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This year is the 20th anniversary of the National Agricultural Pesticide Impact Assessment Program (NAPIAP). The original purpose of this cooperative United States Department of Agriculture (USDA) and State program was to develop and make available science-based information which evaluates the benefits pesticides provide to United States agriculture. Science-based benefits data are necessary to allow regulatory agency personnel to make informed decisions and estimate potential impacts of proposed regulatory changes. The documents in which these benefits data are published have become known as "NAPIAP Assessment Reports." Originally, assessments focused on active ingredients since this was the unit of regulation and interest to the United States Environmental Protection Agency (EPA). Recently, in order to build background information which will be readily available to evaluate specific pesticides, the trend in NAPIAP has been toward a more holistic, commodity based approach to the evaluation of pest management tactics and usage. The reason for this shift in emphasis is that producers, agricultural scientists, and commodity groups, which are each important sources of information and cooperation in the assessment process, have their interest and expertise focused on crops or cropping systems, not on active ingredients.

The primary audience, for whom assessment documents are developed, is the EPA. However, the information developed in assessment documents are also used by personnel and scientists working in the USDA, State regulatory agencies, land grant colleges, private industry, commodity groups, and environmental groups.

In the past, the regulatory community has questioned the accuracy of estimates of economic impact in NAPIAP assessment documents; so a concerted effort has been made to improve data collection and the estimates in NAPIAP reports. For the past six years, NAPIAP personnel have made a concerted effort to improve the timeliness of completion, publication, and distribution of assessment documents. In the rapidly changing scene of pesticide regulatory action, timeliness is essential in the development of assessment documents. EPA scientists often need the NAPIAP assessment information during a very short time frame. Pesticide usage data also ages very rapidly, due to the changes in the availability of alternative pest management technology, new pesticides and new registrations and cancellations of pesticides. A timely produced assessment document, based upon sound scientific information, concisely written, and with accurate conclusions can focus vital benefits information for use by EPA in balancing the risk-benefit equation of the regulatory process.

Traditional NAPIAP assessment documents provide a national summary of the biological and the economical components of pest management information on an active ingredient or a commodity. Weed scientists, plant pathologists and entomologists from land grant universities have been the principal authors and information sources of NAPIAP assessments. These biological scientists describe the aspects of the life histories of target insect pests, weeds, or plant diseases which are important to crop production systems. Biologists also describe, quantify, and point out limitations of alternative pest management technology available to producers.

The economic components of an assessment places values upon the different management options and develops "what if" scenarios that estimate impacts to producers and consumers should certain management options no longer be available. With the publication of the phenoxy herbicide assessment, NAPIAP has completed and published 66 assessment documents. At present eleven additional assessments are in various stages of completion.. These are alfalfa, apple, asparagus, citrus,

diazinon, nursery and greenhouse, onion, potato, strawberry, tomato, and the triazine herbicides.

This year is the 51st anniversary of 2,4-D being commercially produced and marketed as an agricultural herbicide. Throughout the past five decades, weed management provided by 2,4-D has contributed to the production of billions of tons of crops throughout the world, which otherwise would not have been available for human consumption. Scientists from the Office of Pesticide Programs in EPA have had a growing need for additional information on the phenoxy herbicides. EPA, in 1992 and again in 1993, indicated to NAPIAP scientists that a phenoxy herbicide assessment would be helpful in the decision making process within EPA, because of the possible human and canine health risks regarding 2,4-D exposure.

In 1993, my office contacted Dr. Orvin Burnside at the University of Minnesota and asked him if he would chair an assessment Task Force to define the United States agricultural benefits of phenoxy herbicides, with an emphasis on 2,4-D impacts. Burnside agreed and requested and received the commitment of Dr. John Nalewaja to serve on the assessment. Together they selected the eminent slate of weed scientists that have authored this document. Dr. Philip Szmedra, from USDA/Economic Research Service, conducted economic analysis for this assessment.

This NAPIAP assessment has consumed thousands of hours of many scientists gathering and processing data, writing, proofing, and rewriting this assessment. The dedication, commitment, and effort on the part of this assessment Task Force is a reflection of the importance that these learned weed scientists place on the beneficial roles the phenoxy herbicides play in the production of food and fiber in this country and worldwide. A special note of thanks is extended from the leadership of the USDA/NAPIAP to each and every member of this assessment Task Force for their commitment and dedication to American agriculture and to this project.

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Advisor to the NAPIAP, Phenoxy Herbicide Assessment Task Force

EXECUTIVE SUMMARY

Rationale

We are entering an era in the United States where all pesticides registered prior to November 1984 must, by law, either be re-registered by 1997 (recently extended to 2001 with passage of the Food Quality Protection Act of 1996) or their use discontinued. This legislation may result in the cancellation of nearly half of all our pesticides. The first phenoxy herbicide registered was 2,4-D in 1945, and registration of other herbicides in this chemical family followed shortly thereafter. There has been worldwide acceptance and widespread use of the phenoxy herbicides since their introduction. They still represent the most widely used family of herbicides in the world; so it behooves us, to make a concerted effort, to retain humankind's use of the phenoxy herbicides by quantifying their biologic and economic benefits. More effective weed control has been a major factor in increasing crop yields in developed countries worldwide since the introduction of 2,4-D and subsequent selective herbicides.

The phenoxy herbicides were so effective and economical for selectively controlling broadleaf weeds in grass crops that they put selective weed control in the "public spotlight" worldwide. Also, 2,4-D launched accelerated weed management by the use of herbicides in the emerging discipline of weed science. Phenoxy herbicides have provided very economical, selective, pest emergence control of

broadleaf weeds in grass crops and noncropland for the past five decades. The first widely used organic herbicide developed was 2,4-D, and it is still the most widely used herbicide throughout the world.

Today, phenoxy herbicides play a major role in weed management when used either alone or in combination with other herbicides because they economically enhance the weed control spectrum of many herbicides. The herbicide 2,4-D is registered (tolerances have been established) for use on over 65 crops in the United States, and other phenoxy herbicides are registered on over 25 crops. Also, the phenoxy herbicides are registered for numerous noncropland uses.

This biological and economical benefits assessment of phenoxy herbicides encompasses all the cropland and noncropland uses in the United States. Concurrent toxicological studies of 2,4-D have been conducted by an Industry Risk Assessment Task Force, and all studies required for re-registration were completed and submitted to the Environmental Protection Agency (EPA) in December 1995. Thus, this benefits assessment of the phenoxy herbicides provides additional supportive information for the re-registration process.

Objectives

The major objective of this assessment was to determine the biologic and economic benefits from the use of the phenoxy herbicides in the United States. Specific objectives of the study were to review epidemiology and toxicology data of phenoxy herbicides, and determine their use rates, timing of applications, acres treated, and total pounds of acid equivalent utilized on cropland and noncropland in the United States. Estimates were made in each state, plus Puerto Rico, of alternative herbicides or non-chemical weed control methods, availability of alternative methods, use and costs of alternative methods, and crop yield impact with alternative methods if either 2,4-D or all phenoxy herbicides were banned. Thus, estimates were made of the net societal effect (production plus consumer costs) of banning either 2,4-D or all phenoxy herbicides in the United States. Individual authors also listed the various impacts of banning either 2,4-D or all phenoxy herbicides that are not readily amenable to an economic cost estimate, but are important for managing weeds on cropland and noncropland.

Methodology

This assessment was conducted by selecting a Task Force of seven public weed scientists plus an epidemiologist, toxicologist, and economist; developing a generic questionnaire for all phenoxy herbicide uses in the United States; and selecting weed scientists in each state to provide the use and benefit information. State weed scientists used state and federal grower surveys plus any other data available to respond to our questionnaires. Common sources of information included publications for federal and state agencies, data from industry, grower and agri-business surveys, and journal articles from referred and non-referred sources. Questionnaires were mailed in early 1993 to gather information about phenoxy herbicide use during 1992. Thus, the information received relates mainly to the 1992 growing season, but it is representative of subsequent years because many of the uses of the phenoxy herbicides have stabilized. An exception would be the increased use of 2,4-D preplant for no-till soybean production since 1992. The quantity of the various phenoxy herbicides used was from state surveys and independent estimates, and total use compared favorably with national sales data from basic producers of these phenoxy herbicides. The potential alternative weed management methods (both chemical and non-chemical) to the phenoxy herbicides were provided by the selected weed scientist or other scientists best able to provide that information for the state in question. Quantification of the economic impacts of banning either 2,4-D or all phenoxy herbicides was made using published suggested retail prices of herbicides, estimated costs of tillage and other production practices, reported application and labor costs, estimated yield losses with alternative weed

management the most widely marketed family horticultural commodity in the world; so it behooves us, to make a concerted effort, to retain humankind's use of the phenoxy herbicides by quantifying their biologic and economic benefits. More effective weed control has been a major factor in increasing crop yields in developed countries worldwide since the introduction of 2,4-D and subsequent selective herbicides.

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Today, phenoxy herbicides play a major role in weed management when used either alone or in combination with other herbicides because they economically enhance the weed control spectrum of many herbicides. The herbicide 2,4-D is registered (tolerances have been established) for use on over 65 crops in the United States, and other phenoxy herbicides are registered on over 25 crops. Also, the phenoxy herbicides are registered for numerous noncropland uses.

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Results

Authors of this assessment discussed the use of phenoxy herbicides in over 65 crops and numerous noncropland uses. Usage of all phenoxy herbicides in the United States was estimated at 55 million pounds of acid equivalent (47 million pounds of just 2,4-D) with a retail sales value of \$171 million during 1992.

The estimated net societal loss from banning only 2,4-D in the United States would be \$1.683 billion; whereas, banning all phenoxy herbicides would result in a loss of \$2.559 billion annually (Table 1). Approximately 37% of this net societal loss represents increased weed management costs from the use of more expensive alternative herbicides or non-chemical weed control methods. An additional 36% of the aggregate loss occurs because of decreased crop yields. The remaining 27% is considered a net societal loss for consumers because of higher retail commodity prices. Decreased crop yields occur to a greater degree with the minor acreage crops where alternative herbicide choices are more limited than with the major acreage crops.

Discussion

Loss of the phenoxy herbicides in the United States would markedly reduce our ability to manage broadleaf weeds in over 65 crops and in numerous noncropland situations. In those situations where weeds are manageable without the phenoxy herbicides, weed control costs would increase markedly because alternative herbicides and non-chemical methods are much more expensive or more labor intensive than the phenoxy herbicides. Presently, 2,4-D is one of the lowest cost herbicides for broadleaf weed control in the United States, and this it tends to keep the retail price of substitute herbicides competitive. For example, in Minnesota (Cultural and Chemical Weed Control in Field Crops 1996) the median suggested rate of 2,4-D amine at 0.5 lb/A for broadleaf weed control in spring wheat would cost \$1.59/A, non-phenoxy herbicides suggested for broadleaf weed control at their median rate averaged \$5.05/A, and suggested herbicides for grass (wild oat) control in spring wheat averaged \$15.58/A. Thus, 2,4-D may be partially responsible for the reduced price of other broadleaf herbicides in contrast to the higher price of grass herbicides in these same small grains. Also, the only broadleaf herbicide registered on some minor crops (e.g., almond, blueberry, cranberry, grape, nectarine, pear, strawberry, and wildrice) is 2,4-D, and its loss would adversely affect the production of these crops.

In addition to the need of 2,4-D as a herbicide, it is also important as a plant growth regulator. Navel orange and grapefruit growers in Arizona and California use 2,4-D to stop abscission layer formation in the stems of citrus fruit. Thus, they use 7,600 pounds of 2,4-D at a total chemical cost of \$24,170 which will delay fruit drop up to 2 1/2 months. If these citrus fruits could not be "stored" on the trees (dropped fruit are lost), there would be an estimated annual loss to growers of \$80 million.

Conclusions

Cancellation of all uses of phenoxy herbicides in the United States would have widespread impacts; a few of these concerns are listed below:

- The net societal loss (production plus consumer costs) of banning the phenoxy herbicides would be \$2.559 billion annually.
- Farmers would suffer an annual loss of \$1.868 billion because of yield loss and increased weed control costs in over 65 crops and in many noncropland situations.
- Industry would lose \$171 million in annual retail sales of phenoxy herbicides, but could compete for the new market created for alternative herbicides worth \$914 million.
- Human injuries may increase as farmers shift to greater use of mechanical weed management methods.
- Controlling the development of herbicide resistance in weeds would be more difficult because the phenoxy herbicides have shown little potential for development of weed resistance, and they are widely used with other herbicides to expand the weed control spectrum.
- Phenoxy herbicides are widely used to control plants poisonous to livestock and humans as well as many weeds that cause human discomfort (e.g., hay fever from ragweed pollen to allergic reactions from poison ivy).
- Economically effective herbicides would be lost for many crop production situations, and for numerous noncropland uses (e.g., lawn weed control to brush control under transmission lines).
- Phenoxy herbicides have been used for 51 years with little or no acute or chronic toxicity to humans. Based on extensive animal and human studies, phenoxy herbicides are not likely to cause cancer. Typically, the general public is not exposed to unsafe levels of the phenoxy herbicides. Switching to alternative herbicides does not guarantee increased safety to human health as compared to the enviable human safety record achieved with the phenoxy herbicides.
- The general public would have to accept a decline in the aesthetic value and playability in areas ranging from lawns and parks to golf courses.
- Control of aquatic weeds would decline and the general public would recognize this in activities ranging from swimming to navigation of waterways.
- The net societal loss if 2,4-D were banned would be \$139 million annually for peanut production alone, and the return to Southeastern United States peanut growers would decrease by \$138/A.
- Preplant use of phenoxy herbicides has become increasingly important because of increases in no-till soybean production during the past few years and 2,4-D remains a mainstay in most other no-till crop production systems.
- Minor crops would suffer more production loss per acre from a phenoxy herbicide ban than major crops because these low-acreage, high-value crops do not often justify the cost of registering alternative herbicides.
- Loss of phenoxy herbicides would necessitate increased tillage and thus accelerate soil erosion and water pollution at a time when government programs and farmers are striving to reduce tillage to conserve soil and energy and improve water quality.
- The management of over 100 weeds, classified by law as noxious, would be much more difficult without phenoxy herbicides and the annual net societal loss would be \$180 million.
- The general public would be impacted in areas ranging from increased consumer costs for many foods totalling \$691 million annually to higher lawn and turfgrass management costs.
- The phenoxy herbicides have greatly aided humankind by increasing worldwide food production and reducing the dredgery of weed management while generating an outstanding record of human and environmental safety.

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