Economic Analysis of Avoiding a Potential Health Hazard on an Individual Farm

By Robert O. Burton, Jr., Ross M. Key, Bryan W. Schurle, and David L. Regehr

Abstract

A ten-year linear programming model of a representative dry-land crop farm in North Central Kansas is used to develop and illustrate procedures for analyzing economic impacts of the elimination of one or more pesticides on an individual farm. Atrazine is used as an example pesticide because of its widespread use and because concerns about atrazine have been expressed in the United States and in other countries. An important outcome is that impacts on grain sorghum would likely be greater than impacts on corn because more alternative and effective herbicides are available for corn.

Research indicates that farmers are more likely than the general population to experience certain types of cancer (e.g., Frey; Burmeister; Schuman, Mandel, and Blackard; Blair and Zahm). An ongoing study by the National Cancer Institute (NCI) is addressing links between types of cancer and possible causes such as use of specific agricultural pesticides (Alavanja, et al.). Moreover, chlorinated pesticides are suspected (but not proven) to be endocrine disruptors (Tilson, Keith). The Endocrine Disruptor Research Initiative is analyzing chemicals suspected of being disruptors (EPA July 2003).

Atrazine: An Example Pesticide

This study will analyze the economic impacts of ceasing to use atrazine on a representative Kansas farm. Atrazine is selected because it is widely used and because it has received scrutiny from the U.S. Environmental Protection Agency (EPA) and from regulatory agencies in other countries. Atrazine is a triazine molecule that has chlorinated components.

National Agricultural Statistics Service (NASS 2006) data indicate that the average annual percentages of acres treated with atrazine in their 29 program states were 68 percent of all corn and 69 percent of all sorghum. The EPA recognizes atrazine as "one of the most widely used agricultural pesticides" with approximately 76.5 million pounds of active ingredient applied in the U.S. annually (EPA January 2003a).




Robert O. Burton, Jr. is professor, **Ross M. Key** is former graduate research assistant, and **Bryan W. Schurle** is professor and Head, Department of Agricultural Economics, Kansas State University; **David L. Regehr** is Professor, Department of Agronomy, Kansas State University. **Key** currently works as an Agricultural Loan Officer, Elberfeld State Bank, Elberfeld, IN.

Concerns addressed in EPA's recent review of atrazine included dietary, residential, and occupational risks (EPA January 2003b) and associations between atrazine exposure and cancer, effects of atrazine on amphibians, and atrazine in watersheds (EPA October 2003). EPA noted that it "will continue its review of all new data submissions," including results from the NCI study mentioned above (EPA October 2003).

Concerns about atrazine have been addressed in several other countries. Australian National Registration Authority for Agricultural and Veterinary Chemicals (NRA) concluded that agriculture needs atrazine, but recommended its removal from non-agricultural/home garden use (NRA 2002, Australian Pesticides & Veterinary Medicines Authority). NRA noted that some members of the European Union have discontinued atrazine use (NRA 1997).

Problem Statement

If links between illnesses and causes become more firmly established, there will be a need for economic analysis of impacts of avoiding those causes on individual farms. The purpose of this study is to develop and illustrate procedures for analyzing economic impacts of the elimination of one or more chemicals on an individual farm. Atrazine use on a representative farm in Kansas will be used as an example. The following questions will be addressed:

1) What is the representative farm's return over variable costs with and without atrazine?
2) What is the representative farm's capital carried forward with and without atrazine?
3) What is the representative farm's cost of production with and without atrazine?
4) What is the representative farm's number of acres of corn and grain sorghum farmed with and without atrazine?
5) What level of usage tax might cause producers to cease use of atrazine?
6) What effect does yield reduction have on a producer's decision to eliminate atrazine?

Representative Farm

The representative farm was based on the 2003 average of crop farms in the North Central Kansas Farm Management Association (KFMA). The farm owned 392 acres of land and rented 844 acres. All land was non-irrigated. Representative proportions of crops produced were 40 percent hard red winter wheat, 24 percent grain sorghum, 20 percent soybeans, and 16 percent corn. Average non-farm income was $26,732 and average family living expenses were $39,652, including $4,133 for income taxes and self-employment taxes.

Input costs for seed, fertilizer, and other expenses were based on 2003 Kansas farm management guides (Kansas State University Agricultural Experiment Station and Cooperative Extension Service). Cash rent of $39 per acre was based on 2003 data for North Central Kansas (Dhuyvetter and Kastens). Machinery costs were based on 2003 custom rates for Kansas (KASS).

Herbicide programs and prices were suggested by Dave Regehr, Weed Science Extension Specialist. Dr. Regehr routinely interacts with farmers, crop consultants, and other agricultural professionals. Therefore, he is an excellent source of information about weed management and yield changes associated with alternative weed control programs. Herbicides for wheat and soybeans did not include atrazine. Herbicide programs for corn and grain sorghum with and without atrazine use trade names to identify products. No endorsement is intended, nor is any criticism implied of similar products not mentioned.

Our analyses used the following per acre herbicide programs: for corn, 1 quart of Glyphomax Plus as a burndown application followed by 2.4 quarts of Lumax (s-metolachlor, atrazine and mesotrione) in a pre-emergence application, and 1 ounce of Spirit as a post-emergence herbicide. For sorghum, 1 quart of Glyphomax Plus as a burndown followed by 2.1 quarts of Bicep II Magnum in a pre-emergence application, and 2 pints of Buctril+Atrazine (1 pt. Buctril and 1 pt. atrazine) as a post-emergence herbicide.

Herbicide programs per acre without atrazine were as follows: for corn, 1 quart of Glyphomax Plus as a burndown followed by 12 ounces of Epic (Balance and Define) as a pre-emergence application, and 6 ounces of Distinct as a post-emergence herbicide. Costs of these herbicides for use in corn were $50.37 with atrazine and $53.33 without atrazine. Thus, corn herbicide costs without atrazine were $2.96 (5.88%) higher than corn herbicide costs with atrazine. For sorghum, 1 quart of Glyphomax Plus as a burndown followed by 1.6 pints of Dual Magnum as a pre-emergence application and 1.5 pints of Buctril as a post-emergence herbicide. Costs for weed control on sorghum were $41.37 with atrazine and $44.72 without atrazine. Thus, sorghum herbicide costs without atrazine were $3.35 (8.10%) higher that sorghum herbicide costs with atrazine. These costs represent a 2003 price level and include appropriate adjuvants. Herbicide application costs were the same for corn and grain sorghum with and without atrazine.

Weed scientist Regehr stated that a 10-20 percent yield reduction in sorghum can occur when the program changes from using atrazine to not using atrazine. No yield reduction is expected when the corn program changes from using atrazine to not using atrazine. This study accounts for sorghum yield reductions by analyzing reductions of 5, 10, and 20 percent.

Revenue from the crop activities included crop sales and government payments. The average yield for 1992-2003 for Mitchell County Kansas was used. A twelve-year average was used because the data were readily available (NASS 2004). The county average for 1998-2001 established the government program yields for this analysis.

Government payment data were obtained from the Farm Service Agency (FSA). Target prices and loan rates for each commodity were established through 2007. Direct, counter-cyclical (CCP), and loan deficiency payments (LDP) were calculated in accordance with FSA guidelines. We assumed that the government program will not change over the 10-year time period modeled. We know that farm programs change more frequently than this. However, at the time this study was prepared, details of future farm programs were unknown and we wanted to use a ten-year time period to model how capital carried forward might be affected over time.

Prices were based on historical data and price estimates from the Food and Agricultural Policy Research Institute (FAPRI). The FAPRI 2003 price level estimates for 2004-2013 were used as national price levels for the analysis. For the calculation of the loan deficiency payment portion of the government program, it is necessary to have county-level price information. County prices were established by calculating the 12-year average price basis (1992-2003) between national and county prices obtained from NASS for each commodity and subtracting this basis from the FAPRI prices.

Capital Carried Forward

Capital carried forward was investigated to determine how the amount of capital available at the end of each year was affected by elimination of atrazine. Capital carried forward was calculated by subtracting fixed costs of land and buildings, adding non-farm income and subtracting the cost of living from return over variable costs.

Fixed Costs

For machinery costs, this analysis used custom rates which include variable and fixed costs for machinery and labor. However, to calculate capital carried forward, fixed costs of land and buildings are needed. Initially fixed costs for land and buildings were calculated by multiplying the total value of land and buildings by a rent-to-value percentage of 5.1 percent, established by Dhuyvetter and Kastens, plus 0.5 percent for building depreciation (based on KFMA data) and another 0.4 percent for insurance and any miscellaneous expense. In preliminary model runs, when fixed costs for land and buildings were estimated as 6 percent of value, capital carried forward was negative in all 10 years. For most operations, not all fixed costs are cash costs and not all farmers consider all economic cost when evaluating their operations. Therefore, for this study, fixed costs of land and buildings were estimated as three percent of value.

Linear Programming Model

The linear programming (LP) model of the representative farm maximizes return over variable cost for a ten-year period. Crop production activities included corn, grain sorghum, soybeans, and wheat. Constraints included owned and rented land and rotation restrictions. In order to measure the economic impacts associated with ceasing to use atrazine, the amount of capital available without borrowing was set at a high level to ensure that acres farmed in all model runs would be the same as total acres for the representative farm. Labor and machinery constraints are not included because all machinery operations are custom hired. The LP model was run in Excel using the simplex solver. The model included corn and grain sorghum production activities with atrazine and with the alternative weed control program.

An initial base run represents the current situation. The remaining runs will examine the effect of increased herbicide costs (modeled as a per acre tax on acres that use atrazine) and possible yield reductions of 5, 10, and 20 percent for grain sorghum production without atrazine. Weed control options other than chemical use are not analyzed.

Results

Discussion of results addresses the six questions in the problem statement.

What is the representative farm's return over variable costs with and without atrazine?

The base model run shows a ten-year total return over variable cost of $266,285. When no atrazine is used, return over variable cost declines to $254,389. Thus, the ten-year return decreases by $11,896 when the alternative chemical program is used with no sorghum yield reduction. A 5, 10, or 20 percent sorghum yield reduction resulting from substituting other chemicals for atrazine reduces the ten-year return by $29,561, $47,229, and $82,561, respectively. Thus, return over variable cost with no atrazine and a 20 percent yield reduction is $82,561 less than the base run return; $70,665 of this decline in return is caused by the 20 percent grain sorghum yield reduction and $11,896 of the decline is caused by use of chemicals on corn and grain sorghum that are more expensive than atrazine. Returns also decline when the use of atrazine is taxed.

What is the representative farm's capital carried forward with and without atrazine?

Capital carried forward paralleled the profit levels. Increasing the per acre tax on atrazine or increasing the yield reduction associated with the elimination of atrazine causes the capital carried forward to decrease. The base model run shows ten-year capital carried forward of $52,499 while the run assuming no atrazine use and a 20 percent yield reduction in sorghum shows ten-year capital carried forward of $-30,059. A $4.00 per acre tax with no sorghum yield reduction causes a shift away from atrazine use with capital carried forward of $40,603. An $11.00 per acre tax with a 5 percent sorghum yield reduction causes a shift away from atrazine use with capital carried forward of $22,936. A $19.00 per acre tax with 10 percent sorghum yield reduction causes a shift away from atrazine use with capital carried forward of $5,279.

What is the representative farm's cost of production with and without atrazine?

The ten-year base run cost of production is $1,882,199. Cost of production increases from the base model run. With no tax and no atrazine used, cost of production increases to $1,894,099. In model runs where atrazine use was the same as the base run, a $1.00 per acre increase in tax on sorghum acres that used atrazine increased the ten-year cost of production by $2,350 and a $1.00 per acre increase in tax on corn acres that used atrazine increased the ten-year cost of production by $1,360.

What is the representative farm's number of acres of corn and grain sorghum farmed with and without atrazine?

The decision was made to force the linear programming model to farm all acres owned and rented each year to isolate the effect of taxing or removing atrazine from production practices. Constraints also force production of these crops to maintain percentages of each crop similar to those in the base representative farm. The model produced 136 acres of corn in each of the 10 years. Corn was produced with atrazine in the base run and in the three model runs with $.50, $1.00, and $2.00 per acre taxes on atrazine use. In all other model runs corn was produced without atrazine. The model produced 235 acres of grain sorghum in each of the 10 years. Sorghum was produced with atrazine in the base run and in most of the other model runs. The exceptions were that sorghum was produced without atrazine in the four model runs that did not allow atrazine use and in the three model runs for which the tax per acre for atrazine use (with or without yield reductions for sorghum) was high enough to eliminate atrazine.

What level of usage tax might cause producers to cease use of atrazine?

The answer to this question differed for corn and grain sorghum. When the tax per acre for atrazine use increased from $2.00 to $3.00 the modeled farm ceased to use atrazine on corn. Because yield was not considered affected when other chemicals were substituted for atrazine, a small per acre tax eliminated the use of atrazine on corn.

If grain sorghum yield is affected by ceasing to use atrazine, the tax necessary to eliminate atrazine use on sorghum will depend on the yield reduction. Based on our $3.35 higher cost for sorghum production without atrazine, if there is no yield reduction, a $4.00 tax per acre will eliminate atrazine use on sorghum. If a 5 percent yield reduction is expected, an $11.00 per acre tax will be required or if a 10 percent yield reduction is expected, a $19.00 per acre tax will be required to eliminate atrazine from sorghum production. In some situations, yield reductions associated with ceasing to use atrazine might be large enough to eliminate sorghum production if atrazine were not available.

What effect does yield reduction have on a producer's decision to eliminate atrazine?

As illustrated in this study in which no yield reduction is associated with ceasing to use atrazine on corn and various yield reductions associated with ceasing to use atrazine on grain sorghum are modeled, yield reductions associated with ceasing to use atrazine could have a large effect on producers' decisions.

Conclusions

Results indicate that if no yield reduction occurs as a result of elimination of atrazine on the representative farm, the ten-year return over variable costs would decrease by under $12,000. If sorghum yields decrease by 5, 10, or 20 percent because of elimination of atrazine, ten-year return over variable cost would decrease by $29,561; $47,229; and $82,561, respectively. For the model run with a 20 percent yield reduction, $70,665 of the $82,561 decline in return is caused by the yield reduction and $11,896 of the decline is caused by use of herbicides on corn and grain sorghum that are more expensive than atrazine. Thus, in our example, increased costs associated with more expensive herbicides would reduce net income; but reduced yields associated with less effective herbicides could potentially reduce net income more than increased costs. A $3.00 per acre tax eliminated the use of atrazine on corn. Per acre taxes of $4.00 with no yield reduction, $11.00 with a 5 percent yield reduction, and $19.00 with a 10 percent yield reduction eliminated the use of atrazine on grain sorghum. As expected, increased taxes at a given yield reduction always reduced net income.

Capital carried forward results were parallel to net return results. Increasing the per acre tax on atrazine or increasing the yield reduction associated with the elimination of atrazine caused the capital carried forward to decrease. Capital carried forward would likely be needed to purchase operating inputs and to rent or purchase additional land. Thus, elimination of an important pesticide could have a large impact on farm growth and survival.

An important outcome of this research is the difference between corn and grain sorghum. In the U. S., corn is a major crop and although very important in the semi-arid west, sorghum is a minor crop. Thus, if atrazine were not available, there are more substitute herbicides for corn than for sorghum. In this study, a $3 per acre tax would eliminate atrazine in modeled corn production because effective substitute herbicides are available to maintain corn yields. However, a large decrease in the use of atrazine could result in significant price increases for substitute herbicides. It could also result in reduced acreage and high prices for crops that use atrazine. Because there is much greater likelihood of yield reductions with the elimination of atrazine from sorghum production, the elimination of atrazine could make sorghum production economically infeasible.

Although the use of atrazine in U.S. agriculture currently has not been restricted, this research example could prove valuable in the future. Possible actions by government, activist groups, or farmers desiring to use alternative inputs may require reduced rates or elimination of cost-effective pest control programs. Biotypes of some weed species have developed resistance to atrazine, necessitating additional inputs for their control. Research such as this study will help inform producers of the economic impacts that such actions could have on their operations. Research could also identify where new agronomic research is needed and/or where registration of alternative pesticides is needed. If government policy restricts the use of one or more pesticides or land owners desire to reduce or eliminate the use of one or more pesticides, farm managers and agricultural consultants would need to consider yield impacts, cost impacts, and impacts on input and crop markets as they advise their clients.

References

Alavanja, M. et al. "Use of Agricultural Pesticides and Prostate Cancer Risk in the Agricultural Health Study Cohort." *American Journal of Epidemiology* 157(October 2003):800-814.

Australian Pesticides & Veterinary Medicines Authority. *The Reconsideration of Approvals of the Active Constituent Atrazine, Registrations of Products Containing Atrazine, and Their Associated Labels. Second Draft Final Review Report Including Additional Assessments*, October 2004, Internet site: http://www.apvma.gov.au/chemrev/atrazine_draftfinal2.pdf (Accessed September 2006).

Blair, A. and Zahm, S. H. "Cancer Among Farmers." *Occupational Medicine* 6 (July-September 1991):335-354.

Burmeister, L.F. "Cancer Mortality in Iowa Farmers, 1971-1978." *Journal of the National Cancer Institute* 66 (March 1981):461-464.

Dhuyvetter, K.C. and T.L. Kastens. "Kansas Land Prices and Cash Rental Rates." Dept. of Agri. Econ. MF-1100, Kansas State University, October 2005.

Environmental Protection Agency. *Endocrine Disruptors Research Initiative*, EPA, July 2003. Internet site: www.epa.gov/endocrine (Accessed June 2004).

Environmental Protection Agency. *Atrazine Interim Reregistration Eligibility Decision (IRED) Q&A's – January 2003*. January 2003a, Internet site: http://www.epa.gov/pesticides/factsheets/atrazine.htm (Accessed March 2006).

Environmental Protection Agency. *Executive Summary From January 31, 2003, Atrazine IRED*. January 2003b, Internet site: http://www.epa.gov/oppsrrd1/reregistration/atrazine/atrazine_exec_summary.pdf (Accessed March 2006).

Environmental Protection Agency. *October 31, 2003 Revised Atrazine IRED*. October 2003, Internet site: http://www.epa.gov/oppsrrd1/reregistration/atrazine/ (Accessed March 2006).

Food and Agricultural Policy Research Institute (FAPRI). *U.S. and World Agricultural Outlook*, Iowa State University, January 2004. Internet site: www.fapri.iastate.edu/outlook2004 (Accessed July 2004).

Frey, R.S. "Cancer Morbidity Among Kansas Farmers." Kansas State University Agr. Exp. Sta. Rep. of Prog. No. 724, February 1995.

Farm Service Agency (FSA). *County loan rates*, USDA, Internet site: http://farmnetservices.com/ks/ldp/ (Accessed July 2004).

Kansas Agricultural Statistics Service (KASS). *Custom Rates 2003*. Internet site: http://www.nass.usda.gov/ks/custom/custom03.pdf (Accessed June 2006).

Kansas Farm Management Association (KFMA). "2003 Whole-farm Summary Reports." Internet site: http://www.agmanager.info/farmmgt/income/Wholefarm/2003/NC/NCFarmType.pdf (Accessed September 2006).

Kansas State University Agricultural Experiment Station and Cooperative Extension Service. "Farm Management Guide Cost-Return Budgets." October 2003.

Keith, L. H. "Environmental Endocrine Disruptors." Paper presented at Symposium on Analytical Challenges for Assessing Environmental Exposures to Children, New Orleans, LA, August 1999.

National Cancer Institute (NCI). *Prostate Cancer Prevention Trial (PCPT): Questions and Answers)*, NCI, June 2003. Internet site: www.nci.nih.gov/newscenter/pressreleases/PCPTQandA (Accessed June 2004).

National Agricultural Statistics Service (NASS). *Agricultural Chemical Use Database*, NASS, 2006. Internet site: www.pestmanagement.info/nass/ (Accessed March 2006).

National Agricultural Statistics Service (NASS). *State and U.S Average Prices*, NASS, May 2004. Internet site: www.nass.usda.gov:81/ipedb/ (Accessed July 2004).

National Registration Authority for Agricultural and Veterinary Chemicals. *Final Report Review of Atrazine April 2002 NRA Chemical Review Program*. (NRA Draft). Internet site: www.apvma.gov.au/chemrev/atrazine_final.pdf (Accessed September 2006).

National Registration Authority for Agricultural and Veterinary Chemicals. *Review of Atrazine-Registration and Review Process*. 1997, Internet site: http://www.apvma.gov.au/chemrev/atrr.shtml (Accessed September 2006).

Regehr, D., personal interview on pest control programs, July 26, 2004 and March 21, 2006.

Schuman, L.M., Mandel, J., and Blackard, C. "Epidemiologic Study of Prostate Cancer: Preliminary Report." *Cancer Treatment Reports* 61(Spring 1977):181-186.

Tilson, H. A., "Developmental Neurotoxicology of Endocrine Disruptors and Pesticides: Identification of Information Gaps and Research Needs." *Environmental Health Perspectives Supplements* Volume 106, No. S3 (June 1998):807-811.