Farm Advisory Services and Pesticide Toxicity on Cotton and Peanuts in the Albemarle-Pamlico Watershed

by

Sonali Mitra, Darrell J. Bosch, Daniel B. Taylor, and James W. Pease*

*Former Graduate Research Assistant, Associate Professor, Professor, and Associate Professor in the Department of Agricultural and Applied Economics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Paper presented at American Agricultural Economics Association Annual Meeting, Salt Lake City, Utah, August 2-5, 1998. The authors express appreciation to the Economic Research Service, U.S. Department of Agriculture for providing data and other assistance for the research. Views expressed here are not necessarily those of the Economic Research Service.

Farm Advisory Services and Pesticide Toxicity on Cotton and Peanuts in the Albemarle-Pamlico Watershed

Abstract

According to a Virginia-North Carolina watershed survey, farmers view advisory services as having the effect of decreasing pesticide use. However, analysis of pesticide use shows that hired staff, scouting personnel, and extension agents are associated with higher pesticide toxicity applied to cotton while chemical dealers and scouting personnel are associated with higher toxicity applied to peanuts.

Farm Advisory Services and Pesticide Toxicity on Cotton and Peanuts in the Albemarle-Pamlico Watershed

Cropping of cotton in rotation with peanuts is increasing rapidly in the Albemarle-Pamlico Watershed of Virginia and North Carolina. Both crops are pesticide-intensive. Pesticide runoff and leaching may damage surface and groundwater quality. Farm advisory services may help farmers use pesticides and pesticide substitutes more effectively in order to reduce pesticide losses. If advisory services are effective in reducing toxicity of pesticides used, the public may wish to subsidize advisory services in order to reduce potential pesticide damage to the environment and human health. This study analyzes the influence of farm advisory services (hired staff, cooperative extension agents, chemical dealers, and scouting personnel) on the aggregate toxicity of pesticides used by cotton and peanut farmers in the Albemarle-Pamlico Watershed.

Advisory Services and Pesticide Use

The social cost of pesticide use includes the private cost of resources consumed in pesticide manufacture and distribution as well as potential damage to human health of pesticide applicators or consumers from exposure to pesticide residues in crops or water supplies (Mellor and Adams; Pimental and Levitan), disruption of natural pest controls (Mellor and Adams), and development of pest resistance to pesticides (Brattsten et al.). Because social cost exceeds private cost and because farmers only bear private costs, profit-maximizing farmers may use more than the socially optimal amount of pesticides. As a result, public research and education on ways to reduce pesticide use without reducing farmers' profits is justified. Integrated pest management (IPM) research and extension has resulted in ways to control pests with fewer pesticides by using biological, cultural, legal, and chemical controls (Osteen, Bradley, and Moffitt). Farmers require information in order to decide whether to adopt IPM practices. Information services may help farmers decide which IPM strategies will reduce pesticide use without reducing profits. Farmers with better access to pest control information services may reduce pesticide use.

Procedures

In 1993 the Albemarle-Pamlico watershed located in northeastern North Carolina and southeastern Virginia was chosen for an intensive cropping-practice survey conducted jointly by the Economic Research Service (ERS), the National Agricultural Statistics Service (NASS), and the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture. The sample was selected from the NRCS area frame used in the National Resource Inventory (NRI), a survey conducted at five-year intervals. A total of 1,462 primary sampling units (PSU's) ranging in size from 100 to 160 acres were selected for the Albemarle-Pamlico watershed and one point was randomly selected in each PSU. The operator of the farm containing the selected point was personally interviewed about crops and production practices on the field containing the selected point during 1990-1992. Farmers were asked the types and quantities of pesticides applied, the types of information services they used in making pesticide decisions, and other farm and personal characteristics (USDA). Eighty cotton sites and 55 peanut sites from the survey are used for our study. These sites contained at least one crop of cotton or peanuts during 1990-1992.

Toxicity indices have been developed in order to compare the potential environmental and health effects of alternative pesticides (Levitan et al.). Indices are also used to compare the toxicity of pesticide applications within different production systems, which may involve diverse types and amounts of pesticides (Heimlich and Ogg; Teague, et al.). In this study, an aggregate toxicity index was developed for each site based on the quantity, half-life, and potential toxicity to humans of all pesticide active ingredients applied to the site in one season (Barnard). The index was formed by multiplying the inverse of the reference dose of the active ingredient in each pesticide times the half life of the active ingredient times the amount of active ingredient in the pesticide product times the amount of pesticide applied to the site. The reference dose represents the maximum amount of chemical (mg of chemical per kg of body weight per day) that can be ingested by a 70-kg adult on a daily basis over a lifetime without deleterious effects (USEPA). The half-life represents the number of days until the toxicity of the chemical is reduced by 50 percent. The toxicity indices for all pesticides applied to the site during one growing season of cotton or peanut were summed to estimate the aggregate toxicity for the site.

Farmers' perceptions of how advisory services affected their pesticide use were analyzed. Regression analysis was used to estimate how the aggregate toxicity index was affected by socioeconomic and site characteristics as well by the farmer's most important farm advisory service. The explanatory variables used to predict toxicity are described in Table 1. Age and experience of the operator might influence pesticide applications as the operator gains knowledge about pest behavior and crop damage. More education might enable farmers to learn about new IPM methods that reduce pesticides. Farmers on more productive soils (PROD1 is the highest productivity soil) might have higher yield expectations that influence them to use more pesticides. Farmers on soils which are more runoff prone or which are located closer to surface water may reduce pesticide applications in order to decrease risks of pesticide runoff to surface or groundwater. In this study, runoff potential is approximated by the Universal Soil Loss Equation (USLE) which is a measure of potential sediment movement from a site (Wischmeier and Smith). The state where the farmer is located might affect pesticide applications because states differ in their research and extension programs directed at cotton and peanut pest control. Farmers who use hired staff (consultants) or extension as their most important information source may be better informed about IPM techniques that reduce the need for pesticides. Chemical dealers may assist in determining appropriate application rates and timing in order to reduce unnecessary applications. Scouts provide information on pest levels, which can be used to time pesticide applications and reduce unnecessary applications.

Table 2 shows the farmers' ratings of pest advisory services. Cotton respondents appeared to make more use of information services than peanut respondents perhaps reflecting the fact that cotton is a relatively new crop for many farmers in the study area. Forty-five cotton respondents (56 percent) used scouts compared to 42 (53 percent) using extension, 36 (45 percent) chemical dealers, and 27 (34 percent) hired staff (Table 2). Use of advisory services was lower for peanuts as nineteen peanut respondents (35 percent) used chemical dealers, compared to 18 (33 percent) using extension, 14 (25 percent), scouts, and 9 (16 percent) hired staff.

Among cotton farmers, pest scouts were cited most often as the most important advisory service (36 respondents) with extension (11), chemical dealers (11) and hired staff (9) far behind. Among peanut respondents, chemical dealers ranked first with 19 respondents followed by extension (18), scouts (14), and hired staff (9).

Farmers were asked the effect of the most important information service on pesticide use. Of the 67 cotton respondents who identified the most important service, 37 (55 percent) said it decreased their pesticide use, 13 (19 percent) said it increased pesticide use, and 15 (22 percent) said it had no effect on pesticide use. Of the 35 peanut farmers who indicated the most important advisory service, 17 (50 percent) said the information service most important for pest management decreased pesticide use, 16 (46 percent) said it had no effect, and one (three percent) said it increased pesticide use. The responses suggest that advisory services will lower the toxicity of pesticide applications.

Results

The dependent variable, pesticide toxicity index, was not normally distributed. Taking logs of pesticide toxicity resulted in a normally distributed dependent variable which was used in the analysis. Table 3 shows the effects of socioeconomic, physical, and information variables on the log of the pesticide toxicity index on cotton sites. The resulting models passed all misspecification tests (Mitra). The F statistic for the overall regression is 2.547 indicating the model has significant explanatory power (p = 0.005). Age and education were insignificant in explaining toxicity variations. Sites managed by more experienced farmers showed lower pesticide toxicity (p = 0.055). The association between land productivity and pesticide toxicity was positive and highly significant.[1] The USLE index and distance to water were not significant. Sites located in Virginia showed higher toxicity than North Carolina sites. Hired staff, extension, and scouting services were significantly and positively related to pesticide toxicity (p = 0.067). Hired staff had the largest coefficient, nearly twice that of scouting and extension. Chemical dealers were not significantly related to the toxicity index.

Table 4 shows the relationship between pesticide toxicity for peanuts and explanatory variables. The F statistic for the regression is 2.235 indicating that the estimated model has significant explanatory power (p = 0.023). Age is positively related to toxicity indicating higher applications and/or more toxic pesticides used by older farmers. Farmers with high school or some college had significantly higher pesticide indices (p = 0.1). However, farmers with a college degree did not have higher toxicity levels. Soil productivity, USLE, distance to surface water, and location of the site in Virginia were not significantly related to toxicity.

---

[1] Seventy seven of the 80 sites were located in the three highest productivity classes.

Chemical dealers and scouts were significantly and positively related to the toxicity index (p=0.079). Their estimated coefficients were approximately equal indicating similar impacts on pesticide toxicity. Hired staff and extension were not significantly related to the toxicity index.

Discussion

Farmers tend to view pesticide advisory services as reducing their pesticide use but observed pesticide toxicity tends to increase with farmers' use of advisory services. Further research is needed to explain the apparent contradiction. Three alternative explanations should be investigated. First, farmers are misinformed and farm advisory services do cause pesticide use to increase. In this case, education of farm advisors is needed to present them with better substitutes for toxic pesticides. Based on 18 studies of cotton, Norton and Mullen find that IPM reduces pesticide use by an average of 15 percent while increasing net returns by an average of 79 percent. Five peanut studies show an average pesticide reduction of five percent and an average increase in net returns of 100 percent (Norton and Mullen). However, in the Philippines, Tjornhom et al. find that contact with chemical company representatives increases potential pesticide misuse.

Second, farm advisory services may reduce the quantity of pesticides used, but cause substitution of more toxic pesticides resulting in an increase in the overall pesticide toxicity index. If toxicity increases per unit of pesticide applied, more education of farmers and their advisors is needed about the environmental impacts of pesticides so they will recommend and use less toxic pesticides.

Third, other unmeasured variables associated with advisory services may result in higher pesticide use. For example, farmers who use more advisory services may have more pest problems or they may have higher yield or quality goals. In this case, pesticides and advisory services may be complementary inputs. Soil productivity was controlled for in this study and positively related to pesticide use for cotton but not peanuts (Tables 3 and 4). However, the productivity measures may not have been sufficiently sensitive to variations in yield potential. Farm size represented by sales was dropped from the original specification because both sales and the log of sales were not normally distributed. Further research should relate farmers' yield expectations and perceptions of pest pressure to pesticide use. If larger farms use more pesticides and more advisory services, advisory services may pick up the farm size effect when farm size is excluded. If, after controlling for these factors, advisory services result in decreased pesticide toxicity, public subsidies of advisory services may be justified in order to reduce social costs of pesticide use. If advisory services do not reduce pesticide toxicity, then funds are better spent on researching better pesticide substitutes or less toxic pesticides and educating advisory services about available IPM technologies.

Conclusions

Advisory services potentially can encourage farmers to reduce pesticide use while maintaining or increasing farm profits. Results of this study suggest that farmers view advisory services as reducing their pesticide applications. However, the estimated pesticide toxicity for cotton and peanut sites based on reported applications is either unaffected or increased by advisory services. Further research is needed on why the observed increases in toxicity contradict farmers' perceptions.

Table 1. Explanation of variables used to predict pesticide toxicity index.

Variable	Description
Age	Age of farm operator
Experience	Number of years operating farm
No high school	1 if highest education achieved < high school, 0 otherwise
High school	1 if highest education achieved = high school, 0 otherwise
Voc. school	1 if highest education achieved = vocational training, 0 otherwise
Some college	1 if highest education achieved = some college, 0 otherwise
College degree	1 if highest education achieved = completed college, 0 otherwise
PROD1	1 if site located on land capability class 1, 0 otherwise
PROD2	1 if site located on land capability class 2, 0 otherwise
PROD3	1 if site located on land capability class 3, 0 otherwise
USLE	Estimated average soil movement due to sheet and rill erosion (tons/ac/year)
Distance	Distance from sample point to nearest surface water
Virginia	1 if site located in Virginia, 0 otherwise (North Carolina site)
Hired staff	1 if most important pesticide information service is hired staff, 0 otherwise
Extension	1 if most important pesticide information service is extension, 0 otherwise
Chemical dealer	1 if most important pesticide information service is chemical dealer, 0 otherwise
Scouting	1 if most important pesticide information service is pest scouts, 0 otherwise

Table 2. Use of information services by cotton and peanut producers[a]

	Number of respondents who reported:				
Type of information service	they used the service	the service was the most important	the service increased pesticide use	the service decreased pesticide use	the service did not affect pesticide use
Cotton observations					
Hired staff	27	9	2	4	2
Extension	42	11	1	9	1
Scouts	45	36	9	23	4
Chemical dealer	36	11	1	1	8
Peanut observations					
Hired staff	9	5	0	3	2
Extension	18	6	0	4	2
Scouts	14	12	0	5	6
Chemical dealer	19	12	1	5	6

[a] Total cotton observations = 80. Total peanut observations = 55.

Table 3. Estimated relationship between socioeconomic, information, and physical characteristics and the log of pesticide index for cotton sites

Variable	Estimate	Standard error	t-value	Probability >|t|
Constant	-1.604	2.558	-0.627	0.533
Age	0.058	0.037	1.573	0.121
Experience	-0.075	0.038	-1.964	0.055
No high school	-2.106	1.598	-1.318	0.193
High school	0.758	1.498	0.506	0.615
Voc. school	-0.467	2.272	-0.206	0.838
Some college	1.358	1.432	0.948	0.347
College degree	-0.320	1.419	-0.226	0.822
PROD1	5.804	1.560	3.721	0.000
PROD2	5.148	1.500	3.431	0.001
PROD3	5.976	1.536	3.891	0.000
USLE	0.018	0.067	0.267	0.790
Distance	0.000	0.000	0.023	0.982
Virginia	1.550	0.626	2.474	0.016
Hired staff	2.816	0.949	2.968	0.004
Extension	1.467	0.784	1.871	0.067
Chem. dealer	1.190	0.868	1.370	0.176
Scouting	1.496	0.656	2.281	0.026

Dependent variable is log of aggregate pesticide toxicity for the site; valid cases = 74; degrees of freedom = 56; R-squared = 0.436; Adjusted R-squared = 0.265; Std error of estimate = 1.720; F(17,56) = 2.547; probability of F = 0.005.

Table 4. Estimated relationship between socioeconomic, information, and physical characteristics and the log of pesticide index for peanut sites

Variable	Estimate	Std. error	t-value	Prob .>|t|
Constant	0.216	1.725	0.125	0.901
Age	0.076	0.036	2.098	0.043
Experience	0.004	0.033	0.110	0.913
No high school	0.418	1.331	0.314	0.755
High school	2.239	1.224	1.829	0.075
Some college	2.124	1.263	1.682	0.101
College degree	0.986	1.225	0.805	0.426
PROD1	-0.476	0.574	-0.829	0.412
PROD2	-0.168	0.767	-0.219	0.828
USLE	0.124	0.084	1.476	0.148
Distance	0.000	0.000	0.927	0.360
Virginia	-0.609	0.529	-1.150	0.257
Hired staff	0.302	0.884	0.341	0.735
Extension	-0.176	0.826	-0.213	0.833
Chem. dealer	1.188	0.658	1.807	0.079
Scouting	1.074	0.592	1.815	0.077

Dependent variable is log of aggregate pesticide toxicity for the site; valid cases = 54; degrees of freedom = 38; R-squared = 0.469; Adjusted R-squared = 0.259; Std error of estimate = 1.441; F(15,38) = 2.235; probability of F = 0.023.

References

Barnard, C. H. Personal communication. Economic Research Service, U.S. Department of Agriculture, Washington, D.C., 1997.

Brattsten, L. B. et al. “Insecticide Resistance: Challenge to Pest Management and Basic Research.” American Association for the Advancement of Science 231(1986):1255-1260.

Heimlich, Ralph E. And Clayton W. Ogg. “Evaluation of Soil-Erosion and Pesticide-Exposure Control Strategies”. *Journal of Environmental Economics and Management*. 9(1982): 279-288.

Levitan, L., Ian Merwin, J. Kovach. “Assessing the Relative Environmental Impacts of Agricultural Pesticides: the quest for a holistic method”. *Agriculture, Ecosystems and Environment*. 55(1995): 153-168.

Mellor, J. W. and R. H. Adams, Jr. “Feeding the Underdeveloped World.” Special Report, Chemical and Engineering News. (1984):32-39. April 23.

Mitra, S. “The Influence of Farm Advisory Services and Socio-Economic and Physical Factors on the Toxicity of Pesticides Used for Cotton and Peanuts in the Albemarle-Pamlico Watershed.” M.S. thesis, Department of Agricultural and Applied Economics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, October, 1997.

Norton, G. W. and Jeffrey Mullen. Economic Evaluation of Pest Management Programs: A Literature Review Publication 448-120. Virginia Cooperative

Extension. Virginia Polytechnic Institute and State University, Blacksburg, Virginia, March 1994.

Osteen, C. P., E. B. Bradley, and L. J. Moffitt. "The Economics of Agricultural Pest Control." Bibliographies and Literature of Agriculture No. 14. Economics and Statistics Service. Washington, D. C.: U.S. Department of Agriculture, 1981.

Pimental, D. and L. Levitan. "Pesticides: Amounts Applied and Amounts Reaching Pests." American Institute of Biological Sciences. 36(1986):86-91.

Teague, M. L., D. J. Bernardo and H. P. Mapp. "Farm Level Economic Analysis Incorporating Stochastic Environmental Risk Assessment." *Amer. J. Agr. Econ*. 77(1995):8-19.

Tjornhom, J. D., G. W. Norton, K. L. Heong, N. S. Talekar, and V. P. Gapud. "Determinants of Pesticide Misuse in Philippine Onion Production." *The Philippine Entomologist.* 11(1997):139-149.

USDA (U.S. Department of Agriculture). "RTD UPDATES: Area Studies." Economic Research Service. Washington D.C., January 1994.

USEPA (U.S. Environmental Protection Agency) Drinking Water Regulations and Health Advisories EPA 822-4-96-001. Office of Water. Washington D.C.: U.S. Environmental Protection Agency, February 1996.

Wischmeier, W. H. and D. D. Smith. Predicting Rainfall Losses: A Guide to Conservation Planning. Agriculture Handbook No. 537. Washington D.C.: U. S. Department of Agriculture, 1978.