Health Costs and Externalities of Pesticide Use

in Locust and Grasshopper Control in the Sahel

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Introduction

The locust plague of 1986-89, the first in many years, was the cause of serious concern and substantial donor activity. While 25.9 million hectares were sprayed with chemical pesticides at a cost of $275 million (US Congress 1990) dissatisfaction with the heavy and continuing use of chemical pesticides was growing (Berger and Associates 1991). These chemicals are not without danger to human health, and do have an impact on the environment, in particular the flora and fauna of the fragile Sahelian environment (FAO 1993). A consortium of donors therefore agreed to finance LUBILOSA (Lutte Biologique contre les Locusts et Sauteriaux), a research program initiated in 1989. A biopesticide was developed based on the spores of a fungus, *Metarhizium flavoviride*, a natural pathogen of locusts, currently produced at the International Institute of Tropical Agriculture in Benin. The fungus is a virulent endogenous pathogen and in field tests it controls over 85% of the locusts and grasshoppers after two weeks, without any harm to non-target organisms.

An argument against biological control is its higher cost, which makes potential producers hesitant to invest in this technology. If only the production cost is taken into account, biocontrol compares unfavorably to chemical pesticides. Its major advantage, however, is situated in the lesser secondary costs such as human health and environmental costs. The study of these costs in developing countries is fairly recent. A study in the Philippines (Pingali *et al.* 1994), shows that if health costs are taken into account, there is hardly any benefit in using chemical pesticides. In Africa, the impact of chemical pesticides is now being studied (Lafia 1996), but so far no calculation of the health and external costs have been undertaken.

In this paper an attempt is made to quantify hidden costs of pesticide use against locust and grasshoppers in the Sahel, by analyzing data from a survey in Niger. Only those elements of which data are available or can be collected have been withheld, notably human health, loss of domestic animals, and the cost of cleaning up obsolete pesticides. After an overview of the methodology and the conceptual framework, the impact of pesticides on human health will be demonstrated. The costs of that impact is quantified and shown to be small but not negligible. The cost in livestock losses due to pesticides, on the other hand, is shown to be substantial. Finally, the cost of destroying obsolete is estimated, but becomes relatively small when redistributed over the total area treated with pesticides.

Data and methods

An exploratory survey was first conducted in 1996 in three villages around Malanville in northern Benin, and two by Niamey in Niger. During this survey, group interviews were conducted with villagers: farmers, pastoralists and members of village brigades (organized and supported by plant protection services to treat locusts and grasshoppers). Officials of government services present in the villages were also interviewed: public health service, veterinary service, agricultural extension and plant protection. In Benin, public health workers did not receive any training in recognizing pesticide intoxication, and locusts and grasshopper are not that important as pests, so only Niger was maintained for the formal survey.

The formal survey took place in October 1996 in 17 villages in the departments of Tahoua and Zinder, Niger. The criteria of choice were frequency of pesticide use, frequency of locust invasions and accessibility. In each village three farmers, three pastoralists and three brigade members were selected ad random. Information was collected about the past and current pesticide use, health problems and their associated costs, intoxication of humans and domestic animals. The public health agent and the veterinarian of each village were also interviewed with a formal questionnaire. The surveys were executed by a team of three people: two plant protection officers, one regional and one national, and one economist.

Secondary data were obtained from the medical survey on intoxication by pesticides from 1989 and 1991, and from the national statistics on treated areas and number of livestock.

Conceptual framework

Due to the nature of chemical pesticides, their use involves hidden costs related to danger to humans, animals and the environment. These costs are not included in the market price of the pesticide, and are considered externalities and when they are borne by people other than the user (water quality, the environment), in particular by pastoralists (losses in livestock). Health costs to the farmer themselves, on the other hand, are directly related to their production activities and can therefore not be considered as externalities (Ajuzie and Altobello1997, Varian 1992). There are, however, some problems with that reasoning. Health costs to non-farming members of the community can clearly be labeled external, as well as costs that are covered by the communal health centers, and a case can be made for health costs to farmers' children, depending on what intra-household resource allocation model is considered. To avoid this rather theoretical discussion, we prefer to group the indirect costs of chemical pesticides, relevant in their comparison to biological pesticides, into health costs and externalities.

An attempt is thus made to quantify human health costs, as well as following externalities: losses to livestock and the destruction of obsolete pesticides. Other damage to the environment, although not negligible, is hard to measure and will not be considered here. Similarly, we do not include the intangible costs as defined by Gittinger (1982) or the externalities to donor countries such as health hazards and environmental impact (Herok and Krall, 1995) for practical reasons, not because they are not important.

Impact of chemical pesticides on human health

The impact of pesticides on human health can be studied by medical tests or statistical models, as shown by Pingali et al (1994) in the Philippines, but only the second method was used here. The long term use of chemical pesticide can have an effect on the respiratory system, the neurological system, the skin, the eye, and the gastro-intestinal system (Pingali *et al. 1994).* The effects can be estimated empirically with a Logit model. The dependent variable is binary and takes the value 1 for those people who have experienced the disorder at least once, and zero for the others. The independent variables are individual characteristics, indicators of exposure to pesticides, and other factors that might influence health.

Exposure to pesticides can be defined through dose and frequency. Pingali *et al.* (1994) assume the extension dose, and distinguish two categories of pesticides. In this study, farmers recall of pesticide use is used for the last four years (1993 to 1996), and a distinction is made between liters of ULV (Ultra Low Volume) pesticides used, and kg of powder insecticides used. A third indicator of pesticide exposure is the number of years the person used insecticides. In a similar fashion, number of years that the person used fertilizers or fungicides was included in the model.

Individual characteristics assumed to have an impact on health are age and nutritional status, as indicated by the ratio weight for height. Some consumption behavior has also been linked to health (Douda 1989), therefore the consumption of tobacco, cola nuts, alcohol and tea were included. These factors were entered in the model as binary variables (1=user, 0=no user). Similarly, the activities of plant protection brigades, basically treating fields and fallow with chemical pesticides, can lead to health risks for its members. Membership was therefore also entered as a binary variable (1= being member).

Estimation of health costs

In the previous model the quantification of the health costs associated with pesticide use is not possible. To establish this relationship, the dependent variable needs to be defined first. Health costs can be split into expenses of medical services such as medications or consultation fees, and the loss of productive work time. These data were collected through the survey, and lost work time multiplied by the going daily rate. The total health cost was then linked to exposure indicators in a multiple regression model (after Pingali *et al.* , 1994).

Cost in livestock losses

Farmers and pastoralists were asked to recall the number of animals with pesticide intoxication they had observed in their herd over the last five years, and how many of those animals died. Extrapolation of these numbers over the total number of animals in the departments of Tahoua and Zinder give an estimate of the total losses due to intoxication. These losses were then valued at market price, and divided by the number of hectares treated during that year in that region.

Costs of cleaning up obsolete pesticides

It is hard to predict the cost of destroying obsolete pesticides, which depend on their nature, the containers they are stocked in, the building, etc. Since Niger only had one such destruction project, the average cost per liter is used as an indicator, to be divided by ha treated.

Results

Origin and use of pesticides in Niger

Niger is a land locked country situated in the West African Sahel. Only a small part of its land is arable, and the rural economy is based on millet production and livestock. Given the low income of rural population, the government has for many years provided pesticides free of charge. For the last couple of years, however, the amounts of pesticides given for free are decreasing. From 1993 to 1996, the proportion of interviewed farmers who received free pesticides decreased from 67% to 44%, while those having bought their own increased from 20 to 46%. The increase was higher for farmers growing cash crops, especially cotton and onion growers in the Tahoua department.

From 1993 to 1996, the pesticides received for free were used primarily against locusts and grasshoppers, where those bought were used against other insects. This confirms the results of an earlier study (Stonehouse, 1995) that locusts are considered a public pest for which the government should provide the means.

Impact of pesticides on human health

The long term use of chemical pesticide can have an effect on the respiratory system, the neurological system, the skin, the eye, and the gastro-intestinal system (Pingali *et al. 1994).* The effects were measured empirically with a Logit model (Table 1).

The effects on the respiratory system are presented in the first column, with a percentage of correct prediction of 83%. The number of years of pesticide use as well as drinking tea increase respiratory diseases, while the use of fertilizer has a negative impact on incidence. Being a member of the brigade does not have an impact

Neurological disorders include problems such as headaches, behavioral problems, and dizziness. The prediction rate of the model is 76%, and six variables are significantly different from zero. Length of pesticide use, consumption of cola, being a brigade member and age all have a positive effect on the probability of have a neurological disorder.

Table 1 Results of the Logit model for different disorders

Variables	respiratory	neurological	gastro-intestinal	dermatological	eyes
Age	0,0372	0,0403**	-0,0229	0,0086	0,0121
years of pesticide use	0,2684****	0,0994*	0,1214*	-0,0692	0,0946*
years of fertilizer use	-0,1316**	-	-	-0,1000**	-0,0726
member of brigade	-0,2959	1,1184**	0,1219	1,8015****	0,1882
smoker	1,4377*	-	-	-	-
cola eater	-	1,1354*	-0,4018	-	-
tea drinker	2,4384****	0,0047	2,5967	-	-
weight for height ratio	0,1783***	-0,1197**	0,1000*	0,0494	0,0547
quantity of ULV pesticides used from 1993 to1996	-0,0286***	-	-	-0,0025	-
quantity of powder pesticides used between 1993 à 1996	-0,2802	-	-	-0,0037	-
Constant	-11,3948****	-0,7680	-5,6384	-3,3273	-3,8948-
maximum likelihood ratio	38,77****	16,67**	33,15****	15,39***	4,25
number of observations	111	111	111	111	111
% of correct predictions	85,59	76,58	71,17	69,37	75,68

* Significant à 15 %

** Significant à 10 %

*** Significant à 5 %

**** Significant à 1 %

The gastro-intestinal disorders model has a 71% correct prediction rate, with two significant variables: length of use of pesticides and the habit of tea drinking. Skin affections are for 69% correctly predicted by the model, with two significant coefficients: on length of fertilizer use and on being member of a brigade. Finally, a link between eye problems and exposure to pesticides was not found, unlike the results from the Philippines (Pingali *et al.* 1994).

Costs related to health problems

The costs related to a health problems can be considered as the sum of medical expenses and the value of lost working time. The sum is linked to exposure to pesticides by a multiple regression model with the indicators of that exposure and other independent variables. The results are presented in Table 2.

Table 2. Regression for health costs

Variables	Coefficient	t-value
age	-4,2068	-0154
weight for height ratio	153,5661**	2,147
years of pesticide use	270.77***	3,180
years of fertilizer use	-105,704	-1,445
smoker	528,52	0,707
cola user	-274,7711	-0,384
tea drinker	2010,9322***	2,932
brigade member	-246,31	-0,349
Constant	-749,8428	-0,268

R^2 = 0,25

F = 4,29 significant at 1%

Three coefficients are significantly different from zero: nutritional status, years of pesticide use, and tea consumption. The coefficient of each factor can be interpreted as the average yearly health cost due to that factor. In this context, being a brigade member has no effect on health costs, other than the increases number of years having used pesticides. On average, a health cost of 270 FCFA ($1=610 FCFA) per person per year can be attributed for each year of pesticide use. Since it is not possible to measure how long these health effects will last, this yearly cost is simply divided over the average area treated each year, 2.9 ha, to obtain a cost of $0.15 per ha treated.

Livestock losses due to chemical pesticides

The results of the survey showed that between 1992 and 1996, 5.6% of sheep were seriously intoxicated by chemical pesticides, 6.7% of goats and 2.7% of cattle. Of these animals, only 20% survive, the others are slaughtered (59%) or die (21%). Starting with the number of animals in the two departments (Direction des Etudes et de la Programmation 1996), the total number of animals lost can be calculated, and multiplying by the market price gives their value. Divided by the number of ha treated in the area, an estimate of costs in livestock loss per ha treated is obtained.

Table 3 Estimated value of animals died after pesticide intoxication

species	total number	% intoxicated per year	mortality rate (%)	average unit price (FCFA)	value of loss (FCFA)
cattle	686,336	0,2	0.16	75,068	82,435,041
sheep	1,042,602	0,5	0.4	16,500	68,811,719
goats	2,809,704	0,6	0.4	9,125	102,554,196
total					253,800,956
area treated in 1995					279,980
Value of livestock losses due to pesticides per ha treated......................906 FCFA/ha					

The cost in livestock loss that can be attributed to pesticide intoxication amounts to 906 FCFA or $1.5 per treated ha.

Cost of destroying obsolete pesticides in Niger

In 1992 70,000 liters of dieldrin were shipped from Niger to the Netherlands for destruction at a cost of $ 650,000, or $9/liter. In 1995 stocks at Niger were estimated at 45,000 liters of liquid formulation, and 12,000 kg of powder. If these stocks were to be destroyed at the same cost per unit, this would amount to $ $528,960, bringing the total cost of destroying obsolete pesticides for Niger to $1,178,560.

Although a complete time series was not available, the average ha treated from 1975 to 1978 was 275,000 ha (Direction de la Statistique et des Comptes Nationaux. 1980.) and the average from 1987 to 1990 was 690,000 ha (Landry, J.-P., 1992). Extrapolating the first figure over the second half of the 70s and the second over the 80s and first half of the 90s we obtain a total of ha treated of 11.7 million ha treated over the last 20 years. Ignoring discount factors and damage done while being improperly stocked, a rough estimate of the cost of destroying obsolete pesticides can be calculated, resulting in $0.10 per ha treated.

Conclusion

A link between chemical pesticide use and health problems was demonstrated. The cost to human health was calculated at $ 0.15/ha, while externalities were estimated at $ 1.5/ha for livestock losses and $ 0.10/ha for destroying obsolete pesticides. These indirect costs total up to $1.75/ha.

Although these cost are relatively small compared to the purchase price of pesticides against locusts, currently at $12/ha in Benin, they are substantial and far from negligible. The current subsidies of chemical pesticides lead to health costs and externalities, and this policy needs to be reviewed. In light of the evidence presented, a price support policy is justified to bring the price of a biological control method down to $1.75 per ha under that of a chemical alternative.

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