DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

WORKING PAPER

ECONOMIC AND INSTITUTIONAL ASPECTS DETERMINING PESTICIDE USE IN SMALLHOLDER COTTON PRODUCTION IN ZIMBABWE: A CASE STUDY OF RUSHINGA DISTRICT, MOUNT DARWIN

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ABSTRACT
The general objective of the study is to investigate the economics of and factors influencing pesticide use in smallholder cotton production using Rushinga as a case study. The study takes place at a time when there is growing concern about the increased use of pesticides in the developing countries and the associated externality problems.

Gross margin analysis showed that pesticide use is financially profitable for the smallholder cotton producer. Gross margin per hectare averaged $3 173. Gross margin per dollar invested in pesticides and per labour day was $4,14 and $22,19 respectively.

The study established that smallholder cotton farmers do not over-apply pesticides. Pesticide application rates for all types of chemicals applied falls short of the recommended application rates. This was consistent with expert assessment that there is under use of pesticides in the smallholder cotton production in Zimbabwe.

Chemical control emerged as the major strategy available to and practiced by farmers to control pests in cotton production. Non chemical solutions to pest problems and integrated pest management (IPM) are virtually unknown to most of the farmers. The study established that there is lack of information on non-chemical methods at the farm level.

Institutional factors such as credit and extension are the major factors enhancing pesticide use in the Zimbabwean agricultural sector. Virtually all the farmers in the sample received credit for the acquisition of pesticides and other inputs from COTTCO. Extension advice on pesticide use is largely provided by the Cotton Company of Zimbabwe (COTTCO), which provides only chemical solutions to pest problems to smallholder cotton farmers. The role of public extension service in pesticide extension was found to be very limited.

Externalities (poisoning and damage to the environment) of pesticide use are largely unknown at the farm level implying that externality costs are not taken into account in decision making on how much pesticides to use.

The study recommends that policy instruments designed to provide information, education and training on pesticide use and the risks associated with pesticide use should be implemented in Zimbabwe. Integrated Pest Management should also be disseminated to the farm level through active public extension service.

Detailed research on pesticide productivity in cotton production is necessary.

1 BACKGROUND

The pesticide use in Zimbabwe has become an integral component of the cropping system. Pesticides are considered to be a major factor determining productivity of cotton and tobacco. The pesticide industry is worth Z$ million per annum (Rusike and Mudimu, 1996). The horticultural sector is a fast growing market for the pesticides. In addition to protecting crops from the catastrophes of pests and pathogens, pesticides have contributed significantly to improved (optimum) yields, improved quality and quarantine, saving on labour, food security and self sufficiency (Keswani et al, 1996).

1.1. Pesticide Use By Type and Sector.

From Table 1.1 insecticides (in terms of value and quantity) constitute the bulk of the pesticides used in Zimbabwe followed by herbicides. Herbicides, fungicides and growth regulators are predominantly used in the large-scale commercial sub-sector.

Table 1.1 Average Quantity and Share of Value and Annual Pesticide Use by Farming Sector In Zimbabwe, 1986-1991

Pesticide	Annual Average Quantity (Tonnes)	Annual Average Value (%)	Share By Farming Sector %	
			Large Scale	Communal Lands
Insecticides	3 031	60.77	70-80	20-30
Herbicides	1 022	39.03	95-99	1-5
Fungicides	447	14.44	96-98	2-4
Growth regulators	447	6.62	99	<1
Rodenticides	81	0.30	10-15	2-3

Source: Mudimu et al 1995

Table 1.1 shows that the large-scale commercial farmers are the largest users of pesticides whilst the Communal land farmers provide only a small market. Close to 80 percent of the pesticides are used by the Large Scale Commercial Farmers and the rest by small holder farmers and rural and urban households (Mudimu et al, 1995). The share of insecticides used by the smallholder farmers ranges from 20 - 30 percent. Kujeke (1993) estimated that 15 percent of the one million families in the communal and resettlement areas use chemicals or pesticides for pest and disease control on their crops. As the production systems are rainfed pesticide use tends to be erratic in the smallholder-farming sector.

The ranges of types of pesticides used by Communal Area farmers is limited whilst large-scale commercial farmers use a variety of pesticide mix (Mudimu et al, 1995). According to Mudimu et al (1995) Communal Area farmers apply less pesticides compared to the large-scale commercial farmers and they only apply pesticides once they observe the need to apply, while the latter apply as a routinely measure. This is attributed to the Communal Area farmers' unwillingness to make losses from the use of pesticides, as the returns may not justify the use to the farmer (Mudimu et al 1995).

Table 1.2 indicates that tobacco accounts for most of the pesticides used followed by cotton. Tobacco and cotton combined use up to 80 percent of the insecticides whilst maize and soyabeans account for up to 60 percent of the herbicides. Close to 80 percent of the insecticides used by smallholder farmers is applied in cotton and the balance in maize against the stockbroker and grain storage pests (Mudimu et al (1995).

Table 1.2: Average Annual Pesticide Use by Crop, 1986-1993 Percentage by value (Z$ million)

Crop	Insecticides (%)	Herbicides (%)	Fungicides (%)	Regulators (%)
Tobacco	54	18	48	80
Cotton	26	12	-	-
Maize	8	30	-	-
Soyabeans	3	30	-	-
Wheat	4	-	-	-

Source: Mudimu at al 1995

Table 1.3 uses Commercial Farmers' Union (CFU) and AGRITEX crop budgets to give estimates of the share of pesticide costs in the variable production costs of major crops in the smallholder and the large-scale commercial farming sub-sectors.

Table 1.3: Pesticide Costs as Share of Variable Production Cost 1990/1991 - 1997/1998 Seasons (Percent)

Crop	Insecticides	Herbicides	Fungicides	Growth Regulators	Soil Fumigants	Total
A: LARGE-SCALE COMMERCIAL FARMING Sub-sector						
Tobacco	3.0	10.0	0.4	0.3	5.0	18.7
Cotton	8.0	8.5	-	-	-	16.5
Maize	7.7	5.7	-	-	-	13.4
B: SMALLHOLDER FARMING Sub-sector						
Cotton	13.9	-	-	-	-	13.9
Maize	1.5	-	-	-	-	1.5

Source: CFU and AGRITEX Crop Budgets 1990-1998.

1.2 Problem Statement

Literature review and other reports suggest that there is increasing and continuing dependency on pesticides and this has brought about negative externalities on the natural environment, public health, and the sustainability of the agricultural ecosystem (Ajayi, undated; Chivinge et al, 1996. Dover and Croft, 1984. Magadza, 1996 and Nhachi 1996). These side effects in Zimbabwe include the development of secondary pests, pest resistance, pollution of the underground water, off-site effects arising from pesticide seepage downstream and phytotoxicity. Other negative side effects include the poisoning of users, pesticide residues in food and drinking water. Already effects of overuse of pesticides in the sub Saharan region have been documented in recent times and these include pest resistance and phytotoxicity in Cote d'Ivoire and Kenya, cotton whitely in the Sudan and cotton red spider mite in Zimbabwe (Ajayi, undated). This is the major case for the quantification and economic assessment of pesticide use and their external effects.

The economic justification of current levels of chemical pesticide use, both from the private users' and the society's point of view is questioned from two major reasons (Fleischer, 1995). Firstly, social costs are not fully reflected in the user's decision making process. Costs of preventing and abating damage to natural resources are not born by the user. Secondly as observed by Fleischer (1995) benefit of pesticide use is frequently and systematically overestimated because of methodological problems in crop loss assessment and in productivity analysis.

Zimbabwe like other developing countries faces higher potential long term risks than elsewhere because of the increasing trend of use of pesticides coupled with the low levels of farmers' education, poor regulatory mechanisms and poor institutional facilities (e.g. medical) to mitigate the negative effects of pesticides.

This therefore calls for the need to carry out an analysis of the state of pesticide use in the smallholder-farming sector. The focused would be on cotton because it depends on intensive pesticide application and is a major cash crop for many smallholder farmers in Zimbabwe. Pesticides make up a large percentage of the total cash costs in smallholder cotton production in Zimbabwe.

The research questions that need to be addressed include the following:
What is the economics of pesticide use in cotton production?

1. Which factors enhance or discourage the use of pesticides in cotton production?
2. What are the alternative pest management practices available to and used by the smallholder cotton farmers?

1.3 Objectives

The overall objective of this study is to determine the economics of and factors influencing pesticide use in smallholder cotton production. The specific objectives are:

a) To assess the pesticide use levels and the economics of pesticide use in the smallholder cotton production sector.

b) To assess factors influencing pesticide use by smallholder cotton producers.

c) To establish factors that enhances or discourages the use of pesticides in the Zimbabwean farming sector.

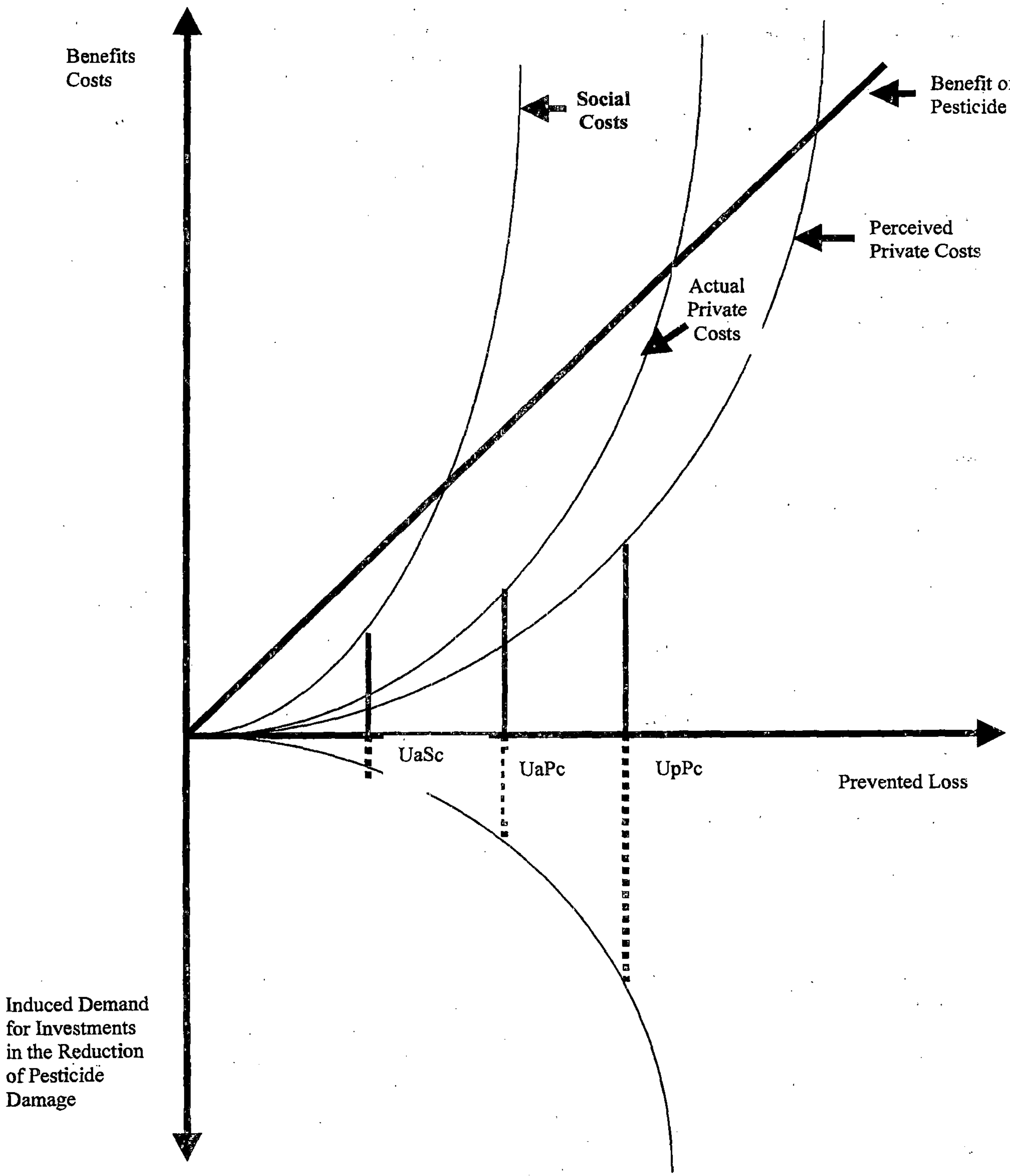
2. LITERATURE REVIEW

This section begins by discussing the general conceptual framework used in the study and in other countries. It then looks at pesticide policy studies done in other countries, methodologies used and the results obtained. Factors affecting pesticide use are also discussed.

2.1 Conceptual Framework

The general conceptual framework of the study draws partly from the guidelines agreed at the pesticide workshop held in Germany in 1994 and discussed by Agne, Fleischer, Jungbluth and Waibel (1995). According to these guidelines the economic assessment of pesticide use has to be treated within a framework that covers the farmer's point-of-view as well as the society's viewpoint (Figure 1). The criterion of the farmer is to maximize expected net returns. Gross returns from applying pesticides are defined as being equal to prevented crop loss in monetary terms. Costs of pesticides are referred to as the amount of farm resources used for every unit of crop loss prevented. Farmer's level of pesticide use is therefore denoted with U_pP_c in Figure 1.

Figure 1: Optimal Level of Pesticide Use and Induced Investments



Source: Waibel, H., 1994

This level depends on the farmer's subjective assessment of crop loss, the effectiveness of the control method and the perceived costs. This may well lead to overestimation of the returns and to an underestimation of costs if, for example, actual health hazards are not fully recognized. If perfect information on the above mentioned variables were available, the optimal level of pesticide use would be reduced to U_aP_c and increase net returns.

The criterion for the society as a whole on deciding the quantity of pesticides to apply is to maximize net social benefit. This differs from the private optimum, because pesticides cause external effects, e.g. through the contamination of ground water or food, which are not taken into account by the farmer. To include these negative externalities shifts the cost curve upward and further reduces the optimal level of pesticide use to U_aS_c.

If governments do not interfere in the pesticide market, adequate information on crop loss will not be provided and externalities will not be internalized. As a consequence the level of pesticide use is likely to be above the social optimum.

The resulting overuse of pesticides causes additional costs, because potential and actual damage caused by pesticides leads to an increased need for government activities which aim at monitoring the implementation of rules and regulations as well as at reducing the environmental and health damage caused by pesticides (Waibel, 1996). Such activities include the establishment of pesticide residue laboratories, residue monitoring programs and training programs on the safe use of pesticides. The extent of these activities must be decided simultaneously with the level of pesticide use, or else over investment is likely to occur. If activities in pesticide damage mitigation measures come up to the current level of pesticide use, public funds are likely to be wasted. If pesticide use would be at the socially optimal level, the induced demand for such activities would be lower. This is shown by the lower panel of Figure 1 (Waibel, 1994).

The framework does not suggest or exactly determine an optimal level of pesticide use but is meant to guide in judging the pesticide situation in a country. As observed by Agne et al (1995), the application of this framework is expected to achieve the following:

a) provision of an overview of pesticide use within the context of the nation's crop protection strategy.
b) create increased awareness of pesticide policy in the context of agricultural, environmental and health policies.
c) stimulate demand for in depth studies addressing specific issues raised by the exploratory studies.

There are a number of problems associated in using this framework (Waibel, 1996). Firstly is the general difficulty of specifying a production function that is really based on cause and effect. Pesticide applications per se do not increase yields; they may reduce yield loss in case of pest infestation, if the right pesticide is used at the right time and at the right dose. In addition there is a problem of measuring units of pesticide inputs. The multitude of pesticide products and their different formulations complicate the use of unitary quantitative measures. In the approach an assumption has to be made as regards the economic efficiency of current use levels

2.2 Benefits of Pesticide Use

According to Waibel (1996) the benefits of pesticide use must be measured in terms of their contribution to increased productivity in food production, i.e. lowering its average costs. Benefits can be identified as:

a) the impact on production in terms of the reduction in crop loss

b) the reduction of risk of sudden drops in production, i.e. reducing the variance in yields.
c) higher commodity prices related to product quality.
d) reduced production costs relating to labour-saving effects of herbicide use.
e) decrease in the costs of soil conservation (soil erosion) through a substitution of tillage by herbicides.

Waibel (1996) contends that the most obvious benefit of pesticide use is the reduction of crop loss that is a major factor influencing pest management decisions by farmers, policy makers, administrators and researchers. Each of these decision-makers has different perceptions of crop loss based on different viewpoints, information, methodology, interpretation and objectives. Research trial data, mostly derived from research stations, are generally used in the quantification of crop loss (Waibel, 1996). Crop loss is usually calculated as the yield difference between a pesticide treatment and maximum protection treatment. This crop loss definition, according to Waibel (1996) completely ignores economic realities on three levels. Firstly, maximum protection is unlikely to result in a yield, which is economically optimal. Secondly, a no pesticide treatment is likely to trigger considerable changes in agronomic practices in order to become an optimal adjustment strategy under a without pesticide situation. By just looking at spray versus no spray strategies unrealistic alternatives are being compared. Thirdly, pest pressure in experiment stations is likely to be higher than under field conditions because of continuous and off-season spraying. Waibel (1996) suggests that economic crop loss must be defined as that level of yield loss and consequently pest population levels where cost of food production reaches its minimum. This level is determined by the costs of control and the monetary value of the crop loss.

According to Chivinge (1996), in Zimbabwe, there are virtually no estimates of crop losses due to the different pests and pathogens. The estimates of crop losses are mainly based on the visual appearance of damage(s) caused by the disease(s). Most of the experiments done by the Plant Protection Research Institute over the years are for the establishment of pesticide efficacy and not the estimation of crop losses. In addition all the trials conducted by the agro-chemical industry are to show efficacy of a pesticide formulation as a requirement for pesticide registration. Chivinge (1996) attributes the apathy towards conducting crop loss assessments to the following reasons:

a) Crops are ravaged by more than one pathogen or insect, hence the need to apply more than one pesticide at frequent intervals in order to identify the cause of the crop loss.
b) Crop losses due to insects and pathogens are location specific as they are influenced by chemical and physical properties of the soil and environmental conditions such as temperature, moisture and relative humidity.
c) The lack of interest and training in crop loss assessment methodologies on the part of the researchers and technicians.

2.2 Factors Determining Pesticide Use

Fleischer (1996) reports that, in analysing the effects that contribute to the distortion of pesticide from its socially optimum level, several groups of subsidising and promoting factors can be distinguished (Table 2.1). The farm gate price of pesticides can be lowered by direct transfer payments to pesticide industries, retailers or by government distribution. These factors are classified as obvious price factors (Fleischer, 1996).

The decision by pesticide user whether to apply pesticides or use alternative crop protection methods is influenced by some other reasons which are indirect and frequently hidden. The hidden factors that lead to biases towards chemical solutions include the education system, priorities in the research programs and organization of the extension service and information on different crop protection strategies. Inappropriate government interventions in case of occurrence of external effects contribute to high pesticide use levels (Table 2.1).

Table 2.1: Factors Causing Excessive Pesticide

PRICE FACTORS	NON-PRICE FACTORS
I. OBVIOUS	**III. OBVIOUS**
1. Government sells or gives pesticides	1. Misguided use of governments' activities in reducing pesticide damage
2. Donors provide pesticides at low or no costs	2. Governments' investment in pesticide research
3. Government refunds pesticide companies costs	3. Inadequate government research in environmentally benign pest management
4. Subsidised credit for pesticides	
5. Preferential rates for tax and exchange rate	
	IV. HIDDEN
II. HIDDEN	1. Lack of adequate procedures • pest definition • crop loss definition • Lack of information
1. Plant Protection Service outbreak budget	2. Lack of transparency in regulatory decision making
2. Pesticide production externalities	3. Curricula of agricultural education and extension
3. Pesticide use externalities	4. Misinformation of farmers by industry

Sources: Waibel, 1994; Fleischer, 1996

In two case studies of stimulating and discouraging factors of chemical pesticide use in Costa Rica and Thailand using the outlined conceptual framework, Agne (1995) and Jungbluth (1995), respectively, showed that the majority of factors promoted pesticide use levels that exceeded the social optimum.

In Costa Rica, intensification of cropping and the shift towards crops that consume high amount of chemical pesticides per unit area (fruits and vegetables) promoted increased use of pesticides. External costs such as environmental pollution were tolerated by society while others, e.g. medical treatment of intoxicated persons, were not but they were paid for by public funds. While the official extension service promoted IPM to reduce dependence on pesticides, the information transmitted by the chemical industry and pesticide retailers stimulated pesticide use. Lack of information on non-chemical methods at the farm-level favoured pesticide use. Credit programs made pesticide use obligatory. Pesticides and complementary inputs such as spraying equipment and fertiliser were exempted from all duties and taxes. This stimulated the demand for pesticides.

Jungbluth's study in Thailand showed similar factors that promoted increased pesticide use. This include diversification from rice to production of horticultural crops, like vegetables and flowers, that were pesticide intensive. Negative externalities such as health hazards (occupational health hazards), residues in food and the environment, destruction of beneficial insects, reduction of bio-diversity and pollution of drinking water were not include social costs because of insufficient information. Pesticides for agricultural use only were exempted from import duty, business and municipal taxes. The tax exemption was an indirect subsidy for pesticide imports and prices and thus encouraging increased pesticide use. Extension and training by both the Government extension service and pesticide companies focused on the safe pesticide use and application methods. The concept of IPM was not sufficiently transferred to the agricultural extension services. All these promoted greater use of pesticides.

2.3 Pesticide Externalities

Overuse and misuse of pesticides has been shown to have effects beyond the fields on which they are applied. Negative externalities of pesticide use are health hazards (occupational health hazards), residues in food and the environment as well as pest resistance and resurgence, destruction of beneficial insects, reduction of bio-diversity and pollution of drinking water.

In Zimbabwe, negative externalities have been shown to be mostly associated with occupational exposure (misuse or unsafe handling/application). A study by Loewenson and Nhachi (1996) on the epidemiology of the health impact of pesticide shows that about 50 percent of the workers on large-scale farms involved in pesticide use are exposed to organophosphates during the spraying season. The study estimated that about 10 000 workers are exposed to organophosphates in this occupational category alone. The pesticide exposure is associated with the use of manual techniques, little provision of protective clothing and inadequate safety information. Another survey by Matchaba (1996), in pesticide factories, revealed the presence of excessive exposure to organophosphates at the workplace. Chitemerere (in Nhachi and Kasilo, 1996) noted that statistical records of accidents in the use of pesticides in the agricultural sector in Zimbabwe does not portray an alarming number of casualties and fatalities.

Occupational exposure to DDT among mosquito control sprayers was found to be evident in Zimbabwe (Nhachi et al, 1996). Forty nine percent of sprayers screened for DDT exposure between 1988 and 1990 showed evidence of DDT exposure.

There is also evidence of pesticide residue build up in Zimbabwean lakes. A study by Phelps and Billings (1972) following the tsetse control spraying in 1962 to 1965 with Dieldrin and DDT confirmed the build up of DDT in lakes as well as in the terrestrial environment (Makhubalo in Nhachi et al, 1996). Dieldrin was found in crocodile tissue whilst DDT was recorded in bird tissue.

3. RESEARCH METHODOLOGY

This section outlines the research methods, site selection and data collection approaches used for the study.

3.1 Study Site Selection

Rushinga Communal Land in Mount Darwin Rural District, Mashonaland Central Province, was purposively selected for the study. It was considered ideal for the study because of the prevalence of cotton and tobacco production which are chemical intensive crops. Smallholder farmers were selected for the study because very little information on pesticide use has been documented from this sector compared to the Large Scale Commercial Farming Sector.

3.2 Sample Selection

Simple random sampling technique was used to select one Ward (Ward 12) from a total of nineteen wards. Similarly, simple random was used to select forty-eight households from a sampling frame (list of all the households in Ward 12) of one hundred and twenty three households provided by AGRITEX officials. The names of household heads from the sampling frame were written on pieces of paper of the same size and then placed in a hat after which forty-eight households were selected at random to form the sample. A sample of forty-eight households was considered ideal considering the resources available (money and time) and the large size of the Ward in terms of land area.

3.3 Data Collection

Primary and secondary data sources were used in the study. The secondary data was collected from publications and organizations that include, Ministry of Lands and Agriculture, AGRITEX. The information collected from secondary sources includes:

- pesticide pricing policy
- pesticide regulatory policies
- importance of pesticides in the various crops
- pesticide marketing arrangements
- trend in the use of pesticides over the past years
- cost of pesticides

Primary data was collected through a formal survey conducted in Rushinga, Mt Darwin. The information obtained was on the following variables:

- socio-demographic information on the households such as age of household head, sex of household head, size of labour force etc.
- level of education and major source of income
- cotton income
- number of years growing cotton
- cropping system
- availability and use of farm inputs
- cost of pesticides
- access to output markets
- alternative pest control mechanisms
- externalities from pesticide use in the form of poisoning, skin irritation, pollution etc.
- the availability and importance of extension advice and training for plant protection in particular.

The questionnaire was administered from the end of May to the end of June, a period of about one-month.

Data on experts' assessment of factors determining pesticide use was obtained through interviews of crop protection researchers and extension specialists in the Department of Research and Specialist Services (DR&SS) and Department of Agricultural, Extension and Technical Services (AGRITEX).

3.4 Data Entry

The data was entered into and analyzed using the statistical package of the social sciences (SPSS). The data was first edited and some of the questions post coded. Other post field activities include data cleaning and preliminary analysis.

4. HOUSEHOLD SOCIO-ECONOMIC CHARACTERISTICS AND PEST MANAGEMENT PRACTICES

This section discusses household socio-economic characteristics, pest management practices and factors influencing pesticide use at the farm level.

4.1 Household Socio-Economic Characteristics

Table 4.1 shows the average socio-economic characteristics of the sample of interviewed farmers in Rushinga District

Table 4.1: Household Socio-Economic Characteristics (N = 48)

Socio-economic Characteristic	Average Result
Average age of household head	52.2
Average years of education of household head	6.9
Average household size	8
Average size of the labour force	5

Source: Survey, 1997

4.1.1 Age, Household Composition and Education Levels

Eighty seven percent of the households were male headed whilst the remainder (12.5 percent) was female headed. The average age of household heads was 52 years.

The household size averaged 8 people. Labour availability averaged five persons per household.

The number of years in school for the household heads ranged from 0 years to 18 years, with an average of seven years. About 58 percent of the surveyed farmers did not go beyond primary school education. Kujeke (1996) reports that a substantial amount of information (including pesticide use information) disseminated to rural communities are incompatible with the prevalent low literacy skills among the recipients.

4.1.2 Farm Production Assets

Table 4.2 shows ownership structure for most of the basic farm implements.

Table 4.2: Ownership Structure for the Basic Farm Implements

Farm Implement	Average Number Per Household	% of the Households Owning
Plough	1.7	87.5
Harrow	1.1	27.1
Hoes	4.9	100.0
Wheel Barrow	1.1	33.3
Cultivator	1.6	50.0
Scotch Cart	1.1	60.4
Water Cart	1.0	10.4
Sprayers	1.7	68.7

Source: Survey, 1997

Thirty-one (31.3) percent of the households do not possessed sprayers, which are vital for applying pesticides. Only 10.4 percent of the surveyed farmers possessed water carts used to supply water for spraying.

4.1.3 Farm Sizes And Crop Production

The total arable area for each farming household averaged 10.3 acres, ranging from two to 28 acres.

Agricultural production systems in Rushinga are based on dryland cropping and livestock production. All the farmers in the sample grew maize, the staple food crop. Eighty-five and 77.1 percent of the farmers grow cotton and groundnuts, respectively (Table 4.3).

Table 4.3: Major Crops by Area Planted, Yield and Percentage of Farmers growing the crop.

Crop	% of Farmers Growing the Crop	Average Area Planted (in acres)	Average Yield per household (50 kg bags unless stated)
Maize	100	3.7	50.3
Groundnut	77.1	1.3	9.0
Sunflower	41.7	1.7	9.4
Sorghum	14.6	0.9	3.9
Cotton	85.4	4.1	903 kg (6.7 bales)

Source: Survey, 1997

Cotton followed by maize are the major crops in terms of arable area allocation. Sunflowers and sorghum are minor crops.

4.2 Pest Management Practices And Factors Determining Pesticide Use

This section outlines the farmers' pest management practices and factors determining pesticide use at the farm-level.

4.2.1 Major Cotton Pests

Aphids, red spidermites and the American Bollworm were identified as the major pests affecting the cotton crop (Table 4.4). Other pests, although less important were jassids, ants and termites.

Table 4.4: Cotton Pests as Identified by Farmers

Major Pests	Percent of farmers
Aphids	38.5
Red spidermite	30.7
American Bollworm	20.5
Ants and Termites	7.7
Jassids	2.6
	100.0

Source: Survey, 1997

4.2.2 Pest Management Practices

4.2.2.1 Cotton Scouting

Scouting refers to the practical examination of a cotton field for the presence of pests and predators (Jarachara, Undated). According to Jarachara (Undated), for any pest control program to be cost effective in cotton production, it has to be based on reliable information. This information should reveal the types and infestation levels of pests present in the field. Given the correct information this information enables the farmer to:

- Determine the need to spray pesticides against pests.
- Make correct choice of pesticides.
- Apply the pesticides at the correct time.
- Evaluate the effectiveness of the spraying program.

Scouting is therefore necessary to ensure that pesticides are applied only when necessary.

Table 4.5: Reasons for Scouting

Reason For Scouting	% of Households
To check for pests	50.0
To determine types of pests and hence select type of pesticide	18.0
To check for presence of diseases	10.5
To decide on whether to use hand-picking as opposed to chemical control of pests	18.5
To observed plant growth and progress	3.0

Source: Survey, 1998

Ninety-seven (97%) percent of the farmers reported that they practiced scouting to detect the presence of pests and disease and select pest control strategy. (Table 4.5).

Cotton experts recommend that farmers should scout at least once a week, starting at one week after thinning but not later than two weeks after emergence. Scouting a cotton field twice per week is recommended from peak flowering onwards, (Jarachara, undated). Table 4.6 shows the frequency of scouting by the households in the surveyed fields.

Table 4.6: Frequency of Scouting by Households

Frequency of Scouting	% of Respondents
Once per week	66.0
Twice per week	5.0
Daily	5.3
Once every fortnight	21.1
Once per month	2.6

Source: Survey 1998

Over 76 percent of the farmers adhere to the recommended scouting rates. The remaining farmers (about 24%) scout once every fortnight (21.1%) and once per month (2.6%). The results therefore indicate that farmers follow the recommended pest management practices with respect to scouting.

4.2.2.2 Pesticide Application Levels

Table 4.7 compares the farmers' application rates with the recommended rates. The recommended application rates are based on the assumption that the cotton crop in the surveyed area had plants with height ranging from 0,3m to 0,6m.

Table 4.7: Pesticides Types and Application Rates

Pesticide	Unit	Qty Applied Per hectare	Recommended Qty/Ha (plants up to 3m)	Recommended Qty/Ha (Plants between 0.3 to 0.6m)
Marshal	Kg	0.147	Na	0.350
Thiodan	Kg	0.143	0.250	0.500
Carbaryl	Kg	0.086	0.294	0.588
Oncol 20EC	Kg	0.112	na	na
Rogor	Litre	0.091	0.062	0.125
Fenvalerate	Kg	0.098	na	0.200

Source: Survey 1998 and Farm Management Handbook

Fifty-four (54) percent of the surveyed farmers indicated that they were aware of the recommended pesticide application rates. The observed average per hectare application rates for all the types of pesticides in the study area are below the recommended rates for both cotton plants between 0,3 to 0,6m and below three metres (Table 4.7).

4.2.3 Pest Management Inputs And Information

This section discusses the survey results pertaining to farmers' access to credit and extension services and how these determine pesticide use.

4.2.3.1 Access To Pesticide Inputs

Table 4.8: Sources of Credit for Pesticide Purchase and the percentage of farmers

Source of Credit for pesticide purchase	Percent of Farmers
Cotton Company of Zimbabwe (Cottco)	96.9
Commercial Banks	3.1
Agricultural Finance Corporation (AFC)	0

Source: Survey, 1997.

The Cotton Company of Zimbabwe (COTTCO) provides seasonal credit for the cotton production. The credit is obtainable in the form of "cotton packs" of seed, fertilizers and pesticides at 19% interest rates that was lower than the commercial interest rate of 23%. The survey showed that 96.9 percent of the farmers obtained credit from the Cotton Company (Cottco) and the remainder (3.1%) from commercial banks (Table 4.8). The COTTCO, through its credit scheme, is therefore the main source of agro-chemicals (pesticides) as a pest control strategy.

4.2.3.2 Pest Management Information And Training

This survey largely centered on agricultural extension and training as they relate to pesticide use. Close to 85 percent of the cotton farmers received extension advice on pest management and pesticide use from the COTTCO as shown in Table 4.9.

Table 4.9 Sources of Advice on Pesticide Use in Cotton Production in Rushinga

Source of Advice	Percentage of Farmers
AGRITEX	7.3
Other farmers	7.3
Cottco	85.4

Source: Survey, 1997

COTTCO is the main source of extension advice on pesticide use, followed by AGRITEX and other farmers. AGRITEX, the national extension agency appears to play a limited role in extension on pesticide use especially in promoting non-chemical methods of pest control such as IPM.

Table 4.10 shows the other pest control strategies available to the surveyed farmers. The range of alternative pest management strategies available to the farmers is very limited. Twenty-nine (29.3) percent of the farmers are unaware of the other recommended technologies (IPM) for combating pest problems.

Table 4.10: Other Pest Control Mechanisms Practiced by the Farmers

Other pest Control Meas	Percentage of Farmers
IPM	4.9
Burning Plant Remains	2.4
Crop Rotations	34.1
Weeding	26.8
None	29.3

Source: Survey, 1997

Kujeke (1995), in a separate study, reported that there was little application of IPM strategies in Zimbabwe. He attributed this to the lack of information and know-how of IPM practices within service institutions, as well as at the user level. The information requirements on pesticide use were reported to be beyond the capabilities of the typical field extension agent. These requirements include knowledge on the hundreds of agro-chemical products available on the market, symptoms of pest attack, pest frequency etc.

4.2.4 Awareness Of Risks Associated With Pesticide Use

The pesticide technology available to the farmers places them in close contact with the pesticides. Knapsack sprayers are the commonly used during pesticide application. As shown in Table 4.2 thirty-one percent of the farmers did not possess any pesticide spraying equipment.

Although pesticide use is the main strategy used to combat pest related problems, there is little knowledge of or experiences with pesticide dangers. Only 9.5 percent of the surveyed farmers reported having experienced any bad effects (such as poisoning, skin burns, irritation and nausea) from pesticide use.

5. ECONOMICS OF PESTICIDE USE

The section analyses the financial returns to cotton production in Rushinga. Gross margin returns to land, pesticide investment and labour at the farmers' yield levels are compared to potential performance when the recommended input levels are applied.

5.1 Gross Margin Analysis

Table 5.1: Cotton Gross Margins for Different Yield Categories, Rushinga

Input and Output	Low Yield (n=14)	Average Yield (N=40)	High Yield (N = 11)
YIELD LEVEL (UNGINNED KG/HA	412	905	1623
BLEND SELLING PRICE ($/KG)	5.41	5.41	5.41
VARIABLE COSTS			
A PRIR TO HARVESTING			
1. Seed	79.25	39.9	266
2. Fertilizer			
a) Compund D	143.2	219	299
b) Ammonium Nitrate	140.71		256
3. Insecticide			
a) Carbarly 85WP	137	91.54	72
b) Thiodin	68.72	77.96	91.02
c) Dimethoate 40EC	41.89	180.98	227.98
d) Marshal	71.99	69.4	116
SUB TOTAL	682.86	1589.27	1441.2
B. MARKETING AND HARVESTING			
1. Packing materials	16	36.2	64.92
a. Bale hire $8 per bale	41.23	90.55	162.32
2. Transport off farm $20 per bale	59.02	133.35	240.45
Total Variable Costs ($/Ha)	741.66	1722.62	1681.7
Gross Income ($/Ha)	2228.92	4898.05	8780.4
Gross Margin ($/Ha)	1487.04	3173.48	7098.7
Gross Margin ($/$100 VC)	200.44	184.22	422.11
Gross Margin Per Labour Hour	2.39	3.8	6.36
Gross Margin Per Labour Day (6hrs)	14.29	22.19	30.73
No Of Labour Days Per Ha	621	827	1115
Gross Margin Per $ Pesticide Costs	4.65	4.15	11.89

Source: Survey and AGRITEX Data

Table 5.1 presents the financial performance of the smallholder cotton farmers in Rushinga based on input and data collected from the survey.

Gross margin is used to measure the economic returns to resources (labour, pesticides and other variable costs). Gross margin per labour day and gross margin per dollar invested in pesticides are thus used as indicators of performance in the smallholder cotton production sector.

The gross margin of a farm activity is the difference between gross income earned and the variable costs incurred (Makeham and Malcolm, 1986). The cotton gross income includes the monetary value of the marketed cotton and quantity paid-out in kind. The blend cotton-selling price of $5.41 per kg for the un-ginned cotton was used to calculate gross income. The blend price takes into account the different cotton grades obtained and the different marketing channels used by the cotton farmers.

To take into account different yield levels and associated input level, the farmers were divided into three categories. The first category comprised of farmers who obtained low cotton yields ranging from 300 kgs to 700 kgs per hectare. Thirty five percent of the sampled farmers fell in this category and their average yield is 415 kgs per hectare. The second category grouped farmers whose average yield ranged from 701 to 1200 kg per hectare. Thirty seven percent of the farmers had their cotton yields in the range 700 to 1200 kgs per hectare. This included the sample average yield of 905 kg per hectare. The third category comprised of farmers who obtained high yields ranging from 1200 kgs and above. About 28 percent of the farmers fell in this category with average yield of 1623 kgs per hectare.

5.1.1 Returns To Land, Labor And Pesticide Investment

Gross margin per hectare for the average yield of 905 kgs is $3 173 implying that most of the smallholder farmers have positive and high financial returns from the cotton enterprise. The gross margin per hectare is also positive for the average low and the average high yield levels indicating positive financial returns per hectare for most of the smallholder farmers.

The returns to labour per day are all positive for the low yield (415 kgs), average yield (905 kg) and for higher yield (1623 kgs), that is $14.29, $22.19 and $30.73, respectively.

On average the smallholder cotton farmers spent $764.78 on pesticides per hectare. This translates into pesticide costs amounting to over 40 percent of the total variable costs per hectare. The gross margin per dollar invested in pesticides for the average cotton yield is $4.15. This implies that for every dollar invested in pesticides farmers earns $4.15 cents.

5.1.4 Comparative Gross Margin Analysis Of Farmers' Versus Recommended Application Rates

Table 5.2 shows the comparisons of the returns to resources for the three observed different yield categories and returns obtainable from recommended input levels. The budgets have been calculated to reflect financial returns at different yields of 500 kgs, 1500 kgs and 2000 kgs per hectare that correspond to different input levels. The recommended yield and input levels are derived on AGRITEX production models using data based on experimental conditions.

Table 5.2: Comparative Returns to Resources for Rushinga Farmers Versus Recommendations

	412 kgs	500 kgs	905 kgs	1000 kgs	1623 kgs	1500 kgs
GM ($/HA)	1487	525.8	3173	2890	7099	5387
GM/$ pesticide	4.65	0.54	4.15	3	11.89	5.59
GM/labour day	14.29	4.98	22.19	21.62	30.73	33.25
GM ($/100)	200	24.3	184	115	422	197

Source: Survey and AGRITEX Data

Financial returns to land, labour and investment in pesticides are positive at the three yield levels determined by AGRITEX. The financial returns to resources obtained by smallholder cotton farmers in Rushinga are higher than the expected returns under the recommended input-output levels for the three different yield categories (Table 5.2). This suggests that the current input application levels are rational.

6. EXPERT ASSESSMENT OF PESTICIDE USE

This section presents the experts' assessment of the pesticide use levels in cotton production and the agricultural sector as a whole. The major aim of this analysis is to present a ranking of factors which influence the use of pesticides and the experts' opinion on the future of crop protection policy in smallholder agriculture.

6.1 Analytical Framework On The Determinants Of Pesticide Use

An expert assessment on the price, institutional and hidden (socio-economic) determinants of pesticide use as done in Costa Rica and Thailand was done for this.

For this study, the experts were drawn from several organizations, with varying viewpoints, targets and backgrounds we expect to gain an overall picture of the current pesticide policy in the country.

The list of factors, which are believed to influence pesticide use in Zimbabwe, was presented to the experts in the form of a questionnaire. The determinants of pesticide use were evaluated by experts in pesticide use on a scale from -3 to +3 (arbitrarily chosen). The data was analyzed using frequencies and descriptive statistics. To facilitate frequency analysis, the impact of each factor was then expressed on a scale in three-category -1, 0 and +1. A -1 value implies a discouraging effect on pesticide use whilst a positive value (+1) indicates a stimulating effect on pesticide use. Factors that do not have an impact at all are given a zero. Frequencies were then used to determine the importance of each factor in influencing pesticide use.

In addition to the frequency analysis, the ranking of determinants of pesticide use was also done using mean, mean absolute deviation and range as done in Costa Rica and Thailand. The experts evaluated the determinants of pesticide use on a scale -3 to 3 (arbitrarily chosen). The impact of each factor was then expressed on a scale in seven-category -3 to +3. A negative value implies a discouraging effect on pesticide use whilst a positive value indicates a stimulating effect on pesticide use. Therefore, -3 is equivalent to the strongest reduction and +3 to an extreme stimulation of pesticide use. Factors that do not have an impact at all are given a zero. The higher the number the higher is the impact of the factor - in the positive and in the negative direction.

The factors have been divided into three groups. The first group consists of price factors, which are believed to have a direct influence on pesticide use. The second group is the institutional factors dealing with the institutional aspects of crop protection policy as well as aspects of information and human resources. The last group is the hidden factors dealing with the tolerance levels of negative externalities. If the tolerance of negative externalities in a society is high little incentives exist to reduce pesticide overuse.

6.2 Pesticide Use Levels

Table 6.1 presents the results of the expert assessment of the pesticide use levels in the Zimbabwean agricultural sector and cotton production, respectively.

Table 6.1 Expert Assessment of Pesticide Use

Level of Use	Zimbabwe Agriculture %	Cotton Production %
Over use	22.2	33.3
Under use	33.3	44.5
Fair (moderate)	33.3	22.2
Recommended Rates Used	11.2	
Total	100	100

Source: Survey, 1997

Regarding pesticide use in the agricultural sector, thirty-three percent (33.3%) of the experts interviewed were of the view there is under use of pesticides, 33.3 percent believe that there is moderate use and 11.1 percent believe that farmers use the recommended rates of pesticides. Overall, the results indicate that, among crop protection experts in Zimbabwe, there is a consensus that there is under use and moderate use of pesticides in the agricultural sector as a whole. Only 22.2 percent of the crop protection experts believe that there is overuse of pesticides.

With respect to the experts' rating of the pesticide use in cotton production in Zimbabwe, forty-four percent of the crop protection experts are in agreement that there is under use of pesticides and 22.2 percent believe that there is moderate use.

6.3 Determinants Of Pesticide Use

Table 6.2 presents the experts' assessment and weighting of the impacts of price, institutional and external factors determining cotton pesticide use.

Table 6.2: Expert Assessment of Determinants of Pesticide Use (N = 10)

	% of Respondents				Ranking		
Determinants of Pesticide Use	**-ve**	**Zero**	**+ve**		**Mean**	**Std Dev**	**Range**
Price Factors:							
Credit requirements	40	20	40		0.3	2.4	-3 to 3
Public Funding of pesticide research	30	30	40		0.2	1	-1 to 2
Outbreak Budget	20	40	40		0.1	1.3	-2 to 2
Current prices	70	0	30		-0.9	2.6	-3 to 3
Institutional Factors:							
Lack of information on non chemical	30	10	60		0.7	1.6	-2 to 3
IPM research, training and extension	50	30	20		-0.3	1.5	-2 to 3
Recommendations of pesticide retailers	10	30	20		0.9	1.4	-2 to 2
Education in crop protection	50	10	40		-0.1	1.6	-3 to 2
Lack of implementation of pesticide legislation	0	20	80		1.2	0.8	0 to 2
Promotion of pesticide intensive agricultural	10	20	70		1.2	1.2	-1 to 3
Extension Services	10	10	80		0.9	0.9	-1 to 2
External Factors:							
Medical treatment	50	30	20		-0.4	1.4	-3 to 2
Environmental costs	40	30	30		-0.2	1.3	-2 to 2
Pesticide resistance	20	30	50		0.9	1.5	-1 to 3

-ve Implies discouraging effect on pesticide use
Zero Implies no effect in determining pesticide use
+ve Implies stimulating effect on pesticide use

6.3.1 Institutional Factors

Institutional and information factors emerge as a major positive effect in promoting pesticide use in the Zimbabwean agricultural sector. The institutional factors with the biggest positive effect on pesticide use are:

1. Extension services,
2. promotion of intensive agricultural systems,
3. lack of implementation of pesticide legislation,
4. the recommendations of pesticide retailers,
5. inadequate information on non-chemical alternatives.

Eighty percent of the experts interviewed are of the opinion that lack of implementation of pesticide legislation enhances pesticide use in Zimbabwean agriculture.

The experts are of the opinion that IPM extension and education in crop protection have a discouraging effect on pesticide use. This implies that IPM research, extension and education in crop protection would be effective in discouraging the increased use of pesticides. However, the degree of impact of these institutional factors in reducing pesticide use is not as strong as the one for factors enhancing pesticide use.

6.3.2 Price Factors
The pesticide prices are considered as discouraging the increased use of pesticides.

Factors promoting increased pesticide use are the current credit policy, public funding of pesticide research and the outbreak budget.

6.3.3 External Factors
Health effects and environmental costs are considered as factors likely to discourage pesticide use while pesticide resistance enhances pesticide use.

6.4 Future Trend In Crop Protection
Table 6.3 shows the future trend in crop protection as assessed by crop protection experts.

Table 6.6: Future Trend in Crop Protection

Future Trend in Crop Protection	% of respondents
Move towards IPM	55.6
More use of pesticides	22.2
No change	22.2

Source: Survey 1998

Most experts (55.6%) agree that the future will see a move towards the increased practice of IPM as a crop protection strategy in the smallholder-farming sector. This would be due to pesticide price increase and more education and improved information on alternatives to pesticide use.

7. CONCLUSIONS
The study sought to investigate the economics of and factors influencing pesticide use by smallholder cotton farmers in Zimbabwe. Farmers' knowledge and practices on pests and pest control are also examined. The study also sought to establish whether the recommended pesticide application rates were being followed. Non-chemical solutions to pest problems available to smallholder farmers are also examined.

Gross margin analysis reveals that returns to pesticide use (investment in pesticides) are high for most of the smallholder cotton farmers. Gross margin per dollar invested in pesticides was $4.07 for the average cotton yield of 927 kgs per hectare. Gross margin per hectare for the average yield of the sampled farmers was $3 694. Pesticide application is thus profitable at the current application rates and output levels.

All the farmers received credit for the acquisition of pesticides and other inputs from COTTCO in the form of cotton packs. In this way farmers are encouraged to use pesticide as the major method to combat pests. In addition extension on pesticide use is largely promoted through COTTCO, a company which is only recommending chemical solutions to pest problems. The role of AGRITEX in pesticide use extension is very limited and the possible reasons for this include insufficient training on the part of extension agents.

Most farmers are unaware of other recommended non-chemical pest control strategies. There is little application of IPM in the surveyed area. In fact the survey shows the range of alternative pest control strategies available to farmers as being limited and rarely practiced. The survey reveals that close to 30 percent of the farmers do not know of any other pest control mechanisms besides chemical strategies.

The majority of the farmers are unaware of the negative externalities of pesticide use especially on the environment and hence social costs (effects) are not taken into account when decisions are taken on whether to use pesticides or not. Only 9.5 percent of the farmers in the sample reported to have experienced external effects from pesticide use. The other farmers seem to have ignored the negative externalities even in their decision making. This leads to the conclusion that the majority of smallholder cotton farmers are uninformed of the health and environmental negative externalities of pesticide use.

The results reveal that there is under use of all the types of pesticides by the smallholder cotton farmers in Rushinga. Under use of pesticides is confirmed also through the expert survey whereby over 60 percent of the experts in cotton protection believe that there is under use to moderate use of pesticides in the Zimbabwean agricultural sector. Over 60 percent of the crop protection experts are in agreement that there is under use to fair use of pesticides in the cotton production sector.

The expert assessment of the factors that determine pesticide use shows that institutional factors are the major factors promoting pesticide use in the Zimbabwean agricultural sector. This supports the hypothesis that institutional factors are the major factors enhancing pesticide use. Lack of information on non-chemical alternatives and the promotion of pesticide intensive agricultural production systems are some of the institutional factors to note that enhances pesticide use.

External factors, such as medical treatment and environmental costs are judged to play a discouraging role in pesticide use. The experts are of the opinion that pesticide resistance promotes the increased use of pesticides. Overall, the factors that encourage pesticide use outweigh those discouraging pesticide use, implying that the use of pesticides in the Zimbabwean agricultural sector is on the increase.

The experts are divided about the role that price factors play in determining pesticide use. The current pesticide pricing policy is viewed as having a discouraging effect on pesticide use. The outbreak budget is viewed as promoting pesticide use.

7.2 Policy Implications And Recommendations

Policy instruments designed to provide information, education and training on pesticide need be implemented in Zimbabwe. These are likely to lead to optimal levels of pesticide use especially at the farm level where decision making is based on adequate information and knowledge being made available. The dissemination of information would be vital in raising awareness and understanding of the risks associated with pesticide use.

AGRITEX extension services need to be improved and updated on technical aspects of pesticide use. The extension package should provide farmers with full information as it relates to benefits and dangers of pesticide use. The possible health and environmental impacts of pesticide use should be clearly extended to farmers. Additional training for AGRITEX field agents is necessary on pesticide use as they have been shown to offer advice on outdated chemicals.

The credit policy for pesticide purchase through COTTCO should be reviewed with the possibility of including non-chemical pest control methods in the cotton packs.

Although the expert assessment has revealed a general under use of pesticides, the experts agree that pesticide use is on the increase. In this light there is need for government to encourage the adoption of environmentally friendly pest management strategies such as IPM.

Training should include pest management and pesticide use in agricultural college curricula. According to Kujeke (undated) the curriculum for most agricultural colleges does not have a core course in pest management. Training should also cover alternative pest control strategies such as IPM. The pesticide industry through the Agricultural Chemicals Industry Association (ACIA) should also be actively involved in training. The extension would ensure greater publicity on the consequences of pesticide misuse and overuse.

7.2 Areas For Further Research

The study did not, however, determine the optimal pesticide use levels as all the information required on the costs and benefits of pesticide use was not available.

Further research on pesticide productivity is necessary. This is normally determined through field trials at experimental stations by comparing plots treated with chemicals and untreated plots.

Research is also needed to identify and quantify negative external effects of pesticide use in agriculture and where possible estimate the costs. This is necessary in order to determine the optimal levels of pesticide use.

The impact of the economic and institutional reforms on pesticide use in agriculture is another area worth researching. This will give the direction of movement of pesticide policy in a liberalized market environment. Factors that affect pesticide use should also be studied for other crops with the purpose of determining whether there is overuse or misuse of the chemicals.

More emphasis should be placed on conducting crop loss assessments in Zimbabwe. These studies could lead to the establishment of threshold values of loss by insects and disease and the development of effective pest management strategies, including cultural practices, use of host resistance in the development of Integrated Pest Management (IPM) and biotechnology. Ultimately, crop loss information would lead to reduction, judicious use of pesticides and the development of environmentally sustainable pesticides. The assessment could be effectively undertaken either by the Plant Protection Unit or the Agro-chemical industries in the country.

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