons that can be applied in the event that "softer" low-pesticide use methods fail. Without those powerful back-up weapons, more frequent sprays would probably be required, if current quality standards were to be met with assurance.

It may be prudent, therefore, to examine the various services provided by each FQPA targeted chemical. For example, a pesticide might be used as a backup weapon in support of IPM techniques, it may be used for cosmetic purposes, or it may be used to protect the crop from pest-related destruction. In the instance of FQPA-targeted pesticides that enhance food safety indirectly (e.g., by reducing the potential for major pests to develop genetic resistance to a small set of remaining pest controls), such compounds might be found worth maintaining for restricted use. Even relatively risky pesticides could play valuable roles in the near future for maintaining the viability of IPM programs and preventing pest resistance to safer pesticides. The validity of these concerns is dependent on the FQPA implementation details and whether some uses of relatively risky chemicals remain available.

State of Knowledge: pest resistance

The development of pest resistance to chemical controls is well-documented (Office of Technology Assessment, 1995). Recent experience with corn rootworm in the Midwest has shown that pests can even develop resistance to nonchemical controls such as crop rotation. There is also a growing literature on the effectiveness of various IPM programs, but any assessments of these programs' effectiveness is complicated by the heterogeneity of regions, time, and crops involved (Fernandez-Cornejo, Jans, and Smith, 1998). Norton and Mullen (1994) reviewed 44 studies of IPM programs and concluded that IPM use reduced pesticide use by 15 percent. However, there do not appear to be studies that link the success of IPM to the availability of particular chemicals as backup weapons.

There is also considerable research now being directed at the development of biological pesticides–or biopesticides. These include bacteria, viruses and fungi. In addition, genetic engineering holds promise to reduce dependence of certain pesticides. Without a lengthy transition plan under the FQPA, however, the introduction of new products may be too far out in time to ameliorate immediate concerns about some pesticide losses.

Policy research needs

In addition to research addressing the role played by specific pesticides in successful IPM techniques, there is a considerable research agenda for improved bio-based alternatives to chemical-based farming practices. For example, although a great deal of the research on ecological pest management is generalizable and applicable to the FQPA context, some is not. There are numerous research needs in this area. Biological organisms behave differently under different growing conditions, cropping systems and regulations vary among states. Population growth rates, economic thresholds and recommended management practices often differ. Thus, the best ecological pest management research for an individual farmer is that which is designed for his or her own eco-region. In addition, bio-intensive IPM systems must evolve in step with new pests, with changes in the economics of crop production, tillage and planting systems, and with technology and the many other factors that can influence pest populations (Benbrook, 1996). Research is needed to tailor systems to farms and regions. Other examples of possible research are discussed in Textbox 5.

Textbox 5. Illustrations from a Long Term Research Agenda to Complement FQPA

There is considerable research on improved pest control methods that, if completed, would greatly assist in managing dietary risks from pesticides. The following research needs are meant to be illustrative and not comprehensive.

Plant diseases. Soil microbes can either trigger or strengthen plant immune systems so that later in life plants can better withstand a degree of plant pathogen pressure or insect attack. Soil microbial activity also plays a direct role in the bio-control of nematodes, soil-borne insects and associated pest pathogens. This phenomenon is referred to as systemic acquired resistance (SAR), an area receiving much research attention that may lead to a new generation of biopesticides. Research exploring the linkages between plant genetic traits and soil microbial communities is needed to identify those genes in plants which trigger positive changes in microbial communities, in turn benefitting the plant through enhanced nutrition or ability to withstand pest pressure (Benbrook, 1996).

Weeds. Weed management is an area in which scientists are beginning to make important discoveries, but much more research is needed. Most soils contain natural pathogens that survive by attacking the roots of weeds rather than plants. Scientists are discovering that a combination of biological mechanisms can create weed suppressive soils. Additionally, scientists have discovered that microbes and arthropods can play an important role in weed management by eating weed seeds directly or breaking them down through microbial processes (Benbrook, 1996).

Low-risk biopesticides are essential components of biointensive IPM systems, but research directed at biopesticides is fragmentary and incomplete. Low-risk biopesticides are compounds which include microorganisms, viruses, insect pheromones, and natural chemicals derived from plants. Research needs to evolve in tandem with insect resistance to various chemicals so that practices continue to emerge to develop and improve lower risk ways to control or prevent pest damage (Office of Technology Assessment, 1995).

Particularly important for the FQPA purposes is research directed at managing insect pests using pheromones for mating disruption, lures and traps. Pheromones are chemicals naturally secreted by insects for communicating in various ways. Pheromone mating disruption is the use of large amounts synthetically made insect pheromones for the express purpose of confusing male and female insects so that they fail to find each other and mate. Pheromone lures and traps in the field are used by consultants in pest management to monitor insect pest populations for the purpose of timing pesticide sprays and non-chemical pest control practices. Pheromone lures and traps are used differently for each insect and control measure. Research is also needed to lower the cost of adoption of pheromone lures and traps.

Implications: Pest Resistance

The importance of this pest resistance concern is dependent on how the FQPA is implemented. Reduced availability of pesticides, particularly complete bans of classes of chemicals, may translate into over reliance on a few remaining pest control weapons, resulting in accelerated development of genetic pest resistance. This vicious cycle of fewer pest control options hastening the reduced effectiveness of those pest controls that remain can be broken by (1) undertaking considerably more research into non-pesticide methods of pest control, (2) implementing the FQPA in a manner that does not prohibit all uses of broad classes of pesticides, or (3) developing new classes of pesticides that are lower risk.

Conclusion

The four major concerns of producers--producer profitability, international and domestic competitiveness, consumer reactions, and pest resistance development--are all legitimate and should be addressed if the implementation of the FQPA reduces or eliminates broad classes of pesticides. Even in the more likely event that the FQPA prohibits only certain pesticide uses or relies on residue standards, many uncertainties remain. Because these uncertainties potentially impact producers' livelihoods many argue for a go-slow, long transition for any major changes in the way they farm or the pest control products they use.

Balancing these agricultural concerns are a parallel set of concerns expressed by consumer and environmental groups. They are worried that the FQPA's promise to protect infants and children from pesticide risks will be sabotaged by lax implementation. They note that emerging research casts suspicion on various pesticides impact on human health–particularly infants and children. Infants and children proportionally eat, drink and breathe more food, water, and air than do adults. Because they are still developing, their systems are more sensitive to exposure to toxins. Long-term trends show that childhood cancers have risen by one-third since 1950; and similar increases have occurred in neuro-behavioral effects such as attention deficit disorders. Some evidence suggests pesticides may be partially responsible for these trends. There is also concern that there may be possible endocrine disruption and reproduction effects caused by the use of some pesticides. While research and empirical evidence is fragmentary and inconclusive as to how much, if any, of these problems relate to agricultural's use of pesticides, many experts–including National Academy of Science panels–have advocated that the U.S. should adopt a conservative approach in order to protect sensitive sub-populations from cumulative exposures (NRC, 1993). It is this conservative approach that is embedded in the FQPA mandate.

The common element that emerges from this review of the evidence is: Impacts on producers will depend on *how* FQPA is implemented. Having established that bans on the use of broad categories of pesticides would be economically damaging, little value is to be gained from more research measuring just how damaging those impacts would be.

The issue is no longer *whether* to implement FQPA in a way that would cancel broad categories of pesticide uses. Instead, the question is now *how* to implement the Act in a way that meets its food safety mandate while minimizing the likely adjustment costs to food producers. In "Part II: FQPA Implementation Alternatives and Strategies," the authors assess alternative cost-effective ways to prioritize pesticide uses and make the transition to agricultural production that meets FQPA standards for food safe from risky pesticide residues.

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Tables

Table 1: Michigan fruits and vegetables: value of production and number of organophosphate (OP) and carbamate pesticides in use

Michigan Crops	Value of Production–Fresh [1]	Value of Production–Processing [1]	At-Risk Pesticides by Crop [2]	Pesticide classes
Apples	$45,000,000	$54,750,000	11	Organophosphate, carbamate
Potatoes	$14,483,700	$79,566,300	8	Organophosphate, carbamate
Blueberries	$20,748,000	$32,450,000	4	Organophosphate, carbamate
Cucumbers	$15,792,000	$19,760,000	5	Organophosphate, carbamate
Cherries, tart	$156,000	$34,320,000	7	Organophosphate, carbamate
Cherries, sweet	$370,000	$19,610,000	5	Organophosphate, carbamate
Carrots	$16,563,000	$2,340,000	2	Carbamate
Tomatoes	$9,583,000	$9,053,000	6	Organophosphate, carbamate
Asparagus	$3,120,000	$14,672,000	2	Organophosphate, carbamate
Corn, sweet	$17,408,000	no longer grown commercially	4	Organophosphate, carbamate
Celery	$17,081,000 (fresh & processing)		5	Organophosphate, carbamate
Peaches	$16,190,000 (fresh & processing)		7	Organophosphate, carbamate
Beans, snap	$2,146,000	$13,451,000	3	Organophosphate
Grapes	$50,400	$15,321,600	5	Organophosphate, carbamate
Peppers, bell	$7,817,000		4	Organophosphate, carbamate
Strawberries	$6,960,000	$451,000	4	Organophosphate, carbamate
Cabbage	$3,853,000		4	Organophosphate, carbamate
Cantaloupe	$2,237,000		2	Organophosphate, carbamate
Cauliflower	$2,174,000 (fresh & processing)		4	Organophosphate, carbamate
Plums	$532,500	$1,242,500	6	Organophosphate, carbamate
Pears	$1,000,000		6	Organophosphate, carbamate

[1] Michigan Agricultural Statistics 1997-1998

[2] Organophosphate and/or carbamate pesticides identified as potentially affected by the FQPA in one or more of the following sources: U.S. Environmental Protection Agency, Office of Pesticide Programs, Organophosphate Use and Usage Information (http://www.epa.gov/oppbead1/matrices); Consumers Union 1998 study "Worst First: High-Risk Insecticide Uses, Children's Foods and Safer Alternatives; Consumers Union 1999 study "Do You Know What You're Eating? An Analysis Of U.S. Government Data On Pesticide Residues In Foods"; Michigan State University Pesticide Loss Prediction Database (http://www.cips.msu.edu/par).

Table 2: Foreign competition faced by Michigan fruit and vegetable production, 1995-1998

Michigan Crops	Percent of Imported Consumption – Fresh	Percent of Imported Consumption - Processed	Major Foreign Competitors Listed in Rank Order
Apples	7.2	59.6	Fresh: Canada, New Zealand, Chile, South Africa Juice: China, Hungary, Germany, Argentina
Potatoes	5.3	4.6	Canada
Cucumbers	38.6	1.9	Mexico, Canada
Cherries, tart	N/A	0.14	Yugoslavia, E.U.
Cherries, sweet	N/A	10	Chile (fresh, winter)
Carrots	8.4	1.3	Canada
Tomatoes	31.4	3.5	Mexico, Canada, Netherlands
Asparagus	52.6	22.9	Mexico, China
Corn, sweet	0.8	1.8	Canada
Celery	3.4	N/A	Mexico, Canada
Peaches (incl. nectarines)	8.2	N/A	Chile, Canada
Beans, snap		1.7	Canada
Grapes	38.2	N/A	Fresh: Chile, Mexico, S. Africa, Canada Juice: Argentina, Brazil, Chile, Mexico, Spain. Wine: Italy, France, Chile, Australia, Spain
Peppers, bell	20.7	N/A	Mexico, Netherlands
Strawberries	5.8	N/A	Mexico
Cabbage	3.3	1	Canada, Mexico
Cauliflower	3.7	36.9	Mexico
Pears	20.8	N/A	Chile, Argentina

Sources: U.S. Department of Agriculture Economic Research Service, Food Consumption, Prices, and Expenditures, 1970-95; U.S. Department of Agriculture Economic Research Service, Vegetables and Specialties, Situation and Outlook Yearbook, July 1998; U.S. Department of Agriculture Economic Research Service, Fruit and Tree Nuts, Situation and Outlook Report, October 1998; National Association of Beverage Importers, Inc, wine statistics, January - December 1998.

Appendix A
"At-Risk" Pesticides Used on Michigan Crops by Chemical Class and Trade Name

Michigan Crops	Pesticide	Trade Name	Chemical Class*	Pesticide Type**
Apples	methyl-parathion azinphos-methyl chlorpyrifos oxamyl carbaryl dimethoate methomyl phosmet formetanate hydro diazinon malathion	Penncap-M Guthion Lorsban Vydate Sevin Cygon Lannate Imidan Carzol Diazinon Cythion,	OP OP OP Carbamate Carbamate OP Carbamate OP Carbamate OP OP	I I I I I I I I I I I
Potatoes	methamidophos aldicarb parathion-methyl azinphos-methyl dimethoate carbaryl oxamyl diazinon	Monitor Sentry Penncap-M Guthion Cygon Sevin Vydate Diazinon	OP Carbamate OP OP OP Carbamate Carbamate OP	I I I I I I I I
Blueberries	azinphos-methyl carbaryl phosmet methomyl	Guthion Sevin Imidan Lannate	OP Carbamate OP Carbamate	I I I I
Cucumbers	methyl-parathion carbaryl diazinon chlorpyrifos azinphos-methyl	Penncap-M Sevin Dianinon Lorsban Guthion	OP Carbamate OP OP OP	I O I I I
Cherries, tart	azinphos-methyl phosmet chlorpyrifos methyl-parathion methomyl oxamyl carbaryl	Guthion Imidan Lorsban Penncap-M Lannate Vydate Sevin	OP OP OP OP Carbamate Carbamate Carbamate	I I I I I I I
Cherries, sweet	azinphos-methyl methyl-parathion methomyl oxamyl carbaryl	Guthion Penncap-M Lannate Vydate Sevin	OP OP Carbamate Carbamate Carbamate	I I I I I
Carrots	oxamyl carbaryl	Vydate Sevin	Carbamate Carbamate	N I

Tomatoes	azinphos-methyl diazinon carbaryl methomidophos methyl-parathion chlorpyrifos	Guthion Diazinon Sevin Monitor Penncap-M Lorsban	OP OP Carbamate OP OP OP	I I I I I I
Asparagus	chlorpyrifos carbaryl	Lorsban Sevin	OP Carbamate	I I
Corn, sweet	methomyl chlorpyrifos carbaryl methyl parathion	Lannate Lorsban Sevin Penncap-M	Carbamate OP Carbamate OP	I I I I
Celery	oxamyl methomyl azinphos-methyl carbaryl acephate	Vydate Lannate Guthion Sevin Orthene	Carbamate Carbamate OP Carbamate OP	N I I I I
Peaches	azinphos-methyl phosmet methyl-parathion chlorpyrifos oxamyl carbaryl methomyl diazinon formetanate HCL	Guthion Imidan Penncap-M Lorsban Vydate Sevin Lannate Diazinon Carzol	OP OP OP OP Carbamate Carbamate Carbamate Carbamate Carbamate	I I I I I I I I I
Beans, snap	dimethoate acephate methyl parathion	Cygon Orthene Penncap-M	OP OP OP	I I I
Grapes	chlorpyrifos azinphos-methyl methyl-parathion carbaryl methomyl formetanate HCL dimethoate	Lorsban Guthion Penncap-M Sevin Lannate Carzol Cygon	OP OP OP Carbamate Carbamate Carbamate OP	I I I I I I I
Peppers, bell	azinphos-methyl carbaryl dimethoate acephate	Guthion Sevin Cygon Orthene	OP Carbamate OP OP	I I I I
Strawberries	carbaryl azinpos-methyl oxamyl methomyl	Sevin Guthion Vydate Lannate	Carbamate OP Carbamate Carbamate	I I I I

Cabbage	chloryprifos azinphos-methyl methomyl methamidophos	Lorsban Guthion Lannate Monitor	OP OP Carbamate OP	I I I I
Cantaloups	carbaryl azinphos-methyl	Sevin Guthion	Carbamate OP	I I
Cauliflower	chloryprifos azinphos-methyl methomyl diazinon	Lorsban Guthion Lannate Diazinon	OP OP Carbamate OP	I I I I
Plums	phosmet azinphos-methyl methyl-parathion chlorpyrifos methomyl carbaryl	Imidan Guthion Penncap-M Lorsban Lannate Sevin	OP OP OP OP Carbamate Carbamate	I I I I I I
Pears	azinphos-methyl oxamyl phosmet chlorpyrifos methyl-parathion carbaryl	Guthion Vydate Imidan Lorsban Penncap-M Sevin	OP Carbamate OP OP OP Carbamate	I I I I I O

* Chemical class of pesticide; OP = Organophosphate
** Pesticide Type: I = Insecticide; N = Nematicide; O = Other

Sources: EPA Organophosphate Usage Matrix for North Central Region; Consumers Union identified High-Risk Insecticide Uses; Consumers Union identified Risk-Driver Insecticides; MSU Pesticides At Risk: http:www.cips.msu.edu/par/MSUPAR98.pdf