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Essays on the Economics of Cotton Production in Zimbabwe: Policy Implications for Technology Adcption, Farmer Health and Market Liberalization

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ESSAYS ON THE ECONOMICS OF COTTON PRODUCTION IN ZIMBABWE: POLICY IMPLICATIONS FOR TECHNOLOGY ADOPTION, FARMER HEALTH AND MARKET LIBERALIZATION

By

Blessing Mukabeta Maumbe

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ABSTRACT

ESSAYS ON THE ECONOMICS OF COTTON PRODUCTION IN ZIMBABWE: POLICY IMPLICATIONS FOR TECHNOLOGY ADOPTION, FARMER HEALTH AND MARKET LIBERALIZATION

By

Blessing Mukabeta Maumbe

Cotton is grown in more than 30 Sub-Saharan African (SSA) countries and is a vital source of employment, foreign exchange and raw material for textile industries. But cotton industries in Africa face several strategic threats. In Africa, and in particular in Zimbabwe, long-term viability of cotton production will depend on both sustainable technology and policy. A key part of technological sustainability is mitigation of pesticide-related farmer health risks. Integrated Pest Management (IPM) provides some tools to reduce pesticide risks, but why farmers do not adopt IPM in African cotton production is less understood. In the policy arena, both economic and military policy can affect agricultural production. Zimbabwe's cotton sector has faced important policy shocks from Structural Adjustment Programs (SAPs) and the end of civil conflict in neighboring Mozambique.

The first essay analyzes acute health effects associated with pesticide use in two cotton-producing zones of Zimbabwe. The initial cost of illness regression model shows that farmer's reported acute symptoms are key determinants of farmer health costs. Poisson regression model results reveal that pesticide-induced acute symptoms are linked to the most toxic pesticides, use of leaking sprayers, label illiteracy, alcohol intake, and taking meals in the fields after spraying. Exposure averting and mitigating strategies that significantly reduce the incidence of acute symptoms include protective clothing, knowledge of first aid and predisposition toward reform calendar-based spray strategies.

The second essay examines determinants of cotton-IPM adoption in the same two zones. Results from a Poisson model shows that farmer's knowledge is the most important factor influencing the uptake of IPM technology. Pesticide-related health risks played no significant role in the adoption of IPM technology.

The third essay analyzes the determinants of Zimbabwe's cotton supply since 1980. It finds that SAPs have a negative impact on cotton acreage for both the large-scale commercial and small-scale communal farmers. Results show that large-scale cotton growers respond strongly to economic incentives while institutional factors matter for smallholders. Cessation in 1992 of the conflict in Mozambique is associated with positive cotton supply response among Zimbabwe's smallholders. Opportunities for cotton expansion lie with widespread diffusion of technical innovations and refinement of the on-going SAPs in order to generate positive supply response in future.

DEDICATION

To my wonderful parents, Enoch and Violet who have given me so much love, and I give that love in return to you. To the struggling smallholder cotton growers in the semi-arid regions of Africa, hoping that you reap a harvest of hope not sorrow.

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CHAPTER 1

INTRODUCTION

1.1 The Importance of Cotton Production in Africa

Cotton is grown in more than 30 Sub-Saharan African (SSA) countries (Lele, 1989). Although SSA countries differ greatly in their geographic and physical conditions, political disposition, weather patterns and cultural heritage, they do share some common patterns in their economic structures. In most if not all the African countries, agriculture is the dominant sector crucial to the well being of the economy. Over the past century, African agriculture has not grown fast enough to realize its potential as the engine for economic growth and poverty reduction (Binswanger, and Townsend, 2000). Nonetheless, cotton the "white gold" is one of Africa's most successful agricultural export stories (Bingen et al. 1998). The annual market value of African lint exports is about US$1 billion (Lele, 1989). Given that about 50% of Sub-Saharan Africans live below the poverty line, efforts to accelerate cotton production will offer tremendous opportunities for reducing the problem of rural poverty (World Bank, 1996).

In Zimbabwe, cotton was introduced as a commercial crop in the early 19th century and since 1980, its cultivation has expanded rapidly among the smallholders (Blackie, 1983). Zimbabwe ranks among the top five cotton producing countries in Africa (Jowa, 1996). Cotton is the most important cash crop to Zimbabwe's smallholders[1] and it ranks second after tobacco in terms of national foreign exchange earnings. More than half a million Zimbabweans depend on cotton for their livelihood. Cotton is also a major

[1] In Zimbabwe, three primary sub-sectors fall under the smallholder sector; these are Communal Area (CA), Small Scale Commercial Sector (SSCS) and the Resettlement Areas (RA).

source of cooking oil and animal feed (Mariga, 1994). Nonetheless, cotton production in Zimbabwe has reached a turning point.

Prior to independence in 1980, smallholders contributed an insignificant amount of cotton output. But at independence, the GOZ adopted a deliberate policy to stimulate smallholder agriculture and these efforts paid off. Between 1980 and 1985, Zimbabwe experienced a major cotton revolution as smallholder cotton area increased from 15,000 ha to 130,000ha. Smallholders' share of national output rose from 8% to 40% over the same period. Favorable agricultural policy that led to a major increase in support services such as extension, credit and research being directed to serve smallholders helped stimulate smallholder cotton production (Rukuni, 1993). That cotton is a drought tolerant crop might have aided its widespread expansion in semi-arid regions of Zimbabwe as well (Mariga, 1994).

However, the smallholder cotton revolution is under serious threat from risky pesticide use (Gillham, 1993; Jowa, 1996). Part of the reason is that the most toxic chemicals are among the cheapest. Also, pesticide use in Zimbabwe has been shown to be price inelastic (Sukume, 1999). Cotton is exposed to the depredations of various insect species and to achieve acceptable yields Zimbabwe's smallholders have placed heavy reliance on chemical control of pests. Calendar-based spray strategies traditionally used for controlling cotton pests have been blamed for the emerging problems of pest resistance and the outbreak of secondary pests like the red spider mite (Meerman, 1991). More importantly, pesticide-related farmer health risks aggravate the problems of chemical dependent pest management strategies being used in Zimbabwe's agriculture

(Loewenson and Nhachi, 1996). The challenge is to provide alternative effective pest control with less use of toxic pesticides.

In addition to farm level constraints, economic reforms present new challenges for cotton growth in Zimbabwe. Like many other African countries, Zimbabwe adopted International Monetary Fund (IMF)/World Bank inspired Structural Adjustment Programs[2] (SAPs) in the 1990s following a major slow down in economic growth, lack of investment and operating losses of marketing boards. The common elements of the adjustment packages are reduction of trade barriers, elimination of subsidies and price controls, privatization of state owned firms, and realignment of foreign exchange regimes (Ajayi, 1994, UNRISD, 1994). A critical question is whether these reforms have delivered the expected agricultural growth pay-off. Several studies have observed that reform effects in Africa are mixed, and non-adjusting countries face sluggish markets, weak institutions and continued economic stagnation and decline (World Bank,1994 and 2001). Nonetheless, initial evidence from Zimbabwe's experience with SAPs provides important lessons for other countries going through the same cycle of reforms. There is relatively limited research on the evaluation of SAPs effect on agricultural supply response of large versus smallholder farmer groups in Africa.

A significant threat to post-independence agricultural production growth in Zimbabwe has been the civil war in Mozambique. Zimbabwe's economy suffered during the civil war in Mozambique that spilled over into southeast border areas. Transport costs from land locked Zimbabwe to seaports escalated during this period, while the local

[2]Stabilization (or macroeconomic adjustment) refers to a standard set of policies designed to manage balance of payment, inflation and the government budget deficit through elimination of subsidies, wage freeze, and restricted growth in government expenditure. Adjustment (or structural transformation) policies

people were displaced from their farms. Lost economic opportunities from armed conflicts and civil strife have not been seriously studied yet they fall disproportionately on the rural poor. Also, the recurrent drought at a rate of one in every five years has reversed gains in predominantly rain-fed smallholder agriculture. Understanding farm-level constraints, the impact of the policy setting especially SAPs, and the effects of the end of the war in neighboring Mozambique in engendering cotton supply response in Zimbabwe is a key focus area of our study.

1.2 Study Objectives and Thesis Organization

In view of the importance of agricultural sector for economic growth in SSA, governments need to determine policies best suited to stimulate agricultural production (Bond 1983). Crafting such policies requires a good understanding of the major barriers to cotton production in Africa that include pest infestation, farmer health risks and misguided policies that marginalize agriculture (Gilham, 1993, Kiss and Meerman, 1991; World Bank, 1995). These key threats to sustainable cotton production in Africa are discussed in three interrelated essays whose main objectives are to:

- Evaluate the pesticide-induced health risks associated with conventional pesticide application in cotton production in Zimbabwe.
- Determine the factors affecting IPM use among Zimbabwe's smallholder cotton farmers.
- Estimate supply response models for both large-scale commercial (LSC) and smallholder cotton growers.

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focus on removing restriction on and interference with the market. Adjustment policies have stabilization consequences and vice versa (Davies et al., 1988).

- Suggest policy guidelines for the future growth in Zimbabwe's cotton production.

Data to address the first two objectives of this study was collected from smallholders in Sanyati and Chipinge, two leading cotton regions in Zimbabwe. Sanyati is situated in the Middleveld and is a traditional cotton region being among the first in Zimbabwe where Farmer Field School (FFS) –based cotton Integrated Pest and Production Management (IPPM) extension efforts were introduced in 1996. Most of the district is located in natural region III suitable for semi-intensive cultivation and the mean annual rainfall is 650-800 mm. The Cotton Research Institute (CRI) conducts research trials in the rural areas and is located in Kadoma less than an hour's drive from Sanyati. Chipinge district is a relatively new frontier cotton zone. It is situated in Manicaland Province (Lowveld) and it falls under natural region IV suitable for semi-extensive to extensive farming with a mean annual rainfall range of 450-650mm (Central Statistical Office, 1989). Time series data used to address the third objective were obtained from the Ministry of Agriculture and Reserve Bank of Zimbabwe (RBZ) publications.

1.2.1 Farmer Health Risks in Smallholder Cotton Production in Africa

Farmers in Africa face a severe health threat from toxic chemicals currently used in cotton production (Loewenson, R and C.F.B. Nhachi, 1996). Of concern is the fact that local constituencies for the protection of public health are much less influential than in developed countries (Kiss and Meerman, 1991). An estimated 11 million cases of pesticide intoxications are reported to occur annually in Africa although the true extent of the problem might be underestimated due to poor data compilation and misdiagnosis of some of the cases (Jeyaratnam, 1990). Consensus is rapidly growing that health issues in Africa constitute a massive threat to development and have the potential to reverse gains made in agricultural growth (Binswanger and Townsend, 2000;World Bank, 2001). In the past, the health of poor farmers has been trivialized and rarely addressed seriously in many developing countries (Rengam, 1999). Previous effort to put economic gain ahead of farmer health does not make economic sense in the long run. Nonetheless, the health status of the cotton growers is a key ingredient to ensure the attainment of sustainable agriculture. Thus an analysis that identifies the sources of pesticide-related acute health risks and their extent and severity is beneficial to both farmers and policy makers.

The first essay, in Chapter 2 analyzes the health risks of pesticide use in Zimbabwe's smallholder cotton production. The essay uses cost of illness models and Poisson regression analysis to identify factors causing acute health costs and symptom incidences among smallholder cotton growers. Zimbabwe's smallholder cotton growers are often exposed to highly toxic chemicals when they mix, load and spray pesticides. Seminal work on farmer health and agricultural production was conducted in the Philippines and Ecuador (Antle and Pingali, 1994; Pingali et al., 1994, Crissman et al., 1994). In Africa, the empirical evidence in support of the link between pesticide use and farmer health is still patchy (Loewenson, R and C.F.B. Nhachi, 1996). The relatively low level of education and literacy rates in SSA makes the overall risks of pesticides exposure worrisome (Kiss and Meerman, 1991). The experience of Zimbabwe cotton growers in transition from calendar-based chemical control of pests to IPM use provides important lessons for SSA countries undergoing similar transformation. The study uses primary data from Chipinge and Sanyati districts in Zimbabwe. The data covered pesticide use patterns and farmer behavioral practices that contribute to health risks. Since pesticides pose human health risks, to do nothing and let the problem deteriorate into an epidemic that might induce a major exodus from cotton production would be naïve for policy makers and catastrophic for the cotton industry in Africa.

1.2.2 The Adoption of Integrated Pest Management (IPM) in Zimbabwe

Although IPM adoption is assumed to result in improved crop productivity, the circumstances surrounding its adoption in Africa are still unclear and require careful analysis. Elsewhere, the financial and health benefits of IPM use including its role in improving the long run sustainability of agricultural systems has been demonstrated (Norton and Mullen, 1994). Despite the fact that IPM could raise cotton yields significantly, very few farmers in Zimbabwe have adopted cotton IPM as most still rely on calendar-based spraying techniques. Inefficient pesticide use based on prophylactic spray strategies without regard to need increases pest resistance and thus limit the efficacy of most pesticides (Eisa, et al., 1993). Consequently, a wider range of pesticides in increasing amounts and strengths must be used to achieve the same level of plant protection. Further, some cotton pesticides destroy natural pest predators creating a "pesticide treadmill" which results in a steady increase in the cost of pest control and health hazards (Lipton and de Kadt, 1988). To resolve this crisis, current pest control strategies that rely on repeated applications of conventional broad-spectrum pesticides need to be modified. Therefore, Zimbabwe's cotton growers should move away from reliance on pesticides and encouraged to use IPM technology. A fundamental decision confronting cotton growers is the need to adopt effective and affordable pest management strategies yet the motivational factors are not well understood.

To articulate these issues, Chapter 3 analyzes the factors affecting the adoption of IPM in smallholder cotton production in Zimbabwe. Specifically, the study examines IPM-related practices used to control both cotton pests and disease under smallholder conditions. IPM use is operationally defined as a count of IPM related practices used in cotton pest management. This study is based on primary survey data collected in fall 1999 in Sanyati and Chipinge district. As in most cotton growing areas, insect pests are a major problem. The present study on Zimbabwe is among the first in Africa to use Poisson regression as previous studies have either used bivariate statistical analysis and ordinary least squares (OLS) thus leading to statistically undesirable results (Ramirezi and Shultz, 2000). Although IPM is a relatively new phenomenon in much of Africa, it represents an alternative way to stabilize yields, and reduce both pesticide use and readily avoidable health impacts. The magnitude of insect[3] damage under prophylactic spray techniques has been estimated to reduce cotton yields by up to 60% (Jowa, 1996). As a result, insect pest infestation has induced Zimbabwe's smallholder cotton yields to decline from 800kg/ha to 600kg/ha over the past two decades (Jowa, 1996). Knowledge generated by this study provides a basis for the diffusion of IPM among smallholders in Zimbabwe. The question about IPM use is not whether, but when and how the technology could be extended to all cotton growers at risk from exposure to toxic pesticides every year. A key issue though is that successful adoption of IPM requires a policy environment committed to its implementation (World Bank, 1997).

[3] The most damaging insect pests implicated in the cotton yield losses in Zimbabwe are the aphids *(aphis)*, red spider mite *(tetranychus)*, red bollworm *(diparopsis)*, heliothis bollworm *(helicorvepa)*, spiny bollworm *(earias)*, whitefly *(bemisia and trialeurodes)* and the stainers *(dysdercus)*, while verticillium wilt and

1.2.3 The Impact of Structural Adjustment Programs (SAPs) in African Agriculture

More than any other factor, SAPs in Africa have generally been undertaken as a response to fiscal crisis and declining agricultural growth. Since 1980, more than 30 African countries have implemented agricultural policy reforms as part of SAPs (Ajayi, 1994). Many advocates of these reforms have argued that SAPs will result in agriculture-led economic growth in Africa. The central question is have SAPs enhanced or undermined cotton growth in Africa? However, reform packages implemented in Africa, although they vary in content and sequence, provide a degree of considerably uncertainty and results have been mixed. The majority of the adjustment experiences considered "successful" is small in number relative to the total group of countries undergoing reforms (United Nations Research Institute for Social Development, 1994). There is an emerging consensus that future success requires closer attention to the impact of SAPs on agricultural production especially given that more than 70% of the 650 million Africans derive their livelihoods from agriculture (Economic Commission for Africa, 1991; World Bank, 1994).

In Zimbabwe, it is not well established whether SAPs impedes or enhance cotton production, the second major export crop. The contribution of macroeconomic factors has not been clearly studied either. Understanding the effect of SAPs in agricultural supply response would make an important difference to the design of structural adjustment packages (Rodrik, 1990). Further, objective analysis of SAP impacts on agricultural supply response will help us decide whether the pessimism (or optimism in some instances) associated with early generation of the policy reforms is legitimate (Bond,

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bacterial blight are among the common diseases (Gillham,1993; Kiss and Meerman, 1991; Zimbabwe Cotton Handbook, 1998).

1983). So far, there is no firm knowledge about the social impact of SAPs despite the fact that the issue has attracted a lot of attention since the mid-1980s (Azam, 1994).

In the third essay in Chapter 4, we contribute to this debate and analyze cotton supply response to SAPs, macroeconomic policies and exogenous shocks such as drought, and the return to peace in Mozambique. To articulate these issues, the analysis uses aggregate time series data from Zimbabwe focusing on the post-independence period, 1980 to 1996. The generally held view is that SAPs result in a positive impact on cotton production but the empirical evidence to refute or support such claims is scant. Also uninvestigated is the role of regional peace in engendering agricultural supply response. In this respect, we hypothesize that both peace in Mozambique and the reforms enhance cotton acreage expansion among the smallholders and LSC cotton growers. The essay uses autoregressive models to estimate acreage and yield response to macroeconomic policy changes. The main advantage of analyzing large and smallholder farmers separately is to capture equity implications emanating from SAPs and the fact that the growers respond differently to price changes.

The conclusions from the three essays, including lessons for other African countries and opportunities for further research are summarized in Chapter 5.

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CHAPTER 2

ECONOMIC AND HEALTH IMPACTS OF PESTICIDE USE IN ZIMBABWE'S SMALLHOLDER COTTON PRODUCTION

2.0 INTRODUCTION

The health hazards of using pesticides[4] are now globally acknowledged (Burrows, 1983; Fernandez-Cornejo, 1994; Jowa, 1995; van Emden and Peakall, 1996; World Wildlife Fund (WWF), 1998). This recognition has led to social decisions to restrict the use of certain pesticides and forced renewed efforts to promote alternative crop protection methods (Pincus et al., 1999; Sheets and Pimentel, 1979; WHO, 1990). Recently in Southern Africa, attention has been focused on the uptake of alternative approaches like Farmer Field School (FFS)-based Integrated Pest Management (IPM)[5] although its implications for farmer's health remains to be seen.

There are few studies that focus on health risks in agricultural production and yet in Africa, the human health problem is growing (World Bank, 2000; Hurley et al., 2000; Sunding and Zivin, 2000). Farmer health issues can no longer be downplayed while simply worrying about them will not solve the problem, much less understand it. Both economic research and studies conducted in the medical field corroborate that occupational health problems of the agricultural industry as whole have received scant attention (Watterson, 1988; Smith et al., 2000). However, there are good reasons to

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[4]Pesticides is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest and it includes insecticides, herbicides, fungicides, rodenticides etc. (EPA, 1999).

[5] IPM emphasizes natural pest control, host plant resistance, and using chemicals as a last resort. Unlike conventional control, pesticides recommended under IPM approaches target specific pests, are applied at lower rates and are less toxic to beneficial organisms. Therefore, IPM is considered a sustainable pest management practices that confers both health benefits and environmental safety.

expect improved health to result in improved functionality and productivity (Strauss et al., 1998). Using Philippines farm-level data Pingali and his collaborators conclude that pesticide use has a negative effect on farmer health, while farmer health has a positive effect on productivity (Antle and Pingali,1994; Rola and Pingali, 1993). Recent attempts to measure health costs of pesticide use have been made in Ecuador and the United States (Antle et al., 1998; Crissman et al., 1994; Sunding and Zivin, 2000). But the evidence from Africa is thin.

Some key questions remain unanswered: What are the main sources of health risks in smallholder agriculture in Africa? Do these risks threaten farmer livelihoods or the sustainability of cotton production in Africa? Are farmers fully aware of the health risks? What intervention strategies are required to minimize the risks? Many now believe that reduction of pesticides use should be the primary goal of IPM (Burrows, 1983; Pesticide Policy Project, 1999; Czapar et al., 1995; Jorge Fernandez-Cornejo, 1996; Ajayi, 1999). Nonetheless, the question whether cotton IPM confers any health benefits to smallholder pesticide users has not been systematically explored.

Nhachi and Loewenson (1996) looked narrowly at occupational health problems among commercial farm workers in Zimbabwe. No study has looked specifically at the health effects under smallholder farming context. In Africa, less work has been done to understand the important sources of occupational health risks for farmers. In West Africa, a survey on pesticide-related occupational health effects found that the social cost of acute poisoning in cotton is substantial (Ajayi, 1999; Fleischer, et al., 1998). However comprehensive analysis of the individual-specific acute effects is lacking in several countries in Sub-Saharan Africa.

The human health threat appears particularly evident in LDCs where environmental laws tend to be lax and farmers lack sufficient information about the products they apply (WHO, 1990; Chitemerere, 1996; Mbanga, 1996; Tjornhom et al., 1997; The Pesticide Trust (TPT), 1993). The risk of exposure is worsened by the farmer's inability to afford protective equipment and also the general lack of health insurance markets in most LDCs (Antle et al., 1994;World Bank, 2000). Although the problem is acknowledged, the extent of the health problems among farm workers in Africa remains unclear. Only a few African countries monitor health effects or keep statistics and information about pesticide poisonings (World Bank 1996; Rother and London, 1998). As a result, pesticide poisonings are grossly under-reported and under-notification is still a serious problem on the continent.

Cotton is vulnerable to a wide range of diverse insect pests[6] the control of which makes it one of the leading users of chemical pesticides. Although in general Africa uses relatively less pesticides than Asia and Latin America, pesticides are widely used in African cotton production. Most smallholders rely on pesticides as one of the efficient and effective ways to manage the diverse number of cotton insect pests. Such chemical crop protection strategies have been sustained by vertically integrated production systems and contract farming (Fleischer, 1999; World Bank, 1996).

Prolonged exposure to pesticides has been associated with several chronic and acute health illnesses like non-Hodgkin's lymphoma, leukemia, cardio-pulmonary disorders, neurological and hematological symptoms, and adverse skin effects. Some older

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[6] The cotton pests of economic significance in Zimbabwe are cotton bollworm, aphids, jassids, stainers, whitefly, and diseases such as wilt and bacterial blight. Pest-related yield losses in Africa have been estimated to range between 40 and 65 percent (Jowa, 1996; Zethner, 1995).

pesticides have been reported as causing parkinsonism, asthma, cancer, tumors, miscarriages, birth defects, still births, male sterility, genetic mutations and behavioral changes (Watterson, 1988; Moses, 1992; Fernandez-Cornejo, 1997; Yudelman, 1998; Cuyno, 1999). Impaired vigilance, reduced concentration, memory deficit, linguistic disturbances, allergies, hypertension, depression and repeated irritability are some of the frequently reported clusters of symptoms linked to pesticides exposure (TFECHLD, 1988). Chronic effects are particularly alarming in the light of new studies linking immune system suppression to some pesticides (Rengam, 1999; EPA, 2000).

When farmers take the health risks into consideration, the risk-reducing role of pesticides becomes less important than previously assumed. An increasing body of evidence suggests that the benefits of pesticides are obtained at a substantial cost to the society (Antle and Pingali, 1994; Antle et al., 1998; Cole et al., 1998; Pingali et al., 1995; Crissman and Cole, 1994; Pincus et al., 1999; Nhachi and Loewenson 1996; Watts, 1993; WWF, 1998; Czapar et al., 1998; WHO, 1990). The principal insight from these studies is the negative impact of pesticides on the health of farmers and farm workers, particularly in LDCs.

Global acute poisoning figures are quite alarming as the negative trends are fueled by the widespread use of more relatively toxic organophosphates and carbamates (Antle and Capalbo, 1994;WHO, 1990). Nonetheless, IPM was developed in the 1950s as a response to the negative side effects of using pesticides, but has not been in use in many African countries until only recently (Maumbe and Swinton, 2000). IPM use in LDCs can be enhanced by the development of institutions that simplify choices by making it more attractive and accessible to farmers (Zilberman and Castilo, 1994; van Emden and

Peakall, 1996). Little empirical evidence is actually available about the health benefits of IPM use (Antle and Capalbo, 1994).

Africa cannot afford to be left behind as the world shifts from broad-spectrum pesticides to IPM and highly selective, rapidly degradable, and environmentally safe products (Forney, 1999; Cartwright, et al., 1993; TPT, 1993; Jowa, 1995). Distorted policies that subsidize pesticide use worsen health hazards experienced in most African countries (Zethner, 1995; Fleischer, 1999). At the same time, poor access to health services and a medical profession who lacks the ability to recognize pesticide-related morbidity raises further concerns (TPT, 1993). Such policy shortcomings, information gaps and institutional rigidities create a bias towards pesticide-dependent paths of technological development (Pincus et al., 1999).

The potential health risks from pesticide exposure vary with the pesticide products, quantities, and application methods used. Since pesticides are not widely applied in Africa, their health effects have eluded attention. But pesticides are heavily applied to cotton, and their effects on humans deserve attention. This study examines the degree and determinants of acute pesticide health symptoms among Zimbabwe's smallholder cotton growers. The results are specific to Zimbabwe, but the analysis provides useful lessons for cotton growers in other African countries.

2.1 Objectives of the Study

The central focus of this paper is to analyze the pesticide-related health risks among smallholder cotton farmers in Zimbabwe. The study examines the extent of pesticide–induced acute health risks among cotton growers in two cotton-growing regions of Zimbabwe. The specific objectives the study addresses are to:

- Describe pesticide-induced farmer health impairments and pest management practices,
- Estimate a health cost function for smallholder cotton growers,
- Identify the determinants of incidences of acute farmer health risks,
- Determine pesticide-related farmer behavior that mitigates or averts the observed illnesses and,
- Propose policies that help reduce pesticide-related health risks.

We hypothesize that due to the problem of thermal discomfort in tropical agriculture, ownership of protective clothing does not lower farmer's health risks as available protective clothing are not worn. In terms of the impact of pesticide-related behavior, we hypothesize that contact with extension workers is negatively correlated with smallholder cotton farmer's health risks. Finally, we hypothesize that FFS-IPM graduates experience lower pesticide-induced health risks than non-IPM farmers, assuming that growers who are aware of IPM apply less pesticides which in turn lowers health risks.

2.2 Methodology and Data

2.2.1 Theoretical Model

In order to understand the benefits and costs pesticides impose on society, we need to assess social costs and benefits as well as the private ones. The social costs of pesticides include pesticide residue monitoring, exposure to pesticide drift, and contact with freshly sprayed foliage by non-applicators, health care facilities and clean up programs. Due to limited information and methodological flaws, the costs of externalities caused by pesticides and the implied mitigation costs have not been adequately accounted for, resulting in a tendency to over-estimate net benefits of pesticides use (Pincus et al., 1999). Over-estimation of pesticide net benefits has led to benefit assessment of pesticides based on social welfare theory (Waibel, 1999). This requires placing a value on the adverse health effects associated with pesticide use (Cropper, 1994). Including health in farmer's utility function tends to reduce demand for harmful divisible production inputs (Swinton, 1998). Consider first a single farm household, with one adult member, the farmer who aims to maximize profit with respect to pesticide use. For simplicity, we assume perfect information regarding positive and negative externalities of pesticide use. The farmer derives utility from his or her level of health $\boldsymbol{H}$, and consumption goods $\boldsymbol{G}$ obtained from marketed cash crop output $\boldsymbol{Y}$, such that:

$$(1)\ U=U(H,Y,G)$$

We assume that the utility function is concave and increasing in consumption goods $\boldsymbol{G}$, marketed output $\boldsymbol{Y}$ and health status $\boldsymbol{H}$. The level of health of the pesticide applicator is represented by a health function (Cole et al., 1998, Strauss et al., 1998, Pitt et al.,1986 and Hurley et al., 2000):

$$(2)\ H=f((X^P, E(X^P,A)), M^P, h, \mu)$$

Where $\boldsymbol{H}$ represents a measure of health status or outcomes that depends on personal characteristics that impact health such as age, gender, use of alcohol and smoking; exposure to pesticides X^P and pesticide exposure averting behavior $E(X^P, A)$. Exposure mitigating strategies M^P, that includes human capital variables such as IPM knowledge, are assumed to improve health via judicious use of pesticides. Similarly, a farmer's knowledge of basic first aid[7] is assumed to mitigate pesticide–induced health risks. We

[7] First aid is the initial effort designed to save the life of a worker exposed to pesticide poisoning while medical help is on the way or in worst cases is unavailable.

further assume that farmer's health status is influenced by institutional factors such as access to local public health infrastructure or health services $\boldsymbol{h}$, whose price is W_h and μ is an individual specific health (genetic or hereditary) endowment. Assume that $(\delta H/\delta X^p)<0$, $(\delta H/\delta E(X^p, A)) >0$, $(\delta H/\delta M^p) >0$, and $(\delta H/\delta h)>0$. The farm output production function is unconventional as it also captures how farmer's health and risk perception may affect production; that is,

$$(3)\ Y=\Gamma(X^P, X^0, L(H_i L^o), P, Z)$$

where Y is cotton output, X^p represents variable pesticide inputs, X^0 is non-pesticide inputs, L refers to household head's effective field labor, P is a vector of output price and Z is conditioning variables such as age, gender, educational levels and risk perception. Farmer's health status affects the number of healthy man-days and the total time available for leisure and work. Therefore, effective labor input or management is a function of available work hours or man-days L^o and also worker's functionality which depends on individual health status (H_i) so that $L=f(H_i, L^o)$ (Antle et al., 1994; Strauss et al., 1998). Assuming that the smallholder farmer operates in perfect competitive conditions, the household's utility is maximized subject to constraints of budget, safe minimum health and environmental standard. Letting P denote product Y's price, W_g and W_h are prices of household consumption goods G and health services h. W_p and W_0 is the price vector of inputs X^p and X^0 respectively. In addition, W_a and W_m refer to the price of exposure averting and mitigating inputs A and M^p respectively. H_m and EQ_m is the minimum acceptable health level of the farmer and environmental conditions respectively. The resulting extended profit function is given by:

$\pi(P, X, G, A, M^P) = PY - W_p X^P - W_0 X^0 - W_a A - W_m M^P - W_g G - W_h h$. The utility maximizing first order conditions are obtained from the optimization of a constrained function represented below;

$$(4)\ Max_{(y)(x)(g)(a)}\ U(Y, G, H)$$

$$s.t.\quad (i)\ pY(L, X^0; X^P; A; M^P) - W_p X^P - W_0 X^0 - W_a A - W_m M^P - W_g G - W_h h \geq 0$$

$$(ii)\ H_M \leq = f(X^P, E(X^P, A), M^P, W_h, \mu).$$

$$(iii)\ EQ_M \geq E_0(X^{PD}, X^{PT}, X^{PS}, \mu)$$

In constraint *(iii)* minimum environmental quality EQ_M, X^{PD}, X^{PT} and X^{PS} refer to pesticide disposal, toxicity and storage hazards. We did not collect environmental data of sufficient variability to warrant the analysis of this constraint as our focus is on farmer health. When health costs are considered, optimal levels of pesticide use will solve:

$$(5)\ P(\partial Y / \partial X^P) = W_p - W_h[(\partial U/\partial H)(\partial H/\partial X)] / [(\partial U/\partial H)(\partial H/\partial h)]$$

The second term on the RHS of equation (5) is a money-metric of the marginal utility loss from pesticide-related health damage. Since it is greater than zero, the result implies reduced optimal pesticide use (Appendix 1). In practice, the exact determination of the socially optimal level of pesticide use may not always be feasible due to uncertainty regarding the magnitude of pesticide effects and lack of reliable data (Oskam, 1994 cited in Fleischer, 1999).

2.2.2 Data Sources and Sampling Strategies

Farm level data were obtained from a primary survey conducted from June to December, 1999 in two leading cotton-producing regions of Zimbabwe. Due to differences in dialects we pre-tested the questionnaire in each region resulting in modifications of wording, and sequence of the questions. In Sanyati district, located in the Middleveld (altitude 600-1200m), clusters of villages with exposure to Farmer Field School Integrated Pest and Production Management [FFS-IPPM] training were first identified. Next, we stratified on the basis of farmer participation or non-participation in FFS-IPPM. The sampled IPM and non-IPM farmers were randomly drawn from within the same villages. In the Chipinge district, located in the South-eastern Lowveld of Zimbabwe (altitude 300-600m) no FFS-IPPM program was available for rain-fed cotton production. Clusters were determined on the basis of relative distance from markets and farm sizes. Chipinge district lies in the Lowveld of Zimbabwe (altitude 300-600m).

Primary data were gathered on field pest management practices and farmer health status. Health variables included incidences, treatments and degree of severity of pesticide-related acute illnesses. Pest management data were collected on type of pesticide used by target insect, number of applications made in each cotton field, as well as cotton pesticide storage and disposal practices. Usable responses were obtained from a total of 280 growers. The main incentive for participating in the survey was the certificate of participation awarded to farmers who completed the interview. All farmers gave informed consent prior to the interview.

Data used to estimate the empirical cost of illness models are grouped into the following categories, (1) farmer characteristics, (2) health-related factors and (3) institutional variables. Farmer characteristics include age, education and gender. Health variables included the incidence and severity of pesticide skin, eye, and stomach poisoning acute symptoms, as well as personal habits like smoking and alcohol intake.

Institutional variables include access to a borehole for drinking water and health center for treatment.

2.2.3 Empirical Model: Estimation of the Health Cost of Pesticide Exposure

The empirical analysis is in three stages [Figure 2.1]. The first stage involves the estimation of a cost of illness model for smallholder cotton growers in the two districts. In the second stage, we estimate Poisson illness incidence models in order to help us understand the determinants of the specific acute illness episodes experienced by the pesticide applicators. The final stage uses probit analysis of the significant pest management and farmer behavioral practices driving the observed incidences.

Empirical variables that influence health outcomes come in two different specifications, continuous and dichotomous variables. For continuous variables like number of specific acute symptom type ***ACUTESYM***, severity of acute symptom episodes ***ACUTINDX***, alcohol use and smoking duration, that also take zero variables we added 0.1 factor in all cases to account for the problem of taking logarithm of zeros and to distinguish responses with the value zero from positive non-zero responses. We specify the health cost function simply as $HC=f(SYM, DSS, C, W_k)$ where previously undefined ***SYM*** is the sum of pesticide-induced acute symptom types experienced by the farmer which takes the range 0 to 3, ***DSS*** sums the degree of severity[8] of acute symptoms and **C** is a vector of farmer characteristics. The general form of the health cost model estimated is given by:

Health cost =f (Acute symptoms, farmer characteristics, institutional factors) + e

[8] Acute symptom severity is defined on a monotonic scale of 0 to 3 with 0=absence of symptom, 1=mild, 2=severe and 3= very severe.

An individual farmer's health cost is calculated as a sum of both cash and non-cash costs. The health cost variable is a composite of (1) farmer treatment costs per visit either to the clinic or local private physician, (2) annual levy of Z$100 contributed to the local rural health facility and (3) opportunity cost of lost time due to days farmer was ill and recuperating. We used the 1998/99 agricultural minimum wage of Z$1,400 per month or Z$38.00 per day for costing lost days due to illness. Missing in the composite value of health cost variable are individual patient's travel cost to the nearest health facility, waiting time costs prior to treatment, cost of leisure forgone due to illness and the cost of home-based health care. We did not collect data on the cost of traditional healing strategies because farmers are generally reluctant to volunteer such information. We assume health costs of pesticide exposure to hired labor are borne by the hired workers themselves (Antle and Capalbo, 1994). The rationale for using the logarithmic functional form is that it is parsimonious in parameters, can be interpreted as first order approximation to the true cost function, and is globally well behaved (Antle and Pingali, 1994).

$$(5)\ Ln(HC) = \delta_0 + \delta_1 Ln\,(AGE) + \delta_2 Ln\,(EDUCATION) + \delta_3 Ln\,(ACUTE\ SYMPTOMS) + \delta_4 Ln(ACUTE\ SYMPTOM\ SEVERITY) + \delta_5 Ln(ALCOHOL) + \delta_6 Ln(SMOKE) + \delta_7 Ln(HEALTH\ CENTER\ DISTANCE) + \delta_8 (GENDER) + \delta_9 (FIRST\ AID) + \delta_{10} (BOREHOLE) + e$$

The dependent variable is the logarithm of an individual farmer's aggregate health costs (HC) measured in Zimbabwe dollars. The exogenous variables are defined in Table 2.1.

We decided to assess the relative health impact of pesticides on the basis of toxicity ranking as defined by the Plant Protection Research Institute in collaboration with the Zimbabwe Hazardous Substance and Articles Control Board. Four pesticide hazard classes are distinguished by their color codes: green, amber, red, and purple, in rising order of toxicity. Survey farmers did not use any green label pesticides, so our analysis uses only three pesticide classes. Color codes are assigned based on three criteria, (1) acute oral lethal dose (LD_{50})[9] of the pesticide, (2) the concentration of the formulation and (3) the persistence of the pesticide in the ecosystem (Nhachi, 1999). We focused on acute effects since these are health problems that occur very close to the time when one is exposed to the pesticides (Moses, 1992). We measure pesticide exposure as a product of the active ingredients per application and the number of chemical applications made (Honsby et al., 1996; EPA, 1999).

Acute symptom incidences are estimated as a Poisson regression model specified as $E(Y_i) = (\beta\chi_i)+\nu \quad (i=1,...n)$ where $E(Y_i)$ is the expected value of the dependent variable of the i^{th} observation, ν is stochastic error term, β is a **1* k** vector of parameters, X_i is a **k*1** vector with the values of the **k** independent variables in the i^{th} observation, and n is the sample size. The elasticity estimate at X_j, a continuous independent variable is given by $(\partial E(Y_i)/\partial X_{ji})(X_{ji}/E(Y_i)) = \beta_j X_{ji}$. Now, assuming that X_j is dichotomous, the percentage change on $E(Y)$ when X_j changes from 0 to 1 is given by $100(exp^{(\beta\chi_i)}-1)$ a different relative impact on the dependent variable (Ramirez and Shultz, 2000). The estimated empirical Poisson regression model for the specific and multiple symptom incidences is stated below:

(6) $SINCID= \lambda(C, M, X^p, A, M^p, I) + \mu$ where ***SINCID*** is a positive integer count of the number of self-reported pesticide caused acute symptom episodes or incidences

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[9] Oral LD_{50} refers to the orally ingested dose (mg of toxicant/kg of body weight) of a pesticide which kills 50 percent of the test population animals. Similarly, the dermal LD_{50} is the dose of a pesticide applied to the skin which kills 50 percent of the test population animals (The Pesticide Manual, 1997).

experienced by the farmer. C is a vector of farmer characteristics as already mentioned above, M refers to farm management variables, exposure to pesticides X^P dosage used on the farm, and A is a vector of pesticide averting behavior among farmers such as use of protective clothing. M^P refers to pesticide mitigating strategies, and I is institutional variables affecting farmer health such as relative location to a health care facility.
A full description of the variables used to estimate the model is presented in Table 2.1.

2.3 RESULTS AND DISCUSSION

Results show that pesticide use in smallholder cotton production is associated with adverse health consequences for the poor farmers. The illness spectrum associated with pesticides exposure varies from acute, systemic to chronic effects (Appendix table A1.1). In 1998/99 season, the estimated average cost of pesticide-related health risks is Z$180 and Z$316 for Sanyati and Chipinge districts respectively. The costs represent 45% and 83% of the household seasonal total chemical outlay in Sanyati and Chipinge respectively. The health costs are attributed to the pesticide applicators and we infer that costs are much higher per household when we take into consideration other members of the household who are potentially exposed. Factoring in these unrecognized costs reduces the net benefits of pesticides among growers.

Farmer illness imposes a significant constraint to achieving higher net returns in agriculture (Ruttan, 2001). During the season, farmers lose an average of about 4 and 10 days recuperating from pesticide-induced illnesses in Sanyati and Chipinge respectively. Although the average distance to the nearest health facility is 5km in Sanyati and 9km in Chipinge district, the proportion of farmers who visited the clinic to seek medical attention after acute pesticide poisoning or irritation was very low, about 3% in Sanyati and 7% in Chipinge. Use of home-based mitigating strategies and religious beliefs that encourage the use of prayer to end health ailments partly explain why farmers do not often seek medical assistance from health facilities in the study zones. The study focused mainly on acute effects of pesticides such as skin and eye irritations, and stomach poisoning. However, between 40% and 50% of households in Sanyati and Chipinge respectively have at least one family member suffering from chronic illness. Our assessment was limited to cancer, blindness, back problems, and asthma or lung problems.

The predominant route of exposure of pesticide use in the survey areas was through the skin and eyes. More than half of the applicators in Sanyati (67%) reported skin irritations compared to 55% from Chipinge. The proportion of farmers reporting eye irritations was also higher in Sanyati (38%) than Chipinge (26%). Only 7% and 12% of the farmers in Sanyati and Chipinge reported having experienced stomach poisoning after spraying[10] respectively. We did not ask the farmers to indicate the specific chemicals responsible for the reported acute symptoms. However, in both districts, male farmers are the major risk group as they are responsible for most of the spraying. The descriptive statistics for the main variables used in our analysis are summarized in Table 2.1.

2.3.1 Farmer Health Cost of Pesticide Use: Cost of Illness Model Results

The number and severity of acute pesticide symptoms are the main determinants of the cost of farm household illnesses. The elasticity of health costs with respect to positive symptoms is 0.16 and 0.29 in Sanyati and Chipinge respectively. The results clearly

[10] The dominant chemicals used by farmers are monocroptophos, larvin, carbaryl, dimethoate and fenvalerate. Among these, the most commonly implicated chemicals in stomach poisonings and skin irritations are the organophosphates (e.g. monocrotophos and dimethoate) and carbamates (e.g. carbaryl

suggest that Chipinge cotton growers experience greater health costs than their Sanyati counterparts. In addition, the elasticity of health cost with respect to symptom severity is 0.11 in Chipinge and 0.09 in Sanyati, reinforcing the fact that Chipinge farmers could be facing higher risk of pesticide exposure costs compared to Sanyati. Health conditioning variables such as alcohol intake and smoking habits were also assessed to see their effect on health costs in both regions. In Sanyati, the coefficient for smoking is statistically significant at 10% and its positive sign indicates that farmers who smoke incur relatively higher pesticide-related health costs. None of the health conditioning variables are significant in the Chipinge cost-of-illness model.

2.3.2 Evidence of Health Impairments Among the Cotton Growers

Given the critical contribution of pesticide-related acute symptoms to health costs, the second stage analysis investigated determinants of these symptoms. Poisson regression models were used to relate the incidences of self-reported acute symptoms to farmer characteristics, farm management variables, health, pesticide exposure, exposure averting and mitigating, institutional and perception variables.

2.3.2.1 Incidence of Skin Effects

In Sanyati, skin irritation incidences are positively associated with the use of a knapsack sprayer, and calendar-based prophylactic spraying (Table 2.3). The use of a knapsack sprayer is positive and significant at all conventional levels while the prophylactic spray approach is also positive but significant at 5% level. This means that

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and larvin) (TFECHLD, 1988; WHO, 1990; Cole et al., 1998).

greater skin incidences are associated with calendar-based spraying. Also, the positive significant coefficient for the knapsack sprayer implies that farmers using a knapsack sprayer obtain higher incidences of skin irritations. In Chipinge, the coefficient for knapsack is significant but negative, perhaps because most Chipinge farmers use ultra-low volume (ULV) sprayers.

The coefficient on the use of leaking sprayers is statistically significant at 1% level and 10% level in Chipinge and Sanyati district. Results suggest that use of defective sprayers explain the occurrence of positive skin incidences in the cotton regions. A significant proportion of farmers in Sanyati (39%) and Chipinge (34%) reported that sprayers leak on their back when they apply chemicals. The high risk of pesticide exposure attributed to leaking sprayers implies the prevalence of poor maintanance procedures or lack of local expertise for sprayer maintanance. In addition, hazardous storage of pesticides in Chipinge is positive and significant at 1% level implying the critical role of unsafe storage practices in determining the presence of positive skin incidences. Farmers who keep pesticides in the same huts used for cooking and or sleeping are more predisposed to have skin irritations than ones who keep pesticides locked in a separate store-room elsewhere.

In Chipinge, the incidence of skin problems is positively associated with the use of both "purple" and "red" pesticides. The "red" and "purple" pesticides comprise mostly the organophosphates and organochlorines that are known to cause skin irritation problems when spray men do not use protective clothing. None of the pesticide dosage variables were significant determinants of skin incidence in Sanyati.

The coefficient for attendance at extension meetings was positively significant at 1% level in both Sanyati and Chipinge. This implies that farmers attending extension meetings reported more incidences of pesticide-related skin irritations. This raises the question of the health content of the extension messages directed at the farmers. It is possible that farmers' participation in extension meetings makes them aware that pesticides can cause skin irritation. But it also appears that extension contact does not significantly improve their knowledge of how to prevent skin irritations.

Among the farmer characteristics, formal education and farmer's age have a positive and significant effect on self-reported skin incidences in Chipinge while in Sanyati, age was highly significant with a negative coefficient. The evidence from Chipinge suggests that older and more educated farmers tended to report more positive incidences of skin incidences. However, in Sanyati older farmers are less likely to report skin irritation problems. This result probably reflects the fact that older farmers are more experienced with chemical handling and application than their younger counterparts.

Alcohol consumption and cotton area cultivated are both positively related with skin irritations in Sanyati at the 10% level of significance. Alcohol affects judgment about use of safety precautions when farmer is exposed to pesticides.

The coefficient on farmer's use of protective clothing was statistically significant at 1% with a negative sign in both districts. The negative sign suggests that there is a significant reduction in dermal contamination when farmers spray with the necessary protective clothing. This was however contrary to our hypothesis that because of the weather-related discomforts, smallholders do not effectively use their protective clothing resulting in greater health risks .The evidence clearly shows that those who wear protective clothing are able to significantly reduce their pesticide exposure.

The perception variable on reforming calendar-based spray was negative and significant at 5% and 1% in Chipinge and Sanyati respectively; that result is consistent with our expectations. Although label illiteracy coefficient for Sanyati was insignficant, in Chipinge, it was negative and highly significant at 1%, contrary to our expectations. We expect poor literacy to be associated with inability to follow instructions for safe use of pesticides leading to greater exposure risks in terms of higher positive symptom incidences. A possible explanation for the reason why illiterate Chipinge farmers reported less skin incidences could be attributed to the problem of lack of hazard awareness. It is possible some illiterate farmers may notice skin sensations but fail to make the link that their symptoms are a function of their exposure to pesticides thus resulting in more illiterate farmers reporting less pesticide caused skin incidences. Similarly, negative correlation between skin effects and formal employment in Chipinge can be explained by the fact that farmers with full-time jobs are farming part-time and may not spray chemicals as frequently as their full-time counterparts. Also, the part-time farmers may suffer from the same hazard awareness problem explained above, leading to less reported cases of skin irritation incidences. The coefficient for formal employment in Sanyati was insignificant.

2.3.2.2 Incidence of Eye Effects

Results from Sanyati show that incidence of eye symptoms increases with the use of a knapsack sprayer, calendar-based spraying and alcohol intake (Table 2.4). In contrast, eye incidences in Chipinge were positively associated with farmer's age, cotton area cultivated, formal employment, smoking and amber pesticides. In Sanyati, farmer's age is statistically significant at 5% level with a negative sign. The result suggests that older farmers are less likely to experience eye irritation incidences than their younger counterparts; a fact we attribute to greater experience with pesticide use or a higher risk averse behavior. In Chipinge, the habit of smoking is positively associated with eye incidences at 10% level while alcohol consumption had a negative but highly significant effect on reported eye incidences. The effect of alcohol is contrary to theoretical expectations. The result may indicate that alcohol consumption interferes with farmer's capacity to recall or recognize health hazard of pesticides thus allowing drinkers to report less eye incidences, when the opposite was expected. In Sanyati, alcohol consumption had a significant positive influence on reported eye symptoms while the effect of smoking was insignificant.

Exposure to cotton IPM training among Sanyati growers has an unexpected positive significant effect on eye symptoms. This could be attributed to greater awareness of pesticide-caused eye symptoms among IPM graduates. Farmers' use of protective clothing and first aid knowledge are negatively associated with reported eye incidences in Sanyati and Chipinge respectively. Use of protective clothing in Sanyati is significant at the 1% level suggesting that these farmers effectively use eyeglasses, and or facemasks when spraying pesticides. Protective clothing use in Chipinge has the expected negative sign but is insignificant.

The coefficient on the need to review weekly spray approach is negative and significant at all conventional levels in Sanyati. We interpret this result to mean that cotton growers who hold the perception that there is a need to reform the calendar-based preventative spraying technique are less likely to report eye incidences because they are more likely to rely less on chemical pest management strategies. The coefficient for the perception variable was insignificant in Chipinge district. The foregoing section analyzed the relative impact of different factors on specific pesticide-induced illness. However, since farmers may be exposed to multiple illnesses at the same time, we address this issue in the next stage of our analysis.

2.3.3 Multiple Health Impairments: Total Symptom Incidence Model Results

The Poisson total symptom incidence model results presented in Table 2.5 shows that pesticide-related acute symptoms in Sanyati are significantly associated with dosage of the most toxic pesticides, male farmers, larger farm sizes, and extension meetings attended. The practice of taking meals in cotton fields where there are no washing facilities is positively and significantly correlated with positive acute symptoms at 5% level. In addition, after combining the acute symptoms, label illiteracy contributes significantly to positive acute symptom incidences among the cotton growers in Sanyati. This result suggests that a higher risk of pesticide exposure confronts cotton growers who are either partially or completely label illiterate. Likewise, recent evidence from Cambodia indicates negative correlation between adult education levels and probability of illness (Deolalikar and Laxminarayan, 2000). The aggregate incidence model also shows that farmer's age, protective clothing, radio ownership, and first aid knowledge are all significantly associated with reduced occurrence of acute pesticide symptoms in Sanyati. Clearly, first aid knowledge and protective clothing have theoretically consistent results as they are predicted to play a mitigating and averting role in pesticide-induced ailments respectively. Further, farmers who hold the view that calendar-based spraying ought to be reformed are less likely to experience acute symptoms in Sanyati and that is consistent with our expectations. Exposure to IPM training had the hypothesized negative sign, but was not significant. The evidence is therefore insufficient to prove that IPM training can significantly lower the incidence of pesticide-induced multiple health impairments in Sanyati. Empirical evidence on the health benefits of IPM on pesticide use is still mixed. Studies on IPM in Vietnam and West Africa showed that farmers practicing IPM have substantially lowered occupational health risks (Kenmore, 1997). Some evidence of reduced average human toxicity with insect IPM adoption has been cited in the literature (Fernandez-Cornejo, 1997). Nonetheless, evidence emerging from Zimbabwe reveals that pesticide-related health risks do not significantly determine farmer adoption of IPM practices (Maumbe and Swinton, 2000).

In Chipinge, the total incidence model results show that the coefficients for leaking sprayer, formal education and extension meetings are positive and statistically significant at 1% level. The results suggest that sprayer malfunction contributes to greater incidences of acute dermal symptoms among cotton growers in the Lowveld area. The positive effect of extension and formal education on symptom incidences is unexpected. Such a perplexing outcome could be attributed to the 'chemical solutions' that are generally proposed by traditional extension workers. The results suggest that the specific nature of health education needed to limit pesticide exposure is potentially missing in extension messages. That traditional extension services lack a health focus and need revitalization has been mooted in the literature (Sasakawa-Global 2000, 1999; Fleischer, 1999). It is also possible that farmers who attend extension meetings are more aware of the health risks of pesticides and were more likely to report such incidences during the survey. Male pesticide applicators and cotton area treated with pesticides positively influence the number of reported acute symptom incidences, all are significant at 5% level. The total incidences of acute symptoms are positively related to "red" pesticides. The need to reform the calendar based-preventative spray technique, credit use, formal employment, knapsack sprayers, and first aid knowledge all contribute to less acute symptom incidences in Chipinge. In addition, the incidence of acute symptoms is significant and negatively related to "amber" pesticide classes in Chipinge suggesting the possibility that this class comprises mostly safer chemicals. We did not expect a negative effect as any exposure to pesticides is likely to cause acute poisoning among unprotected cotton growers. Since pesticide use is a function of farmer behavior and choice, in the next section we provide an analysis of the factors driving some of the pesticide management behavior that is likely to endanger farmer's health.

2.3.4 Poisson Protective Clothing Model Regression Results

In order to understand why farmers engaged in practices that mitigated and averted pesticide symptoms, the third stage of the analysis looked at determinants of these behavioral practices. Pesticide averting behavior involved wearing protective clothing while spraying. The number of protective clothing items owned by the farmer consistently reduced pesticide-related health symptoms in both Sanyati and Chipinge. To understand the individual decision maker's choice of using protective clothing, we conduct a Poisson regression analysis of the count of individual protective clothing items adopted by the farmers in the two districts.

Evidence from Sanyati reveals that farmers who attend a greater number of extension meetings are likely to use protective clothing when making pesticide treatments

(Table 2.6). Attendance at extension meetings was significant at the 10% level. Ownership of knapsack sprayers is positively associated with the use of protective clothing at the 5% level of significance. The coefficient for IPM awareness was positive and significant at 10% implying that farmers who were exposed to FFS-IPM training are likely to have more protective clothing equipment. The predicted value for skin illness episodes was negative and significantly associated with the use of protective clothing, and this is theoretically consistent as the likelihood of skin incidence is bound to decrease with increased use of protective clothing. The highly significant but negative effect of age was unexpected. The coefficient for label illiteracy had the correct sign but was not significantly different from zero.

In Chipinge, protective clothing ownership was positive and significantly associated with attendance at extension meetings, educational attainment, and use of the relatively toxic red pesticide category. These results suggests that better informed individuals are more likely to wear protective clothing when handling and applying pesticides and the use of "red class" pesticides appears to instill the same discipline. The predicted skin illness incidences are significant and negatively associated with the use of protective clothing at all conventional levels. This suggests that Chipinge farmers generally perceive that pesticide-induced skin-related health risks decrease with greater use of protective clothing equipment. Alcohol intake and the ownership of knapsack sprayers are negatively associated with use of protective clothing at 10% and 5% level of significance respectively. Meanwhile formal employment and label illiteracy are both highly significant and negatively associated with protective clothing use in the Lowveld. This suggests that farmers who engage in off-farm employment and thus grow cotton on a part-time basis are less likely to invest in protective clothing equipment. The evidence also shows that those farmers who exhibit higher levels of pesticide label illiteracy are more likely to make pesticide treatments with inadequate protective clothing equipment.

Apart from risk averting behavior, pesticide exposure is also affected by explicitly risky behavior such as taking meals in cotton fields and using leaky sprayers. Risky behavior such as taking meals in cotton fields is associated with smoking and label illiteracy in Sanyati and Chipinge respectively (Table 2.7). Formal education, extension contact, qualified master farmers, and protective clothing use were negatively associated with eating in cotton fields. Use of leaky sprayers is explained by among others larger farm sizes and prophylactic spray strategies, while exposure to IPM training appears to reduce the use of leaky sprayers in Sanyati (Table 2.8).

Finally, pesticide symptoms are also affected by the ability to treat symptoms. Knowledge of first aid was enhanced by farmer's education and cotton area cultivated (Chipinge) and formal employment (Sanyati) (Table 2.9). As expected, knowledge of first aid was negatively associated with exposure variables such as taking meals in cotton fields and label illiteracy.

2.4 Conclusions

Balancing the numerous benefits that may accrue from pesticide use in cotton production, farmers face adverse health risks. Looking at the cost of illness model results for both regions, the conclusion one comes to is that pesticide-induced acute symptoms significantly influence smallholder farmer health risk costs. Cotton growers lose a mean of Z$180 in Sanyati and Z$316 per year in Chipinge on pesticide-related direct and indirect acute health effects. Pesticide-related health costs average 45% and 83% of the household annual pesticide budget in Sanayati and Chipinge respectively. The average number of days spent recuperating from illnesses attributed to pesticides varies from 4 days in Sanyati to 10 days in Chipinge in 1998/99 growing season.

Exposure variables that are significant in predicting acute symptom incidences among cotton growers in the study zones are the use of toxic pesticides, leaking sprayers, unsafe pesticide storage, pesticide label illiteracy and taking meals in cotton fields. Also, personal habits like smoking and alcohol consumption confound farmer health risks in the cotton growing regions of Zimbabwe. In contrast, practices that effectively reduces health risks in the study zones are the use of protective clothing, knowledge of first aid and a disposition towards reforming calendar-based spraying strategies.

The need for farmer education in exposure averting strategies is evident particularly in the new cotton region of Chipinge. Since farmers in Chipinge face relatively greater exposure to pesticide risks, targeting farmers in the new regions will contribute most to minimizing the health risks. Evidence from the traditional cotton producing zone of Sanyati suggests that farmer's participation in FFS-based IPM training does not significantly reduce the incidence of acute symptoms, contrary to our expectation. However, the IPM awareness variable positively influences the farmer's decision to adopt protective clothing for making pesticide treatments. The mixed results on IPM impact could be attributed to the fact that IPM use is still in its infancy in Sanyati district where it was introduced in 1997, two years prior to our survey.

Although the pesticide label provides information on pesticide hazard categories, it is ineffective for the many farmers who are illiterate. Nor has the use of color codes helped much as revealed by the inability of 28% in Sanyati and 58% in Chipinge to associate colored triangles to pesticide toxicity. Ignorance about pesticide toxicity prevalent among survey farmers ought to be seriously addressed by policy makers. Perhaps the use of local languages on labels for pesticides targeted to small farmers and educational campaigns about the dangers of pesticides could alleviate the situation.

A very small proportion of cotton growers in both regions reported that pesticide-related health problems resulted in a visit to seek medical attention to a local health facility. The evidence seems to suggest that some smallholders treat acute pesticide effects as minor side effects that do not warrant medical attention (Flesicher, 1999). The minimal access to formal health care services further suggests reliance on informal health care system and or adherence to religious values that discourage seeking treatment for any ailments. In addition, our study seems to corroborate the fact that due to poor reporting systems, formal health sector statistics under-reports pesticide-induced acute symptoms, as most cases do not seek medical care (Chitemerere, 1996; Rother and London, 1998; WHO, 1990).

An important result of our empirical analysis is that access to extension is positively significantly correlated with incidences of acute symptoms. This raises questions about the health content of the extension message. Alternatively, and perhaps more fundamental, is the question of who attends the meetings and whether safety information from extension agents filters directly to the pesticide applicators. Nonetheless, the evidence implies the need to effectively utilize traditional extension services for the delivery of pesticide-related farmer health and safety information. This is important given that lack of contact with the formal health system may perpetuate farmer's ignorance about pesticide-related health risks. Therefore, a firm commitment to utilize existing extension networks and rural pesticide vendors for the delivery of health and safety information could heighten farmer awareness and decrease pesticide-related health risks.

2.4.1 Policy Options and Knowledge Gaps

In Zimbabwe, much effort is currently devoted to promoting new strategies like FFS-based IPM techniques. While IPM allows for judicious use, what is lacking is an in-depth study to provide essential information on rational use of pesticides. A clear policy implication of these findings is that farmers would be healthier if less toxic pesticides are used in cotton production because they cause significant health problems for the farmers. However, a policy to phase out or reduce the use of the risky "purple" and "red" pesticides without identifying safer substitutes could be short sighted for Zimbabwe. It is also possible that toxic pesticides may not be the only problem but also the way they are handled or both.

The health risks of pesticide use can be reduced by effective regulatory systems that could aid in increasing on-farm human safety. Some important areas for intervention include expanding farmer first aid education, eliminating the risk of taking meals in cotton fields, improvements in sprayer maintanance, and promoting the safe use of protective clothing. Cotton growers face serious knowledge constraints and on-farm safety policy should enhance farmer awareness of the link between pesticide hazards, human health and on-farm pesticide management practices.

Educational policy that targets labeling policy reform is needed in order to improve farmer's hazard awareness so they can in turn make more informed choices about cotton pesticides and required protective clothing. Without label reforms, pesticide choices will continue to be distorted and thus endanger farmers' health. Widespread label illiteracy particularly in Chipinge is associated with difficulty in interpreting pictorial safety labels. Given the existing pesticide dependency in smallholder cotton production, policy failure to improve farmer health and safety will result in ruined agriculture and human livelihoods.

Future research work should attempt to measure health costs to all the individuals exposed to pesticides including children and hired workers. Self-reported health conditions due to pesticide exposure leads to problems of bias and endogeneity. Future attempts to increase the accuracy of measurement of pesticide-related health symptoms should consider an independent assessment of farmer's health condition by a health expert. Also, the true health risk budget can be obtained by incorporating the costs of pesticide-induced chronic illnesses including deaths. Longitudinal farmer health study designs could provide more insights about causality of chronic health effects. More importantly, growing evidence about the linkage between smallholder cotton production and farmer health risks implies a greater need to transform the current delivery of rural health services and provide extension a more prominent role in the diffusion of health information. Finally, a more permanent solution requires pest management methods that are effective, economic, long lasting and not damaging to farmer health.

Table 2.1: Descriptive statistics for Sanyati and Chipinge districts, 1998/99

Variable	Sanyati		Chipinge	
	Mean	Standard Dev.	Mean	Standard Dev.
Farmer characteristics				
Age (years)	46.40	14.20	42.70	12.58
Education (years)	6.54	3.72	6.54	3.75
Male farmers (0,1)	0.83	0.38	0.91	0.29
Health-related and pesticide exposure variables				
Acute symptom cases	1.12	0.84	0.95	0.88
Acute symptom severity	0.60	1.00	1.01	1.42
Health cost (Z$)	180.15	157.16	315.63	504.59
Purple pesticides[11] (mg/kg/farm)	415.69	2,982.97	1,218.90	6,568.76
Red pesticides (mg/kg/farm)	2,428.98	5,758.26	4,600.08	9,499.08
Amber pesticides (mg/kg/farm)	3,423.04	14,334.94	5,496.06	16,536.52
Eat in cotton fields (1,0)	0.10	0.30	0.28	0.45
Label illiteracy (1,0)	0.32	0.47	0.54	0.50
Sprayer leak (1,0)	0.39	0.49	0.34	0.48
Storage hazard (1,0)	0.36	0.48	0.21	0.41
Smoking duration (years)	2.14	5.11	2.78	7.03
Alcohol intake duration (years)	3.65	6.63	9.66	13.70
Farm management variables				
Cotton area (ha)	4.57	3.98	8.74	11.56
Cotton bales (bales)	8.12	7.63	19.30	16.82
Extension meetings	4.67	6.37	13.04	11.24
Knapsack (1,0)	0.69	0.47	0.42	0.49
Ultra-Low Volume (1,0)	0.05	0.22	0.26	0.44
Formal employment (1,0)	0.46	0.50	0.43	0.50
Prophylactic spray (1,0)	0.30	0.46	0.26	0.44
Pesticide exposure averting and mitigating variables				
IPM Train (0.1)	0.48	0.50	-	-
Number of protective clothing	3.76	1.54	1.76	1.77
First aid knowledge (0.1)	0.61	0.49	0.19	0.40
Institutional variables				
Access to borehole (1,0)	0.37	0.48	0.67	0.47
Distance to health center (km)	4.93	2.82	9.30	5.63
Radio ownership (1,0)	0.68	0.47	0.73	0.45

Source: Field survey data, 1999

[11] Pesticide dosage/concentration is expressed as active ingredients that are measured in mg/kg. Farmer's exposure is measured as product of pesticide concentration and rate of pesticide application per farm.

Table 2.2: Cost of Illness Model Results for Sanyati and Chipinge Districts, 1998/99.

Dependent variable: Natural logarithm of farmer health costs (Z$)

Independent variables	**Sanyati District**		**Chipinge District**	
	coefficient	**t-statistic**	**coefficient**	**t-statistic**
Farmer characteristics				
FARMER'S AGE	0.0060	0.04	0.1800	0.83
MALE FARMER	-0.1700	-1.51	0.0049	0.02
FORMAL EDUCATION	0.0330	1.34	0.0310	0.66
Health-related variables				
ACUTE SYMPTOMS[1]	***0.1600	4.54	***0.2900	4.35
SYMPTOM SEVERITY[2]	***0.0890	2.63	**0.1200	2.01
ALCOHOL CONSUMPTION	0.0067	0.30	-0.0210	-0.73
SMOKING	*0.0470	1.92	-0.0032	-0.09
Institutional variables				
BOREHOLE ACCESS	-0.0074	-0.09	-0.0820	-0.63
HEALTH CENTER DISTANCE	-0.0088	-0.63	0.0340	0.42
FIRST AID KNOWLEDGE	-0.0830	-1.04	-0.0730	-0.46
Adjusted R^2	**31**		**35**	
N	**137**		**131**	
p-value	**0.000**		**0.000**	

***=significance at 1% level, **=significance at 5% level, * =significance at 10% level

Note:

1. Three types of pesticide-induced acute symptoms were assessed in detail, eye irritations, skin irritations and stomach(gastro-intestinal effects) irritations.
2. Symptom severity was assessed on a scale of 1 to 3 with 1= mild, 2=severe and 3=very severe. The severity variable is a product of positive acute symptom and its severity aggregated across all the three acute symptoms under investigation. Its value ranges from 0 to 9.

Source: Field survey data, 1999

Table 2. 3: Poisson Model Results for Self-reported Acute Skin Symptom Incidences.

	Sanyati District Skin Symptom Incidences		Chipinge District Skin Symptom Incidences	
Independent variables	**coefficient**	**z-value**	**Coefficient**	**z-value**
Farmer characteristics				
FARMER'S AGE	***-0.0350	-4.95	**0.0190	1.95
FORMAL EDUCATION	-0.0100	-0.41	***0.0680	2.50
MALE FARMER	0.3300	1.18	-0.2200	-0.80
Farm management variables				
COTTON AREA	*0.0330	1.65	***-0.0700	-2.40
EXTENSION MEETINGS	***0.0670	4.15	***0.0480	6.87
FORMAL EMPLOYMENT	0.1700	0.86	***-0.9100	-5.31
KNAPSACK	***0.6700	3.17	***-0.7700	-3.69
PROPHYLACTIC SPRAY	**0.4300	2.25	0.0770	0.37
Health-related variables				
ALCOHOL CONSUMPTION	*0.0270	1.89	0.0081	0.98
SMOKING	-0.0290	-1.51	0.0070	0.98
Exposure variables				
PURPLE PESTICIDE DOSAGE	-0.0230	-0.30	***0.1100	2.43
RED PESTICIDE DOSAGE	0.0230	0.33	***0.0440	2.56
AMBER PESTICIDE DOSAGE	0.0088	-0.46	***-0.0640	-3.61
SPRAYER LEAK	*0.3000	1.62	***0.5300	3.15
MEALS IN COTTON FIELDS	-0.1600	-0.52	0.3100	0.29
LABEL ILLITERACY	-0.1700	-0.97	***-0.5600	-3.22
STORAGE HAZARD	-0.2900	-1.38	***0.6700	3.66
Exposure averting and mitigating variables				
IPM GRADUATE	0.0260	0.11	-	-
FIRST AID KNOWLEDGE	-0.2800	-1.56	-0.4000	-1.51
PROTECTIVE CLOTHING	***-0.3100	-5.58	***-0.3700	-6.34
Institutional variables				
BOREHOLE ACCESS	0.2200	1.21	0.1100	0.56
RADIO OWNERSHIP	***-0.5800	-3.13	-0.0360	-0.18
Pest management perception variable(s)				
REVIEW CALENDAR SPRAY	***-0.6200	-2.74	**-0.4200	-2.23
N	**133**		**117**	
Log likelihood chi-square	**125.27**		**307.73**	
χ^2-p value	**0.0000**		**0.0000**	

***=significance at 1% level, **=significance at 5% level, * =significance at 10% level

Source: Field survey data, 1999

Table 2. 4: Poisson Model Results for Self-reported Acute Eye Symptom Incidences.

	Sanyati District Eye Symptom Incidences		Chipinge District Eye Symptom Incidences	
Independent variables	**coefficient**	**z-value**	**Coefficient**	**z-value**
Farmer characteristics				
FARMER'S AGE	**-0.0210	-2.05	**0.0360	1.99
FORMAL EDUCATION	-0.0120	-0.04	-0.0900	-1.57
MALE FARMER	0.5000	1.30	-0.2500	-0.55
Farm management variables				
COTTON AREA	0.0160	-0.54	**0.0260	2.29
EXTENSION MEETINGS	0.0190	0.82	-0.0100	-0.53
FORMAL EMPLOYMENT	-0.3800	-1.41	**0.8000	2.11
KNAPSACK	***0.8400	2.72	**-0.7800	-2.00
PROPHYLACTIC SPRAY	***0.7500	2.74	***-1.5900	-2.98
Health-related variables				
ALCOHOL CONSUMPTION	**0.0420	2.25	***-0.0530	-3.35
SMOKING	0.0004	0.02	*0.0520	1.87
Exposure variables				
PURPLE PESTICIDE DOSAGE	0.0710	0.51	-0.0024	-0.26
RED PESTICIDE DOSAGE	-0.1000	-1.13	-0.1800	-2.31
AMBER PESTICIDE DOSAGE	0.0220	1.03	**0.0950	2.65
SPRAYER LEAK	0.4800	0.19	0.0078	0.02
MEALS IN COTTON FIELDS	0.4300	1.11	0.5900	1.53
LABEL ILLITERACY	0.3300	1.39	-0.3200	-0.82
STORAGE HAZARD	0.0490	0.16	-0.3100	-0.77
Exposure averting and mitigating variables				
IPM GRADUATE	**0.8800	2.36	-	-
FIRST AID KNOWLEDGE	0.0220	0.09	*-0.8200	-1.82
PROTECTIVE CLOTHING	***-0.2100	-2.67	-0.0400	0.72
Institutional variables				
BOREHOLE ACCESS	0.1300	0.53	-0.3200	-0.91
RADIO OWNERSHIP	0.0420	0.15	0.6400	1.56
Pest management perception variable				
REVIEW CALENDAR SPRAY	***-1.1000	-2.77	-0.5500	-1.50
N	**133**		**117**	
Log likelihood chi-square	**111.54**		**96.10**	
χ^2-p value	**0.0000**		**0.0000**	

***=significance at 1% level, **=significance at 5% level, * =significance at 10% level

Source: Field survey data, 1999

Table 2. 5: Poisson Results for Self-reported Total Acute Symptom Incidences, 1998/99

	Sanyati District Total Incidences[12]		Chipinge District Total Incidences	
Independent variables	**coefficient**	**z-value**	**coefficient**	**z-value**
Farmer characteristics				
FARMER'S AGE	***-0.0790	11.01	*0.0150	1.71
FORMAL EDUCATION	0.0210	0.95	***0.1000	3.69
MALE FARMER	***1.4100	4.37	**0.8900	2.32
Farm management variables				
COTTON AREA	***0.0630	3.40	**0.0120	2.08
EXTENSION MEETINGS	***0.0930	6.44	***0.0170	2.06
FORMAL EMPLOYMENT	0.0530	0.30	***-0.6800	-3.72
KNAPSACK	0.1900	1.19	***-0.8800	-4.27
Health-related variables				
ALCOHOL CONSUMPTION	*0.0280	1.79	0.0130	1.30
SMOKING	-0.0060	-0.34	0.0140	1.01
Exposure variables				
PURPLE PESTICIDE DOSAGE	***0.3100	2.77	0.0380	0.57
RED PESTICIDE DOSAGE	*0.1300	1.86	***0.0970	2.86
AMBER PESTICIDE DOSAGE	-0.0210	-0.58	**-0.0620	-2.26
SPRAYER LEAK	0.1700	1.09	***0.8200	4.91
MEALS IN COTTON FIELDS	**0.6000	2.29	0.2900	1.52
LABEL ILLITERACY	*0.2600	1.75	0.4200	0.25E-1
Exposure averting and mitigating variables				
IPM GRADUATE	-0.2800	-1.35	-	-
FIRST AID KNOWLEDGE	***-0.5100	-3.46	**-0.5000	-2.14
PROTECTIVE CLOTHING	***-0.1500	-3.56	*-0.1000	-1.76
Institutional variables				
BOREHOLE ACCESS	***0.6900	4.23	0.2000	1.13
CREDIT USE	-0.3000	-1.51	***-0.6200	-2.98
RADIO OWNERSHIP	***-1.2100	-7.66	0.1600	0.78
Pest management perception variable				
REVIEW CALENDAR SPRAY	***-1.1500	-4.75	*-0.3100	-1.71
N	**133**		**119**	
Log likelihood chi-square	**495.54**		**165.81**	
χ^2 **-p value**	**0.0000**		**0.0000**	

***=significance at 1% level, **=significance at 5% level, * =significance at 10% level

Source: Field survey data, 1999

[12] Acute symptom incidences refer to short-term illness episodes experienced by the farmers and these include both the dermal (eye and skin irritation) and oral (ingestion) symptoms. Therefore, the total incidence model aggregates skin, eye and stomach (gastro-intestinal) poisoning episodes incurred by the farmer during and or soon after spraying pesticides.

Table 2.6: Poisson Protective Clothing Adoption Model Results, 1998/99

Dependent variable: Count of protective clothing ownership

	Sanyati District		Chipinge District	
Independent Variables	**Coefficient Estimate**	**z-value**	**Coefficient Estimate**	**z-value**
Farmer characteristics				
Farmer's age	***-0.0140	-2.97	0.0120	1.32
Education	-0.1300	-1.06	***0.5700	2.48
Male farmer	0.0790	0.56	0.2200	0.64
Farm management variables				
Total area cultivated	0.0046	0.34	-0.0110	-1.29
Extension meetings	*0.0190	1.88	***0.0460	5.58
Formal employment	0.0840	0.73	**-0.5200	-2.93
Certified master farmer	-0.0440	-0.36	-0.1200	-0.63
Knapsack	**0.2300	2.15	**-0.4100	-2.06
Prophylactic spray	0.1800	1.50	0.2600	1.38
Health-related variables				
Predicted skin incidences	***-0.3000	-3.91	***-0.4300	-5.80
Predicted eye incidences	-0.0880	-0.99	-0.0850	-0.49
Alcohol consumption	0.0860	0.66	*-0.2800	-1.63
Smoking	-0.0410	-0.29	0.0790	0.35
Exposure variables				
Purple pesticide class	-0.3100	-0.62	-0.3900	-1.20
Red pesticide class	0.2400	0.58	***0.6000	3.23
Amber pesticide class	0.0082	-0.86	-0.2100	-1.50
Label illiteracy	-0.0410	-0.36	***-0.8000	-4.76
Exposure averting and mitigating variables				
First aid knowledge	0.0610	0.60	0.2500	-1.37
IPM awareness	*0.1200	1.72	-	-
Institutional variables				
Distance to health center	0.0085	0.44	-0.0036	-0.25
Radio ownership	-0.1700	-1.43	-0.2500	-1.36
N	**133**		**117**	
Log Likelihood χ^2	**44.69**		**101.43**	
χ^2–p value	**0.0019**		**0.0000**	

***=significance at 1% level, **=significance at 5% level, * =significance at 10% level

Source: Field survey data, 1999

Table 2.7: Probit Results for Eating in Cotton Fields in Survey Districts, 1998/99

Dependent variable: Eating in Cotton Fields

	SANYATI DISTRICT		CHIPINGE DISTRICT	
Independent variables	**coefficient**	**z-value**	**coefficient**	**z-value**
Farmer characteristics				
Farmer's age	-0.0003	-0.75	-0.0017	-0.45
Male farmer	-0.0130	-1.45	-0.2700	-1.45
Formal education	**-0.0190	-2.07	0.1100	1.04
Farm management variables				
Extension meetings	0.0004	0.55	***-0.0130	-2.89
Cotton area cultivated	0.0012	0.63	0.0047	0.44
Cotton bales harvested	0.0007	0.87	0.0027	0.90
Knapsack sprayer	0.0140	1.51	***-0.3100	-3.68
Master farmer certified	*-0.0130	-1.62	0.0570	0.50
Health-related variables				
Alcohol intake	0.1300	0.83	0.0970	1.14
Smoking	**0.0710	2.23	***-0.2900	-3.16
Exposure variables				
IPM graduate	0.0013	0.12	-	-
Label illiteracy	0.0270	1.49	***0.2000	2.30
Exposure averting and mitigating variables				
First aid knowledge	0.0074	0.87	-0.14	1.46
Protective clothing	***-0.1000	-2.58	*0.047	1.90
Institutional variables				
Borehole	**-0.0220	-1.95	-0.0380	-0.44
Health center distance	-0.0030	-1.54	-0.0034	-0.46
Pest Management Perception variable				
Review calendar spray	***0.1100	2.51	-0.1100	-1.3400
N	**137**		**134**	
Log likelihood χ^2	**35.50**		**42.79**	
χ^2–p value	**0.0006**		**0.0003**	

***-significance at 1% level,**-significance at 5% level, *-significance at 10% level

Source: Field survey data, 1999

Table 2.8: Probit Results for Leaking Sprayers in Survey Districts[13], 1998/99

Dependent variable: Leaking sprayers

	SANYATI DISTRICT		CHIPINGE DISTRICT	
Independent variables	**coefficient**	**z-value**	**coefficient**	**z-value**
Farmer Characteristics				
Farmer's age	0.3200	0.82	-0.0028	-0.68
Male farmer	-0.0210	-0.15	-0.1103	-0.66
Formal education	*0.2300	1.85	-0.0056	-0.39
Farm Management variables				
Extension meetings	*0.1300	1.62	-0.0017	-0.72
Cotton area cultivated	***0.0560	2.44	0.0061	1.60
Formal employment	0.0310	0.28	-0.0200	-0.21
Knapsack sprayer	0.8400	0.80	-0.1000	-1.06
Knapsack Age	-0.6400	-1.36	-0.0027	-0.54
Master farmer certified	-0.0730	-0.59	-0.1373	-1.25
Prophylactic spray	*0.1800	1.67	0.0988	0.61
Exposure variables				
IPM graduate	***-0.3700	-3.06	-	-
Label illiteracy	-0.0500	-0.48	-0.0109	-0.12
Exposure averting and mitigating variables				
First aid knowledge	-0.0700	-0.71	-0.0475	-0.43
Protective clothing	-0.0520	-1.60	-0.0197	-0.75
N	**138**		**134**	
Log likelihood χ^2	**41.70**		**13.86**	
χ^2–p value	**0.0001**		**0.3838**	

***-significance at 1% level,**-significance at 5% level, *-significance at 10% level

Source: Field survey data, 1999

13 Sprayer leakage probit model for Chipinge District is not significant.

Table 2. 9: Probit Results for First Aid Knowledge in Survey Districts, 1998/99

Dependent variable: First Aid Knowledge

	SANYATI DISTRICT		**CHIPINGE DISTRICT**	
Independent variables	**coefficient**	**z-value**	**coefficient**	**z-value**
Farmer characteristics				
Farmer's age	0.0009	0.23	0.0051	1.47
Formal education	-0.0620	-0.55	***0.3300	3.01
Farm management variables				
Cotton area cultivated	0.0040	0.33	**0.0054	1.97
Formal employment	*0.1600	1.69	0.5300	0.71
Knapsack sprayer	-0.0570	-0.57	-0.0450	-0.64
Prophylactic spray	0.0210	0.21	0.0680	0.85
Health-related variables				
Alcohol intake	0.1100	0.90	0.0520	0.69
Smoking	-0.0640	-0.50	-0.0570	-0.71
Exposure variables				
Meals in cotton fields	0.1100	0.75	*-0.1400	-1.80
Label illiteracy	*-0.1700	-1.73	0.0760	1.09
Exposure averting variables				
Protective clothing	0.0420	1.40	0.0300	1.60
Institutional variables				
Received Treatment[14]	-0.0270	-0.11	*-0.1500	-1.77
Pest management perception variable				
Review calendar spray	-0.1100	-1.34	0.0520	0.78
N	**134**		**123**	
Log likelihood χ^2	**42.79**		**27.95**	
χ^2−p value	**0.0003**		**0.0072**	

***-significance at 1% level,**-significance at 5% level, *-significance at 10% level

Source: Field survey data, 1999

[14] Treatment received is a dichotomous response variable which assesses whether or not a farmer received formal treatment from a health facility [i.e. clinic or hospital] or private physician.

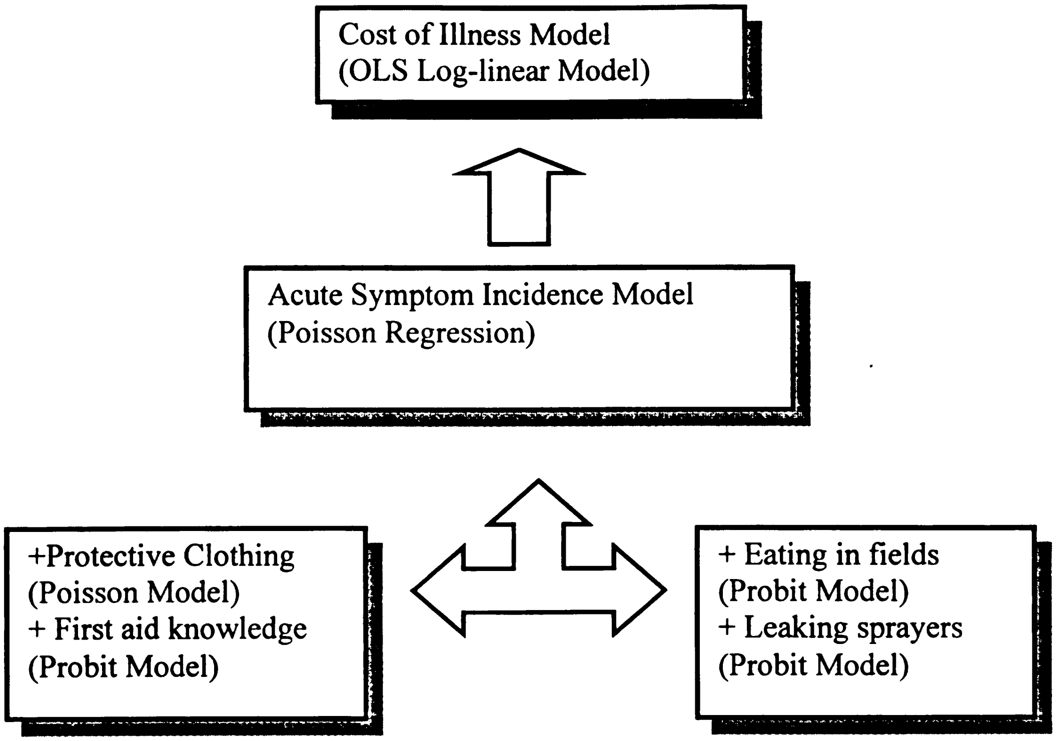

Figure 2.1: Structure of Econometric Analysis

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APPENDICES

Appendix A1: Langragian Function

The associated Langragian function is given by:

$$(1)\ L = U(Y,G,H) + \lambda((pY(x) - wx)-(W_a A+ W_g G+W_h h))+ \mu(H_m - H(x^p, M^p h, A))$$

First order conditions:

$$(2)\ \delta L / \delta x: \quad \lambda(p\delta Y/ \delta x - w) - \mu\ \delta H / \delta x \quad = 0$$

$$(3)\ \delta L / \delta G: \quad \delta U / \delta G - \lambda W_g \quad = 0$$

$$(4)\ \delta L / \delta h: \quad -\lambda W_h - \mu\ \delta H / \delta h \quad = 0$$

$$(5)\ \delta L / \delta \lambda: \quad pY(x) - wx - W_a A - W_g G - W_h h \quad = 0$$

$$(6)\ \delta L / \delta \mu: \quad H_m - H(G, x, h) \quad = 0$$

$$(7)\ \delta L / \delta H: \quad \delta U / \delta H + \mu \quad = 0$$

$$(8)\ \delta L / \delta A: \quad -\lambda W_a - \mu\ \delta H / \delta A \quad = 0$$

Rearrange ***(7)*** to make μ the subject of the formula and substituting the result into equation ***(4)*** i.e. first order conditions with respect to health care services to obtain the following:

$$(9)\quad \mu = - (\delta U / \delta H)$$

$$(10)\quad \lambda = ((\delta U / \delta H)(\delta H / \delta h)) / W_h$$

Substituting μ in equation ***(9)*** into equation ***(2)*** and divide through by λ as follows:

$$(11)\ p\ \delta Y / \delta x = w - (\delta U / \delta H * \delta H / \delta x) / \lambda$$

Now substitute equation ***(10)*** into equation ***(11)*** to obtain the following:

$$(12)\ p\ \delta Y / \delta x = w - (W_h / (\delta U / \delta H * \delta H / \delta h)(\delta U / \delta H * \delta H / \delta x)$$

Equating LHS of equations ***(11)*** and ***(12)*** we obtain the following expression:

$$(13)\ w - (\delta U / \delta H * \delta H / \delta x) / \lambda = w - (W_h / (\delta U / \delta H * \delta H / \delta h)(\delta U / \delta H * \delta H / \delta x)$$

$$(14)\ (\delta U / \delta H * \delta H / \delta x) / \lambda = (W_h / (\delta U / \delta H * \delta H / \delta h)(\delta U / \delta H * \delta H / \delta x)$$

$$(15)(\delta U / \delta H * \delta H / \delta x) / \lambda = \frac{[(\delta U / \delta H * \delta H / \delta h) / 1]}{(\delta U / \delta H * \delta H / \delta x) / W_h} = \frac{W_h(\delta U / \delta H * \delta H / \delta x)}{(\delta U / \delta H * \delta H / \delta h)}$$

Table A1.1: Pesticide-related health symptoms for cotton growers, 1998/99

PESTICIDE-RELATED SYMPTOMS	SANYATI (N=140) %	Number	CHIPINGE (N=140) %	Number
Acute Health Costs (Z$ Mean)		180		316
Acute Health Symptoms				
Skin irritations	67.4	95	55.0	77
Eye irritations	37.6	53	26.4	37
Stomach poisoning	7.1	10	12.1	17
Systemic Health Symptoms				
Nausea	1.4	2	5.7	8
Vomiting	1.4	2	0.0	0
Abdominal pains	9.2	13	2.9	4
Blurred vision	5.0	7	6.4	9
Dizziness	19.9	28	10.0	14
Nasal bleeding	1.4	2	0.7	1
Severe headache	3.5	5	0.0	0
Coughing	1.4	2	1.4	2
Sneezing	9.2	13	0.0	0
Diarrhea	0.0	0	1.4	2
Multiple symptoms	7.8	11	23.6	33
None of the above	39.7	56	47.9	67
Chronic Health Symptoms Type of Individual Affected				
Household head	20.6	29	11.5	16
Spouse	21.3	30	4.3	6
Child	2.1	3	13.7	19
Resident relative	5.0	7	7.9	11
None	49.6	69	61.4	85

Chronic diseases surveyed: 1=Cancer 2=Back pain 3=Lung problem 4=Blindness

Source: Field survey data, 1999.

Table A1.2: Pesticide-related farmer health characteristics in study regions, 1998/99

FARMER CHARACTERISTICS	SANYATI N=141	CHIPINGE N=140
Pesticide Applicator Health-Related Characteristics		
Current smoker (%)	22.7	26.4
Current drinker (%)	47.5	58.6
Previous smoker (%)	15.6	7.1
Previous drinker (%)	16.3	12.9
Eat in cotton fields (%)	9.9	27.9
Smoke in cotton fields (%)	2.1	5.0
Knowledge of first aid (%)	61.0	19.3
Ownership first aid kit (%)	6.4	2.1
Prophylactic spray (%)	29.8	25.9
Leaking sprayer (%)	39.0	34.3
No protective clothing (%)	3.6	34.3
Ownership of sprayer (%)	73.8	69.3
Average scouting (Sessions)	17	16
Smoking duration (Years)		
Mean	2.13	2.79
Standard Deviation	5.09	7.03
Alcohol Drinking Duration (Years)		
Mean	3.62	9.66
Standard deviation	6.61	13.70
Sick Days/Recuperation Period (Days)		
Mean	1.60	4.34
Standard Deviation	3.11	10.29
Clinical treatment costs (Z$)		
Mean	5.29	16.32
Standard Deviation	37.31	147.46
Health Information Sources		
Mean	2.06	1.29
Standard deviation	1.14	0.63

Source: Survey data, 1999.

Table A1.3: Distribution of pesticide storage strategies in study regions, 1998/99

PESTICIDE STORAGE STRATEGY	SANYATI (%) N=141	CHIPINGE (%) N=140
Pesticide store-room	22.0	41.4
Pesticide and food store-room	35.5	17.9
Bedroom	30.5	17.1
Locked suitcase/trunk	4.3	2.1
Bush	0.7	0.7
None of the above	6.4	17.9

Source: Field Survey, 1999.

Table A1.4: Label literacy among cotton growers in survey areas, 1998/99

COLOR CODE TOXICITY RANKING	SANYATI (%) N=138	CHIPINGE (%) N=140
Correct ranking all color codes	71.8	41.7
Most toxic color code identified	1.7	5.0
Least toxic color code identified	8.9	7.2
Complete ignorance	9.3	46.1

Source: Survey data, 1999

Table A1.5: Knowledge of triangles in correct order of toxicity, 1998/99

KNOWLEDGE OF COLOR CODE RANKING	SANYATI NUMBER	SANYATI PERCENT	CHIPINGE NUMBER	CHIPINGE PERCENT
None	13	9.3	65	46.1
Partial	15	10.6	17	12.2
Complete	101	71.8	58	41.7
Total	129	91.7	140	100.0

Source: Survey data, 1999

Table A1.6: Pesticide use and toxicity classes by farmers in survey area, 1998/99

PESTICIDE TOXICITY COLOR CODES (CLASSES)	PESTICIDE CLASS DESCRIPTION	SANYATI DISTRICT (%) N=140	CHIPINGE DISTRICT (%) N=140
I. Purple	Very Dangerous	5.1	5.1
II. Red	Dangerous	54.3	19.9
III. Amber	Poisonous	40.6	75.0
IV. Green	Harmful if swallowed	0.0	0.0

Source: Field Survey data, 1999

Table A1.7: Cotton pesticides used in Sanyati and Chipinge districts, 1998/99

Chemical Trade Name	Chemical Common Name	Color Code	Chemical Group	Dermal LD_{50} mg/kg	Oral LD_{50} mg/kg
AGRITHRIN	FENVALERATE	AMBER	Pyrethroid	>5000.0	451
FERNVALERATE	FENVALERATE	AMBER	Pyrethroid	>5000.0	451
AGRITHRIN SUPER	ESFENVALERATE	RED	Pyrethroid	>5000.0	75 to 88
PFUMO	FENVALERATE	AMBER	Pyrethroid	>5000.0	451
MOTO	FENVALERATE	AMBER	Pyrerhroid	>5000.0	451
CARBARYL	CARBARYL	AMBER	Carbamate	>2000.0	590.0
SEVIN	CARBARYL	AMBER	Carbamate	>2000.0	590.0
DIMETHOATE	DIMETHOATE	RED	Organophosphate	1000.0	60.0
ROGOR	DIMETHOATE	RED	Organophosphate	1000.0	230.0
KARATE	LAMPDA-CYHALOTHRIN	RED	Pyrethroid	>5000	11000
LARVIN	THIODICARB	RED	Carbamate	>2000.0	166.0
MARSHAL/SHASHA	CARBOSULFAN	RED	Carbamate	>2000	250
ONCOL	BENFURACARB	AMBER		>2000	222.6
THIODAN	ENDOSULFAN	PURPLE	Organochlorine	256.0	44.9
THIONEX	ENDOSULFAN	PURPLE	Organochlorine	256.0	44.9
MITAC	AMITRAZ	AMBER	Acaricide	>2000.0	1000.0 to 2000.0
MONOCROTOPHOS	MONOCROTOPHOS	PURPLE	Organophosphate	126	18
NUVACRON	MONOCROTOPHOS	PURPLE	Organophosphate	126	18
AZODRIN	MONOCROTOPHOS	PURPLE	Organophosphate	126	18
SECURE	CHLORFENAPYR	RED	Organophosphate	>2000	441
FASTAC	ALPHAMETHRIN	AMBER	Organochlorine	>2000	79-400

Source: 1.Field Survey, 1999
2. www.cdms.net/ldt/mp27Q000.pdf
3.The Pesticide Manual, 1997

Table A1.8: Spaying equipment distribution in cotton growing regions, 1998/99

SPRAYER TYPE	SANYATI DISTRICT (%) N=141	CHIPINGE DISTRICT (%) N=140
Knapsack	68.80	42.00
Ultra-Low –Volume (ULV)	5.00	26.40
No sprayer	26.20	31.40
Hired sprayer	10.00	1.00

Source: Field survey data, 1999

Table A1.9: Average cotton pesticide applications by region, 1998/99

CHEMICAL APPLICATIONS PER SEASON	SANYATI (%) N=129	CHIPINGE (%) N=114
Less than 3	64.00	20.00
Between 4 and 7	26.80	31.20
Between 8 and 11	0.00	14.20
Between 12 and 14	0.00	3.50
More than 15	0.00	11.30

Source: Field survey data, 1999

Table A1.10: Pesticide-related treatment patterns in survey areas, 1998/99

PESTICIDE-RELATED HEALTH AILMENT	SANYATI % TREATED	CHIPINGE % TREATED
Stomach Poisoning	2.8	5.0
Skin Irritation	2.8	7.9
Eye Irritation	2.1	7.9
Mean	2.6	6.9
N	140	140

Source: Field survey, 1999

Table A1.11: Types of protective clothing worn by pesticide applicators, 1998/99.

PROTECTIVE CLOTHING	SANYATI (%) N=140	CHIPINGE (%) N=140
Rubber boots	88.0	37.8
Protective eye glasses	29.6	10.0
Long sleeved overall	93.8	53.3
Face mask	56.4	20.6
Respirator	57.0	25.0
Rubber gloves	61.2	27.8

Source: Field survey data, 1999

Table A.12: Mean health costs as a proportion of household income and costs

HEALTH COSTS AS PERCENT OF COST/INCOME ITEM	SANYATI (%) N=140	CHIPINGE(%) N=140
Total chemical cost outlay	45	83
Cotton sales revenue	2	5
Off –farm income	14	6

Source: Field survey data, 1999

CHAPTER 3

ADOPTION OF COTTON I.P.M. IN ZIMBABWE: THE ROLE OF TECHNOLOGY AWARENESS AND PESTICIDE-RELATED HEALTH RISKS

3.0 Introduction

In Africa, crop protection is centered on chemical control of pests with alternative approaches still in minimal use (Adesina, 1994; Ajayi, 1999). Cash crops like cotton have relied on chemical pesticides but the limitations of chemical pest control have become increasingly clear to both farmers and policy makers. Pesticide use in Africa has been tied to small farm credit programs (Fleischer, 1999). Although the application of chemical pesticides has alleviated pest problems in the short term, pesticide use has led to negative externalities such as secondary pest outbreaks, development of pesticide resistance and the destruction of natural enemies thereby putting farmers in a vicious pesticide treadmill (Burrows, 1983;World Bank, 1996).

The calendar-based techniques are increasingly being questioned for a number of reasons. First, these traditional chemical-based pest management tactics have failed to provide essential ingredients for sustainable crop production, which includes the attainment of multiple benefits such as effective pest control, raising agricultural productivity and minimum damage to the environment. Second, chemical control of pests has elevated occupational health hazards particularly in less developed countries (LDCs) where farmers do not afford protective clothing (Cole et al., 1998; Loewenson and Nhachi 1996; WHO, 1990). Rising concern for public health risks of pesticide use as well as its burden on the environment has added momentum to the need to re-evaluate the current chemical-based pest management practices (Rola and Pingali, 1993). Until the past decade, the debate advocating the substitution of pest control based exclusively on chemicals with new approaches such as integrated pest management (IPM)[15] has not been strong in Africa. Local constituents advocating the protection of the environment and public health are still in their development stages on the continent. Yet the farmers' low level of literacy and education makes the overall risk of exposure to pesticide greater than elsewhere in the world despite the fact that Africa uses about 2% of the world chemical sales (Kiss and Meerman, 1993;Fleischer, 1999).

The benefits of knowledge-based technologies such as IPM in reducing over-application of pesticides thus improving productivity, human health and the environment have been demonstrated in a number of studies conducted mostly in developed countries (Fernandez-Cornejo, 1998; Swinton, et al., 1999; Norton and Mullen, 1993;Thomas et al., 1990) and also in Asia (Antle and Pingali, 1994) and South America (Antle et al., 1998). The momentum for the development of IPM is relatively high in Asia but is still very limited in Africa (Adesina, 1994). The general consensus on IPM recognizes that control of pests exclusively with pesticides satisfies a short-term need.

An increasing number of development agencies including the Food and Agriculture Organization (FAO), the International Labor Organization (ILO) and the World Health Organization (WHO) observe that priority should be given to education of pesticide users and promoting systems that restrict or eliminate pesticide use (Weber, 1996). Smallholder cotton growers can make the transition from the use of calendar-based chemical pest management through exposure to Farmer Field School (FFS)[16]. The

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[15] IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks (Vandeman et al 1994).

[16] FFS is a participatory training approach that uses discovery-based learning techniques in pest and crop management. Its aim is to help farmer groups understand agro-ecosystems analysis in order to cope with biotic (insect, pests and weeds) and abiotic (water soil and weather) stresses (Rola, undated). Farmer-to-

concept of FFS arose from the dual problem of development of pesticide resistance and increasing health risks among farmers in rice–based monocultures in Asia. The FSS philosophy revolves on four principles; (1) growing a healthy crop, (2) weekly field observations, (3) conserving natural enemies and (4) understanding the field ecology including water and nutrient management (Fleischer et al., 1999). In Zimbabwe, this approach is being used to disseminate Integrated Production and Pest Management (IPPM)[17] technology widely viewed as the means to ameliorate the pesticide menace. IPPM, unlike single item innovations such as high-yielding varieties (HYVs), relies on multiple pest management practices, soil and water conservation, and weather assessments in making pest management interventions. It is essential to understand how such an information-intensive technology is adopted in practice if its prospects for widespread implementation are to be fulfilled.

Although several studies have examined the adoption of IPM in cotton, (Thomas,1990; Ladewig and McIntosh, 1990; Fernandez-Cornejo, 1996; Napit et al., 1988), none addresses the smallholder context and none focuses on Africa. Our study differs from previous studies in that we focus on an emerging innovation still in its early stage of the diffusion cycle in a region that has received no similar systematic studies in the past. This study looks at the adoption of different cotton pest management practices by smallholders in transition from conventional calendar-based chemical pest control to FFS-IPPM strategy. In particular it examines the roles of 1) IPM technology awareness and 2) health experience related to pesticide use.

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farmer approaches are then used to spread IPM knowledge as the process involves selecting farmers who excel in each FFS group and empowering them to subsequently train other farmers in their own villages.

3.1 Problem Overview

The indiscriminate use of toxic pesticides is associated with farmer health and environmental risks. The severe danger from pesticide use implies that a reduction of pesticides has to take place. The development of risk-reducing technologies such as IPM is now the preferred approach in pest management worldwide. Although farmer pesticide use in Africa is relatively low compared to Asia, there are signs of misuse that require urgent solutions. In Asia, heavy pesticide use in food crops especially rice has triggered widespread farmer health problems (Antle and Pingali, 1994). However, pesticide use among smallholders in Africa is associated with cash crop cultivation especially cotton and tobacco (Sukume, 1999). A key question therefore is how can Africa's export crop production avoid the errors of Asia's pesticide misuse. Developed countries have laws and regulations to limit the negative effects of pesticides yet comparable systems of laws and surveillance have been established only recently in LDCs (Frank, 1996).

Given that IPM is viewed as a more effective pest management option, the next question is: How best can it be implemented under smallholder cotton production systems in Africa? The IPM approach has been well received in Asia, Indonesia and Philippines in particular, and it is in Africa's best interest to draw useful lessons from Asia's success with FFS-IPM. The opportunity cost of not adopting IPM is relatively high in LDCs were most farmers using toxic pesticides have the additional burden of being illiterate and lack protective clothing (Kiss and Meerman, 1993). Despite the fact that IPM is widely recommended, it is still less widely used in LDCs (CAB International et al.,1991). For instance, pesticides remain the dominant pest management tactic in most African

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[3]IPPM combines IPM approaches to manage pests and improve crop production management under mixed farming systems in rural areas of Zimbabwe; it aims to increase crop productivity through interventions in

countries even though majority farmers cannot afford pesticides (Ajayi, 1999; Kiss, 1995). Currently, there is little information about actual adoption of IPM in smallholder agricultural production in Africa.

Empirical evidence from Asia where IPM has been well received shows that pesticide use can have negative effects on farmer health causing reductions in farmer productivity (Antle and Pingali, 1994). Assessment of the Indonesia National IPM program and Philippine IPM for rice farmers reveals that IPM is a successful framework for alleviating pest problems leading to higher crop returns and a reduction of both environmental liabilities and human health risks associated with intensive use of agro-chemicals (Rola and Pingali,1993; Cuyno, 1999; World Bank, 1997). In India, pest suppression was found to be more efficient in bio-control-based IPM with consequent increase in cotton yields of up to 33% compared to farmers' practices of plant protection (Rajendran and Bambawale, 1994). However, a slow down in IPM adoption in the Philippines has been attributed to the fact that its benefits are not apparent in the short-run (Rola, undated).

In contrast, empirical evidence on the adoption of IPM in Africa is scant (Jowa, 1993; Foti, 1999). In Kenya, FFS has empowered local farmers to make more efficient crop management decisions that include assessing crop health and natural enemy activity prior to applying pesticide treatment (Loevinsohn, et al., 1998). The strength of the discovery-based, experimental group-learning model relative to the traditional 'top-down' pest control recommendations is that it takes into account important crop interactions and prevailing field conditions. The FFS approach is now considered the

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both pests and production management.

standard procedure to implement IPM in Asia and is slowly spreading to Latin America and Africa (Fleischer et al., 1999).

Zimbabwe cotton offers a useful test case for determinants of IPM adoption among smallholders with and without exposure to comprehensive extension training. Zimbabwe cotton growers make intensive use of pesticides to control major pests such as aphids *(aphis)*, heliothis bollworm *(helicoverpa)*, termites, stainers *(dysdercus)* and red spider mites *(tetranychus)*. Cotton IPM-FFS was initiated among smallholders in the Sanyati district of the Midlands Province in north central Zimbabwe during 1997 with help from FAO's IPM Global Facility. By 1999, two classes of farmers had graduated from FFSs with IPPM training in cotton production. This early stage of IPPM awareness offers a timely opportunity to analyze IPM adoption determinants among Sanyati cotton farmers, including the technology awareness effect embodied in FFS training.

3.2 Study Objectives

The main purpose of this study is to determine the factors that influence the adoption of IPM practices in smallholder cotton production in Zimbabwe, and to explore the resulting policy implications. Knowledge of the key factors driving the adoption of IPM will facilitate policy formulation, program planning and targeting, and diagnosing constraints in existing methods of IPM dissemination. Therefore, the study addresses a serious challenge facing researchers, extension workers and policy makers involved in the development and implementation of an appropriate IPM strategy for smallholder mixed-cropping systems in Africa. Results also provide insights into the prospects for widespread implementation of IPM in Africa. We hypothesize that pesticide-related health risks positively influence IPM adoption. The remainder of the paper will be organized in the following way. First, the evolution and adoption of IPM in LDCs are highlighted. Second, we develop a working definition of IPM for Zimbabwe cotton. Third, we present an economic behavioral model for IPM adoption followed by specification of the empirical model. Next, results of the econometric estimation are presented and discussed. The final section summarizes the paper and discusses key policy implications.

3.3 The Diffusion of IPM Technologies in Less Developed Countries (LDCs)

In a few countries where IPM has been introduced in Africa (e.g. cotton in Sudan Uganda, and Zimbabwe is now in IPM mode even if only recently), implementation weaknesses in some instances have been associated with farmer's inability to recognize both key pests and beneficial insects a key dimension of IPM use. Also in some cases, farmers are unable to distinguish between stress caused by water deficiency and high temperatures relative to that arising from disease and insect damage. However, the impact of factors that constrain early phases of diffusion processes tends to differ and decline as the technology reaches final stage of the diffusion process (Feder and Umali, 1993).

One of the essential aspects of IPM diffusion is the integration of technical and social knowledge (World Bank, 1997). In particular, knowledge about specific pests as well as location specific farm management systems is critical for the successful design and dissemination of IPM approaches. Some major limiting factors to the successful implementation of IPM-related technologies are lack of farmer-focused research and the availability of effective and competitive alternative non-chemical techniques (World Bank, 1997). In many countries, imbalances exist between IPM dissemination and extension curriculum that emphasizes chemical control at the expense of non-chemical options (Pincus et al., 1997).

Apart from Asia, there is also growing evidence of successful development and use of IPM in South America (soybeans in Brazil) (Gallagher, 1988). However, evidence from Ecuador highlights the fact that farmers are at risk of excessive exposure due to widespread ignorance of pesticide poisoning symptoms and lack of personal protective equipment (Crissman et al., 1994). Therefore, one of the leading concerns of pesticide use in LDCs is that farmer's health is seriously compromised by unsafe application practices (Rola and Pingali, 1993; Tjornhom et al., 1997). The problems of pest resistance, pest resurgence and emergence of secondary pests in Africa further justify the need for IPM diffusion Kiss (1995).

In Africa, rice IPM pilot programs based on FFS-concept were launched in Ghana, Mali, Cote D'Ivoire and Burkina Faso in1994. Over the past five years, IPM-FFSs have expanded to Sudan, East and Central, and Southern Africa regions. Increasingly, the IPM approach has become popular with both African governments and development agencies interested in broader issues of integrated crop and pest management, and various versions of IPM have been tried in the different countries (Gallagher, 1998).

Despite successes in a few countries, widespread implementation of IPM is still an elusive goal in most parts of the world. The momentum for the diffusion of improved technology such as IPM is slowed by policies that discriminate against agriculture in many countries (Birkhaeuser et al., 1991). Past experience shows that immediate and uniform adoption of agricultural innovations is very rare. In addition, technology adoption and diffusion differs across socio-economic groups and over time (Feder et al., 1982). In Africa, the use of Economic Threshold Levels (ETL)[18] is still underdeveloped and requires refinement (Kiss and Meerman, 1993). Also, IPM technologies oriented toward single pests pose serious weaknesses as the challenge lies with development of ETL for several pests (Rola and Pingali, 1993). Outbreak of secondary pests in Africa makes this approach imperative for successful cotton IPM adoption.

3.4 Current Status of IPM Adoption in Less Developed Countries (LDCs)

Experiences from LDCs suggest that successful adoption of IPM on a wide scale requires the following key elements;1) establishing an enabling environment for IPM by eradicating policies in support of environmentally unsustainable pest management and strengthening regulatory institutions, and 2) targeted support for measures that promote the uptake of IPM, such as, public awareness, research, extension and training with an emphasis on decentralized farmer centered initiatives (World Bank, 1997). The desired broad constituency in favor of IPM adoption can be achieved through a clear definition of institutional roles and responsibilities of pest management stakeholders. Also, the World Bank advocates the adoption of a national IPM strategy as crucial for enlisting the necessary commitment to IPM adoption. Such a strategy can secure broad institutional support by addressing both upstream policy elements and on-farm IPM uptake. The introduction of a national IPM strategy has been adopted relatively easily in countries

[18] Economic Threshold Level is the breakeven point at which the dollar value for an increment of loss in yield quantity or quality is equal to the cost of a control method that successfully eliminates pest damage and yield loss (Kiss and Meerman, 1993).

where research evidence has proved that pesticides are not increasing yields significantly (World Bank, 1997).

A critical constraint to IPM adoption in Sub-Saharan Africa (SSA) is the shortage of low-cost IPM technologies that are relevant to the mixed farming systems prevalent on the continent. Besides, encouraging a broad base of farmers to experiment with new practices remains a challenge (World Bank, 1997). IPM adoption relies on farmer-to-farmer diffusion, yet knowledge diffusion by graduates is gender biased as men diffuse to men and women to women. Similarly, an age bias among graduates of FFS in SSA has been reported as IPM adoption by older farmers dominates younger farmers (Loevinsohn, et al., 1998). Inadequate interaction between researchers, extension workers and farmers has inhibited local understanding and adoption of the IPM technologies that are being introduced in Africa (Gallagher, 1998).

In Asia, evidence from Philippines shows that farmers have misconceptions about pests and natural enemies; with leaf eaters generally considered as most important pests. Mismatch between pest damage and responsible pests and confusion between rice and vegetable pests seemed common among farmers. Further, additional IPM adoption hurdle in Asia has been the widespread lack of knowledge about pest resurgence and action thresholds among rice and vegetable farmers (Lazaro et al., 1995). According to Rola and Pingali, (1993), biological control tended to receive less attention in most IPM activities in Asia. Similar deficiencies were identified in cotton-IPM adoption studies in Uganda where farmers failed to recognize some species of insects as beneficiaries (Kiss, 1995).

Empirical evidence on whether multi-component technology like IPM is adopted individually or in package has been mixed and it still requires further research (Feder and

Umali, 1993). Evidence of stepwise adoption patterns of agro-chemical technological components has been reported in the literature (Byerlee and Hesse de Polanco, 1986). Conversely, the sequential adoption hypothesis was later challenged in a study of maize production in Swaziland where farmers were reported to adopt technologies in clusters (Rauniyar and Goode (1992) cited in Feder and Umali, 1993). A later study indicates that the adoption decision is inherently multivariate and univariate modeling excludes valuable economic information (Dorfman, 1996). Since, uncertainty about productive performance of a technological package decreases with experience, while confidence increases with positive experience, usually early adopters choose to adopt only parts of a package rather than a complete package (Feder and Umali, 1993). Generalizing adoption patterns is difficult due to differences in technology adoption arising from diverse agro-climatic regions and farmer's socio-economic conditions.

3.5 Defining Smallholder Cotton-IPM Adoption

The successful assessment of any IPM strategy begins with a clear definition of what is being assessed. Typically, IPM involves a number of pest management practices that are both location and crop specific. There is no consensus in the literature as to what specific pest management practices constitute IPM. IPM definitions have been classified as either "input-oriented" or "output-oriented" (Swinton and Williams, 1998). The latter focus on desired outcomes such as profitability, human health and environmental quality while the former relate to specific IPM practices. Assuming an input-oriented approach, pest management practices can be grouped together and IPM defined as low, medium and high level (Vandeman, 1994; Mullen et al., 1997). Other studies have assigned points to different practices and defined adoption along a scale (Hollings-worth et al cited in

Swinton and Williams, 1998). Yet others have considered both the proportion of practices and the degree of economic importance of the pest. In our study we use the "input-oriented approach" and focus on the actual number of IPM practices. We characterize the cotton growers in terms of how many IPM practices have been adopted.

For the purpose of this study, the specific cotton IPM and production practices examined include; (1) alternating pesticides to slow development of pest resistance, (2) use of less toxic and safer chemicals, (3) adjusting pesticide application frequency and timing, (4) pest scouting (5) adjusting planting dates, (6) use of beneficial insects in pest management, and cultural practices such as (7) crop rotation, (8) legally enforced closed season (or field sanitation) to stop pest carry-over, and (9) use of trap crops. The potential range of adoption was from 0 to 9. However, we did not ask the farmers to rank the relative importance of each IPM practice.

3.6 Methodology and Data

3.6.1 Economic Behavioral Model

Typically, individual households are the primary decision makers concerning agricultural innovations, implying that a household behavioral model is key to understanding the adoption-diffusion process (Feder et al., 1993). Assume the model of an individual household producing multiple crop outputs using multiple inputs that include pesticides. The household maximizes a utility-function $U(\pi)$ that is increasing in net returns (π) subject to constraints from fixed factors.

Several assumptions are made in specifying the model. First, we assume that farmers consider health costs as cost of production. This implies that farmers do care about both economic and pesticide-related health problems associated with the use of agro-chemicals. Also, agrochemical exposure is assumed to reduce health status of the farmer. Second, cotton production and management decisions can be described as static profit maximization or cost minimization. Third, farmers are sensitive to downside yield risk. Fourth, family and hired labor are homogenous and are considered as perfect substitutes when used in cotton production. The labor market is competitive and the returns to farm work and off-farm work are equilibrated. Finally, we also assume that agro-chemicals contribute to cotton productivity only indirectly via reduction in the population of pests, which are considered in our case as the damage agents.

In that respect, smallholder cotton yields are an indirect function of pesticides applied since production functions that treat pesticides as yield increasing inputs over-estimate marginal productivity. Lichtenberg and Zilberman (1986) were among the first to point out that pesticides should be modeled as damage control inputs just like sprinklers for frost protection. Suppose that the actual cotton yield ***(Y)*** is given by:

$$(1)\ Y = Y^{0}(1-D\{N(1-k(X^{P}))\})\ \text{and}\ Y^{0}=f(p_{y}, p_{x}, K, L, I, Z)$$

where the potential pest-free cotton yield Y^0 is a function of cotton price p_y, prices p_x for all variable inputs including pesticides, labor, fertilizer, seeds, and credit; ***K*** is fixed physical capital such as land, ***L*** is labor, ***I*** is pest management information and ***Z*** represents conditioning factors such as soil type, rainfall, farmer's education, gender, experience and managerial capacity. But the actual yield ***Y***, depends on pest damage and its abatement. Therefore, ***D(.)*** represents the pest damage function[19], ***N*** is the pest pressure and X^P is the pesticide or damage control agent purchased at price p_p. Pesticide efficacy range is such that $(0<k(X^P)<1)$ where $k(X^P)$ describes the "kill function". When

[19] Damage function expresses the relationship between pest pressure and yield loss; it varies with presence of different pests and the abundance of natural enemy species that feed on pests (Rola and Pingali, 1993).

a chemical is completely effective, that is $(k(X^p)=1)$, then $Y = Y^0$. We also assume that profits are affected by the level of non-pesticide inputs X^o and health services H^s purchased at p_0 and p_h respectively. Following from the work of Antle et al. (1994) and Swinton (1998), we specify the relevant smallholder maximization problem as follows:

$$(2)\ Max\ \pi\ (Y, X, H, I) = P_y Y(p_y p_x, K, L, I, Z) - p_p X^p - p_0 X^o - p_h H^S$$

$$s.t\ \ (i)\ Y = f(X^p, X^o) - D(N+\varepsilon)(1 - k(X^p)) + \mu$$

$$(ii)\ EXP = P_a(Q_a - S_c) - w\,(L^e - L_f) + R$$

$$(iii)\ L^e \leq L_f + L_h + L_s$$

$$(iv) I_t = \Psi(I_0, FFS, Age, Education, Experience, V)$$

$$(v)\ H = \phi\,(A^p H^s, I, X^p, X^o)$$

where (i) cotton output (Y) is increasing in non-pesticide inputs X^o, $D(.)$ is a concave and increasing in pest population (N), but N is reduced by concave "kill function" $k(.)$ which is increasing in pest management input X^p. Both cotton yield and pest population are stochastic; $Y+\mu$ where $\mu \sim N(0, \sigma_\mu{}^2)$ and $N+\varepsilon$ where $\varepsilon \sim N(0\ \sigma_\varepsilon{}^2)$. Pesticides and non-chemical production inputs are distinguished by variables X^p and X^o respectively. In equation (ii) EXP is expenditure on non-agricultural products, $P_a Q_a$ is cash receipts from agriculture, $P_a S_c$ is value of household consumption of self-produced agricultural staple, R is remittances from relatives and w is wage rate, (iii) L^e is total effective labor requirement, L_h is total hired labor input, L_f is family labor and L_s is shared labor from the community. (iv) I_t refers to farmer's pest information knowledge, I_o represents farmer's initial level of pest management information before exposure to IPM training, ***FFS*** refers to participation in FFS-based IPM training. I_t is also affected by among others farmer's personal and village level characteristics (V). (v) H is a measure of farmer's health endowment and A^p is pesticide-averting behavior. Beside human health, pesticide use X^p also influences environmental quality. However, the data in this study does not provide sufficient farm-level variation to identify this effect, so it is not included in the presentation of the economic behavioral model.

Solving the input and output choice problem, we can derive a factor demand functions for X^p, which is stated as follows:

$$(3)\ X^p = g\,(P_y\ P_x, P_h, H, L, I, K, Z)$$

In particular, the demand for IPM practices X^p will depend on farmer characteristics, available farm resources (L, K), biophysical characteristics of the farm setting (Z), pest pressure N, institutional and relative prices (P), health effects of pesticides (H) and IPM awareness (I). The specific empirical measures of these attributes are presented in Table 1 and discussed below. It is hypothesized that exposure to IPPM training through FFS will do the following; (i) improve farmer's cotton pest management knowledge, (ii) raise cotton yields, (iii) lower pesticide use, (iv) improve farmer's health status and (v) raise farm profitability (Waibel, et al. 1998). The expected outcomes can be summarized as follows:(i)$\delta I / \delta FFS \geq 0$, (ii)$\partial Y / \partial I \geq 0$ (iii)$\partial X^p / \partial I \leq 0$, (iv)$\partial H / \partial I \geq 0$, (v)$\partial \pi / \partial I \geq 0$. Adoption analysis of cotton-IPM, a recently introduced technology in Zimbabwe, will provide insights about the important factors driving the uptake of IPM by both the current and future adopters who will ultimately accept the technology. The inclusion of farmers with different years of experience with FFS-based IPPM can form the basis to explore the adoption process itself. Such information will provide more timely strategic adjustments in future IPPM implementation.

3.6.2 Data and Estimation

The empirical model of IPPM adoption among smallholder cotton growers is estimated using cross-sectional data obtained from a survey conducted through personal interviews in Sanyati, one of the leading cotton growing districts in Zimbabwe. Sanyati was one of the first districts to offer FFS-IPPM training to local cotton farmers in 1997. The district is located in the north central part of the country in the Midlands province. It lies in natural regions III and IV[20]. Farmers in Sanyati have a mean cotton growing experience of 14 years. Survey farmers in Sanyati were identified using a stratified random sampling approach on the basis of villages with FFS groups. The second level of stratification was based on the cotton farmer participation in FFS-based IPPM training groups. A total of 141 farmers were interviewed in Sanyati.

Data used in the analysis was collected at two different levels; household and field. The unit of observation was the household. Variables used in the empirical model are based on previous findings from economic theory of adoption decisions (Feder, Just and Zilberman; D'Souza; Dorfman). In addition, univariate adoption models for individual IPM practices provided a further basis for selecting the final variables used in the model. Farmer characteristics that condition adoption behavior include farmer's age **HHAGE**, extension meetings attended **COTEXTMTG**, cotton growing experience **COTYEARS**, level of formal education **EDUYEARS**, gender of the head of household **HGENDER** and whether certified as a Master Farmer **MASTERFM**. We expect farmer characteristics to positively influence IPM adoption although gender effect cannot be established a priori. Also, the age effect can be ambiguous a priori. As age increases

[20] A natural region is an agro-ecological zone demarcated by rainfall pattern, as well as crop and livestock production potential in the region. Mean annual rainfall for NRs III and IV are 800mm and 400 mm.

hence experience, the time horizon to reap IPM benefits decreases yet experience could lead to better knowledge of IPM and its benefits (Khanna, 2001).

Farm resource endowment variables include total cotton labor **LABDAYS**, cotton land area cultivated **COTAREA**, value of productive assets **PROASSESTS**, ownership of draft animals **DRAFTOWN**, use of credit **CREDIT** and access to formal off-farm employment **FOMEMPLT**. Farm management practices that could influence pest management include use of improved cotton variety **ALBARFQ902**, production of staple maize crop **ALTCROPM**, whether the cotton field was fallowed the previous season **FALLOW**, absence of specific three-year cotton rotation program **NROTPROG** and number of tillage practices used **TILPRACS** in cotton production. Institutional and relative price factors are access to information media **MEDIA**, average walking time from homestead to cotton fields **AVEWALKT** and distance to cotton markets **DISTMKT**.

The health risk variables used to estimate the empirical model are number of pesticide-related acute symptoms **ACUTESYM**, number of individual protective clothing units used by the farmer in making pesticides treatments **SAFINDEX**, measure of farmers ability to rank the toxicity level of pesticides based on color codes on pesticide container labels **LABELIT** and whether or not the head of the household drinks alcohol **HHDRINK**. The last category of the determinants of IPM adoption is the awareness and perception variables. **IPMAWARE** is a measure of post FFS-IPM training years judging from the time when the farmer enrolled. Farmer's perceptions of downside yield risk **YLDRISK** and current chemical-based pest management strategies **PMGTVIEW** were also used in the regression model. All variables and their definitions are listed in Table 3.1.

3.6.3 Empirical Model

In this study, we use a Poisson maximum likelihood regression model to predict the discrete but non-categorical pest management strategies used by cotton growers in Zimbabwe. The shortcomings of using OLS, ordinary probit and or logit analysis in the case of count data are highlighted in the econometric literature (Greene, 1997, Madalla, 1983). The number of additional pest management practices used on a given crop indicates the farmer's reliance on multiple biological and cultural pest management, a key ingredient of IPM use (Vandeman et al , 1994). Since an integrated package of cotton-IPM as an off-the-shelf system does not yet exist, farmers have the flexibility to combine different counts of practices that address specific pest complex in their fields. The predicted values $Y_1\ Y_2,\ldots,Y_n$ are assumed to have independent Poisson distribution with parameters $\lambda_1, \lambda_2,\ldots, \lambda_n$ respectively (Madalla, 1983). According to Greene, 1997, the basic equation for the Poisson regression is represented as follows:

$$(2)\ Prob(Y_i=y_i) = (e^{-\lambda i}\lambda_i)\,/\,y_i \quad \text{where } y_i = 0, 1, 2,\ldots..$$

The parameter λ_i is assumed to be log-linearly related to regressors x_i. Therefore,

$$(3)\ Ln\ (\lambda_i) = \beta'\chi_i$$

The log-likelihood function is given by :

$$(4)\ Ln\ L = \Sigma_{i=1,\ldots,n}(-\lambda_i + y_i\beta'\chi_i - \ln y_i!)$$

The expected number of events per period is given by;

$$(5)\ E(y_i/x_i) = Var\ (y_i/x_i) = \lambda_i = e^{\beta'\chi i + v i}$$

Based on the conceptual framework presented the empirical model is estimated using the following groups of explanatory variables; (1) farmer characteristics **(FC)**, (2) farm resource endowment **(FR)**, (3) farm management practice **(FP)**, (4) pest damage

(PD), (5) institutional and relative prices **(IP)**, (6) health risk **(HR)**, and (7) awareness and perception variables **(AP)**. Therefore the general form of the empirical model estimated is stated mathematically as follows;

$$(6)\ \sum IPM\ Practice_i = \delta\,(FC, FR, FP, PD, IP, HR, AP) + e_i$$

3.7 Results and Discussion

3.7.1 Farmers' Adoption Patterns and Pest Management Perspectives

The majority of farmers (30%) use at least three IPM practices identified earlier. The mean number of IPM practices used is 4.36. About 11% reported using as many as seven IPM practices in 1998/99. All the farmers reported using at least two IPM–related strategies. The survey contained about 48% of the farmers who had some exposure to FFS-IPPM training. The FFS-IPPM graduates were more likely to be male farmers with high school education cultivating more than one cotton field. A cluster analysis of the different IPM practices did not reveal any discernible pattern in terms of adoption of IPM practices in clusters. The leading IPM practices adopted were field sanitation (97%), crop rotations (87%), scouting (89%), alternating pesticides (32%) and preservation of beneficial insects (30%). Correlation analysis suggests practices were adopted independently. Farmers in Sanyati applied an average of three pesticide treatments on each plot in 1998/99. This suggests either a low level of pest infestation that season or a shift towards more efficient non-chemical pest suppression methods.

An important finding is that cotton growers expressed diverse views about motivations for pesticide interventions and use of IPM. Among those exposed to IPM training, 85% believed that IPM knowledge is an effective pest management tool and 8%

felt the opposite. Farmers satisfied with IPM methods constitute a critical mass of the early adopters. The rest were either not sure or had no opinion about IPM. Including the non-FFS graduates, the beliefs about IPM were that 40% felt it was effective while 54% had no idea. The rest felt IPM was ineffective, labor intensive and inferior to the traditional calendar-based chemical control of pests.

Chemical interventions were made for different reasons with 30% of the respondents stating that they spray on fixed calendar basis, while 66% said they applied chemicals only after pest scouting. Other reasons cited for guiding chemical interventions were specific growth stages for the cotton plant. Only 14% of the farmers felt that the major problem in cotton production in Sanyati was pest management. A majority felt that poor prices (53%) were most important, and some felt drought (6%) was a serious problem needing urgent attention.

3.7. 2 Factors Affecting Cotton-IPM Adoption Among Smallholder Farmers

Poisson regression results on the determinants of adoption of aggregate IPM practices in Sanyati District are summarized in table 3.2.The analysis was carried out using STATA version 6.0 (STATA, 1997). The Poisson regression model was significant at the 1% level. However, much variability in IPPM practices adopted was not explained by the model, which had a McFadden R^2 of only 10.2%.

The key result of our analysis is the technology awareness coefficient that is significant at the 1% level. Farmers exposed to cotton-IPM techniques through FFS training, are more likely to use several IPM related practices in cotton pest management. The uniqueness of IPM as a knowledge intensive technology makes the human element an overriding factor in its adoption decisions. Training augments skills and knowledge useful in making innovative decisions. Further it enhances farmer's ability to distinguish technologies that generate opportunities for economic gain from those that do not (Wozniak, 184). The coefficient for the total area cultivated to cotton is positive and significant at the 10% level. This implies a scale-effect in the use of IPM technology in Sanyati. The results suggest that farmers with smaller acreage under cotton are likely to require special adoption incentives such as improved access to technical information to encourage them to use more IPM practices in reducing cotton pest damage. This result matches other several studies that identify farm size as the most prominent variable explaining adoption decisions (Wozniak, 1984; Dorman, 1996)

The coefficient for the cotton variety **ALBARFQ902** is positive and significant at 10%. This implies that farmers growing this HYV are more inclined to use several IPM practices. The unique characteristics of this variety are that it is resistant to bacteria blight and jassids *(empoasca)*, and is more tolerant to aphids and drought. Although it is susceptible to verticillium wilt *(verticillium dahliae)*, **ALBARFQ902** has the highest score on pest and disease resistance among all the cotton varieties grown in the middleveld in Zimbabwe.

Contrary to expectation, the pesticide-related health risk variables **ACUTESYM SAFINDEX, LABELIT** and **HHDRINK** are insignificant. The lack of statistical significance associated with health risk variables does not support the hypothesis that IPM adoption decisions are based on pesticide-related health risks. Analysis of IPM adoption decisions of label literate farmers only did not reveal significant relationship between health risks and IPM adoption. Lack of significance could be attributed to the fact that more than 60% of the IPM practices assessed did not use pesticides. Although farmer characteristics estimated from adoption models are important in the policy arena our results also show such variables as insignificant in the adoption of multiple IPM practices. What we may have demonstrated is several variables that can be excluded from consideration when targeting likely cotton IPM adopters under smallholder conditions.

3.8 Conclusion

The main conclusion is that technology awareness embodied in access to FFS-based IPM training is really important in motivating the use of multiple components of risk-reducing technologies such as IPM. Investment in IPM farmer education and literacy programs targeted to non-adopters will have long-term beneficial impacts on cotton-IPM use. IPM use requires an experimental cotton plot and farmers with more land are more likely to adopt IPM practices. In addition, cotton growers who planted the pest resistant variety **ALBARFQ902** were likely to adopt more IPM practices. Experience with pesticide-related health problems did not significantly affect IPM adoption, suggesting there is still a greater need to sensitize farmers about the health risks of using pesticides. It may be that using IPM does not significantly reduce these risks hence the link between pesticides and human health should be further explored in the context of Zimbabwean smallholders.

3.8.1 Policy Implications and Suggestion for Future Research

Analysis of IPM practices being adopted, the characteristics of smallholders that are adopting and the factors motivating adoption of FFS-IPM is still fragmentary in Africa (Adesina, 1994). Our results indicate that diffusion factors such FFS-IPM training and farmer-to-farmer extension delivery approaches will play a critical role in the delivery and adoption of IPM. Success of IPM adoption will depend on farmer's knowledge and awareness of the technology. Further, rapid adoption could occur if farmers complement adoption of IPM practices with a conscious choice on HYV varieties that confer pest and disease resistance qualities such as **ALBARFQ902**. Both economists and policy makers involved in crafting incentives for widespread diffusion and adoption of FFS-based cotton IPM need to target not only farmers with large cotton acreages but also smaller farmers when planning future IPM programs in Africa. In addition, information about type of farmers most likely to adopt IPM technology and the extent of its adoption is expected to guide agro-chemical firms in their future new product development and marketing strategies given that one of the dimensions of IPM is to emphasizes the use of safer and less toxic products. The pesticide-related health effects require further research to determine their costliness and also their impact on the net benefits of pesticides use under smallholder conditions. As farmers become aware of the health risk costs, it is expected that they will pay more attention to the health factors in IPM adoption decisions. Also, gaps exist in terms of understanding the sequence followed by smallholders in adopting individual IPM practices during its diffusion cycle. Future research must therefore determine the risk-reducing role of individual IPM practices and the bundling strategies used by smallholder cotton growers in adopting compatible combinations of different IPM techniques.

Table 3.1:Descriptive statistics on variables used in Poisson Regression Model

Variable Name	Definition	Units	Mean	Standard Deviation
Dependent Variable				
Number of IPM practices	Count of IPM practices	count	4.36	1.62
Farmer's Characteristics				
HHAGE	Farmer's age	years	46.25	14.26
COTYEARS	Cotton growing experience	years	14.21	10.37
COTEXMTG	Number of extension meetings	number	4.64	6.36
EDUCYEARS	Number of years in formal education	years	6.57	3.72
HGENDER	Head of household's gender	(0,1)	0.83	-
MASTERFM	Certified Master Farmer	(0,1)	0.26	-
Farm Resource Endowment				
LABDAYS	Total labor used in production	man-day	80.93	43.06
COTAREA	Land area cultivated to cotton	(Ha)	4.55	3.97
PROASSET	Value of productive assets	(Z$)	9,506.41	8,298.98
CREDIT	Farmer used credit	(0,1)	0.18	-
DRAFTOWN	Farmer owns draft power	(0,1)	0.69	-
FOMEMPLT	Farmer is in formal employment	(0,1)	0.47	-
Farm Management Practices				
ALTCROPM	Maize is major alternative crop	(0,1)	0.08	-
ALBFQ902	Cotton variety ALBARFQ902 grown	(0,1)	0.81	-
FALLOW	Field was fallowed previous year	(0,1)	0.42	-
NROTPROG	No specific crop rotation program	(0,1)	0.13	-
TILPRACS	Number of tillage practices	number	1.43	0.87
Pest Damage Variable				
PSTPRESS[21]	Pest pressure (scale 0-1)	index	0.46	0.61
Institutional and Relative Prices				
MEDIA	Farmer has access to information media	(0,1)	0.67	-
AVEWALKT	Average walking time to cotton fields	minutes	12.97	15.78
DISTMKT	Distance to markets	(km)	13.49	7.69
Pesticide-Related Health Risks				
ACUTESYM	Pesticide-related acute symptoms	number	1.13	0.84
SAFINDEX	Count of protective clothing	count	3.75	1.53
LABELIT	Count of correct label interpretation	count	2.16	1.26
HHDRINK	Farmer drinks alcohol	(0,1)	0.48	-
Technology Awareness and Perception				
IPMAWARE [22]	Farmer's experience in FFS-IPM	years	0.83	0.93
YLDRISK[23]	Downside yield risk perception	index	2.61	2.82
PMGTVIEW	Maintain calendar-based methods	(0,1) 0.65	-	-

[21] Pest Pressure Index =$\sum$ (pest pressure)/39. The pest pressure indicators are 0=None, 1= Light 2= Average and 3=Severe. The pest pressure is assessed for 13 different cotton pests where a count of 39 represents severe cases for all cotton pests.

[22] IPMAWARE is measured as post FFS-IPM training years; 0=no IPM training, 1= 1998/99 FFS graduate and 2=1997/98 FFS graduate.

[23] Downside yield risk=$(Y_M-Y_L)^2$ where Y_M represents mean cotton yield and Y_L is the perceived lowest cotton yield from the main cotton field during a poor season. The assumption is that farmers care more about downside yield risk.

Table 3.2: Determinants of Cotton IPM Practice Adoption in Sanyati District, 1998/99

Variable	Coefficient	Standard Error	Z-value
Farmer Characteristics			
HHAGE	-0.0002	0.0044	-0.0460
COTEXMTG	0.0072	0.0074	0.9700
COTYEARS	0.0008	0.0058	0.1400
EDUYEARS	0.0100	0.0140	0.7500
HGENDER	0.1200	0.1400	0.8400
MASTERFM	-0.1100	0.1100	-0.9700
Farm Resource Endowment			
LABDAYS	-0.0003	0.0013	-0.2300
COTAREA	*0.0230	0.0120	0.0190
PROASSET	0.0032E-5	0.0064E-5	0.5000
CREDIT	0.0430	0.1300	0.3400
DRAFTOWN	-0.1700	0.1200	-0.1400
FORMEMPLT	-0.0380	0.1000	-0.3600
Farm Management Practices			
ALTCROPM	-0.1200	0.2000	-0.6100
ALBFQ902	*0.2600	0.1400	0.0190
FFALLOW	0.1100	0.0960	0.0100
NROTPROG	-0.0580	0.1500	-0.3800
TILPRACS	0.0330	0.0710	0.4700
Pest Damage			
PSTPRESS	0.0030	0.0730	0.0410
Institutional and Environmental			
MEDIA	-0.0540	0.1100	-0.4900
AVEWALK	0.0006	0.0030	-0.1900
DISTMKT	0.0066	0.0081	0.8200
Pesticide-Related Health Risks			
ACUTESYM	0.0200	0.0650	0.3100
SAFINDEX	0.0340	0.0340	0.9900
LABELIT	-0.0150	0.0390	-0.3800
HHDRINK	-0.1000	0.1100	-0.9500
Technology Awareness and Perception			
IPMAWARE	***0.1900	0.0670	0.0290
YLDRISK	-0.0080	0.0170	-0.4600
PMGTVIEW	-0.0370	0.1000	-0.3500
N	**136**		
McFadden R-squared	**0.1022**		
Log Likelihood Ratio	**53.32**		
χ^2-p value	**0.0027**		

*=significance at 10%, **=significance at 5%, ***=significance at 1%

Source: Field survey, 1999

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Table A3.1: Cotton IPM Practice Probit Model Results for Sanyati District, 1998/99

Variable	Beneficial Pests	Cotton Rotation	Adjust Planting Dates	Adjust Spraying Frequency	Alternate Chemicals	Safer Chemicals	Trap Crops
Farmer Characteristics							
AGE	+ **	+	+	-	-	+	-
EDUCYEARS	+ **	+	+	+ ***	+	+	-
GENDER	-	-	-	+	+	+	+
COTYEARS	+	+	+	+	+	- *	+
Pesticide-Related Health Risks							
ACUTESYM	+	+	+	+ *	-	+	-
ALCOHOL	+	-	- **	+	-	-	- *
PCLOTHES	+ *	+**	- **	+	+	+	+
Farm Resources							
COTAREA	+ ***	+	-	+ **	+ ***	+ **	+
DRAFTOWN	-	-	- *	-	-	-	- **
LABOUR	-	- **	+	+	-	-	-
PROASSETS	+	-	+	-	+	+	+
FORMEMPL	-	-	+ **	-	-*	+	+
Farm Practice(s)							
TILLAGE	- **	+	+	-	- *	+	-
Pest Damage							
PSTPRESS	+	-	-	-	-	+	-
Institutional							
CREDIT	- ***	+	+ *	-	-	-	+
COTEX	+	-	+ ***	+ **	+ ***	+	-
MEDIA	+	+	+ **	-	-	- ***	+
Technology Awareness & Perception							
IPMAWARE	+ ***	-	+	+	-	-	+ ***
IPMVIEW	+	+	+ ***	+ ***	+*	+ ***	-
YLDRISK	- *	- **	+	-	+**	+	- **
PMGTVIEW	-	+	- **	+	-	- *	+ *
GROWSTRG	+ **	-	-	-	+	-	+
N	138	138	138	138	138	138	138
McFadden R^2	0.62	0.36	0.43	0.43	0.26	0.43	0.60
L.L. Ratio (χ^2)	106.08	32.90	58.5	65.75	45.76	55.90	67.16
χ^2-p value	0.00	0.06	0.00	0.00	0.00	0.00	0.00

Source: Field Survey, 1999

Table A3.2: Cotton IPM Practice Probit Model Results for Chipinge District, 1998/99

Variable	Cotton Rotation	Adjust Planting Dates	Adjust Spraying Frequency	Pest Scouting	Alternate Chemicals
Farmer Characteristics					
AGE	-	+	-	+	+
EDUCYEARS	-	-	-	+	+
GENDER	-	+	-	+	+
COTYEARS	+	-	+	+	+
Pesticide-Related Health Risks					
ACUTESYM	-	-	+ *	+	+
ALCOHOL	+	-	-	-	-
PCLOTHES	-	+	-	-	-
Farm Resources					
COTAREA	+	+	+	+	+
DRAFTOWN	+	-	-	-	-*
LABOUR	+	-	-	+*	+
PROASSETS	-	-	-	+	-
FORMEMPL	+	- *	-	-	+
Farm Practice(s)					
TILLAGE	+	+	+	+*	+
Pest Damage					
PSTPRESS	-	-**	-	-	-
Institutional					
CREDIT	+	+ *	+	-	+
COTEX	-**	-	- ***	-	-
MEDIA	-	-	-	+	-
Technology Awareness & Perception					
YLDRISK	+	-	-	-***	-*
PMGTVIEW	+	+*	+	+**	+***
GROWSTRG	-	+	+***	+	+***
N	130	130	130	130	130
McFadden R^2	0.17	0.19	0.37	0.30	0.22
L.L. Ratio (χ^2)	28.97	29.41	47.34	45.80	35.86
χ^2-p value	0.08	0.08	0.00	0.00	0.00

Source: Field Survey, 1999

Note: Probit model for burning stover (field sanitation) was insignificant. No farmer used beneficial insects and trap crops as pest management strategies while less than 10% reported using safer chemicals in their pest management decisions, thus making it statistically impossible to estimate probit models based on such rare practices in Chipinge District.

Table A3.3: List of Cotton IPM-related Practices Used in Survey Areas, 1989/99

COTTON IPM-RELATED PRACTICES	SANYATI DISTICT (%)	CHIPINGE DISTRICT (%)
A. Biological Control		
1.Beneficial insects	31	0
B. Cultural Control		
2.Crop rotations	87	41
3.Field sanitation	97	91
4.Trap crops	14	0
C. Selective Chemical Control		
5.Alternating chemicals	32	31
6.Use of safer chemicals	18	7
7.Adjust frequency and timing of pesticide sprays	23	18
D. Strategic Control		
8.Adjust planting dates	19	28
9.Pest scouting	89	71

Source: Field survey, 1999

CHAPTER 4

COTTON SUPPLY RESPONSE TO MARKET LIBERALIZATION IN ZIMBABWE

4.1 Introduction

Structural change in the agricultural and food system has been receiving increased attention in the last couple of years. The motivation for structural adjustment programs (SAPs) is to address problems of declining agricultural output, limited commercial import capacity, and stagnating economic growth due to distorted pricing and exchange rate policies leading to loss of competitiveness in international markets (Lele, 1990; Jaeger 1992; Ngeno, 1996; Rodrik, 1990). The cornerstone of the reforms is the promotion of private sector participation and the liberalization of agricultural pricing and marketing.

Much debate has focused on SAPs failure to eradicate the problems of deepening poverty on the African continent (Gulhati, 1989; Husain, 1994). The economic hardship facing the poor provides ample evidence that trickle down effects never occurred with the adoption of SAPs (Longhurst, 1988;Quarcoo, 1990). Most SAPs are integrated packages and slippage in one area could have profound impact on the outcome in other areas. In addition, each reform has different impact on the various segments of the population creating both winners and losers (Bates, 1993; Husain, 1994). Consequently, the effects of SAPs, and the constraints arising from them, require careful analysis. Moreover, country experiences show a diversified pattern in terms of the content, implementation process and impacts of SAPs, as other factors such as agrarian structure, frequency of natural disasters and level of prior investments affect performance outcomes (Kayizzi-Mugerwa et al., 1994).

Cotton is a strategic export crop in Sub-Saharan Africa (SSA) and in Zimbabwe it contributed 11% in total exports in 1997 (Zimbabwe Ministry of Agriculture (ZMOA), 1999). The most serious challenges facing cotton industries in SSA are likely to result from the liberalization of markets and the removal of subsidies following the adoption of structural adjustment programs (SAPs) and the abolition of government marketing boards in a number of countries (World Bank, 1995).

The key question this paper will address is this: What has been the response of Zimbabwe's cotton supply to SAPs, including the end of the Cotton Marketing Board (CMB) monopoly on seed cotton marketing and processing? The empirical analysis examines the response of cotton acreage to changes in relative prices, macroeconomic policies (i.e. exchange rates and interests rates), geo-political and institutional factors. The effect of drought, a major shock in the sub-region is also analyzed. To explore the differences in farm sizes, capital intensity, specialization and financial flexibility that make supply response between large scale commercial (LSC) and smallholder growers heterogeneous, we estimate two separate acreage response models.

There have been several recent attempts to understand the effect of economic policies on aggregate agricultural performance in SSA (Ogbu and Gbetibouo, 1990; Mlambo and Kayizz-Mugerwa, 1991). But, there are still few examples of studies that focus on supply response of individual cash crops in Africa (Bond, 1983; Jaeger, 1992; Savadogo et al., 1995;Makanda, 1996). In addition, uncertainty still prevails regarding what SAPs entail for the future of large versus smallholder cotton growers in Africa. Townsend and Thirtle (1998) looked at long run relationships between the major macroeconomic variables and agriculture in South Africa. Recently, Arndt et al., (2000) qualitatively analyzed stabilization and structural adjustment in Mozambique's economy. Magadhlela (1997) adopts a similar approach but focuses narrowly on smallholder irrigators in Zimbabwe. To the extent that previous research in Africa does not provide much illumination about reform impacts by scale of farm, the results of this paper have a bearing on these issues. Moreover, economists are concerned about SAPs as their impact has been mixed and it differs across countries (Putterman, 1995; Weissman, 1990). There is an active debate on the welfare impacts of the reforms leading to growing consensus on the need for human centered adjustment and adjustment with transformation (Kayizzi-Mugerwa et al., 1994; Longhurst et al., 1988; Economic Commission for Africa, 1991). Not surprising, detailed studies on SAPs in East and Southern Africa have focused on the staple food crop maize (Masters, 1993; Argwings-Khodhelk, et al., 1993; Rubey, 1995). But more work remains to be done on the effect of SAPs on cash crops. Policy impact studies provide a road map for expanding agricultural supplies and are imperative whenever policies change significantly (Ramaswanmi, 1993; Chen and Ito, 1992).

Masters (1993) provides an ex-ante critical analysis of proposed maize reforms in Zimbabwe and their implications for short run competition and long run efficiency goals. What is different about our study is that we take an ex-post analysis of the reforms in cotton, a leading cash crop for smallholders. Instead of focusing on SAPs alone, we extend our analysis to include other external shocks that could derail intended outcomes. Zimbabwe's agriculture is dualistic[24] with highly sophisticated LSC farms average size 2,000 hectares (ha) co-existing with numerous smallholder farms that average about 2ha.

[24] Zimbabwe's LSC farmers have title deeds and can use their land as collateral for bank loans while smallholder farms have communal ownership of land; they have usufructory rights but do not have rights to sell, lease or mortgage the land.

In this vein, the two acreage response models help us characterize the current structure of Zimbabwe's cotton production more accurately. Highlighting the diversity in SAP outcomes is important for two reasons. First, it allows the identification of successes and failures and it brings to the fore the fact that aggregate trends can hide significant differences in policy outcomes. Second, awareness of the distributional impacts of SAPs helps policy makers set priorities, concentrating action where they are most needed. As Zimbabwe undergoes SAPs, given its agriculturally based economy, sustained cotton supply is critical to three areas of government objectives in agriculture: 1) expansion of smallholder income earning opportunities 2) improvement of rural infrastructure and employment opportunities and 3) reduction of balance of payment deficits given that about 70% of the cotton produced in Zimbabwe is exported (Sithole and Attwood, 1990; Zimbabwe National Development Plan, 1991).

4.1.1 Overview of Cotton Production Challenges in Africa

Cotton production in Africa dates as far back as the late 18th century when European colonial authorities introduced it in East and Southern Africa in order to reduce dependency on South American imports (Isaacman, 1996; Gibbon, 1998). In West Africa, the evolution of cotton production is associated with the pioneering work by the French dating back to the second half of the 20th century (Fok, undated). Cotton is now successfully grown in more than 30 African countries and the annual market value of African lint exports is approximately US$1 billion. SSA accounts for 4.5% of world cotton production and its share of internationally traded cotton lint was 14% in 1995 (Lele, 1989; Gibbon, 1998). Although cotton has been one of SSA's few exports success stories in recent years, export diversification and food self-sufficiency have often sparked huge policy debates. Consequently, cotton has undergone metamorphosis in the African development literature moving from ascent to decline and to "rehabilitation" (Eicher and Rusike, 1995). Cotton came under severe attack in the 1960s and early 1970s during Africa's food crisis leading to the 'food first paradigm' sharply critical of cash crop expansion. Growing consensus that the "food first" lobby greatly overstated its case against cash crops has now emerged (Maxwell and Fernando, 1989). Further, poor economic growth rates combined with the debt crisis partly attributed to overvalued exchange rates led more countries to shift to export-oriented strategies in the mid-1980s (Dibley et al., 1996; Smith, 1989; Godfrey 1983). In the late 1980s and 1990s, cotton returned to the spotlight with more scientific work advocating its critical role in raising farm incomes, food security and national foreign exchange generation (Bingen, 1998; Dione, 1989; Gibbon, 1998; Jayne, 1992; Stringfellow, 1996; Strasberg et al., 1997). Cotton industries in Africa are facing several strategic issues that will affect both the profitability and sustainability of cotton even in countries with comparative advantage in cotton production (World Bank, 1994). The loss of market share for SSA countries, the demand depressing financial crisis in Asia in 1990s, and the huge production swings in China and India have added momentum to the volatility in world prices raising new concerns about marketing and financial risks crippling the cotton industry (FAO, 1997; World Bank, 1995;Lele, 1989). Highly volatile prices and market share contraction has lead to undesirable fluctuations in farm incomes, foreign exchange revenues and the raw material supply of textile industries in Africa. Above all, the effect of SAPs on the competitive advantage of cotton industries in Africa still remains unclear and uncertain.

Questions still linger about how reforms can revive African agriculture (Kelly, 2000; Anandajayasekerum, 2000).

4.1.2 Contemporary Issues in Cotton Production in Zimbabwe

In Zimbabwe, cotton production is at a turning point. The rapid growth in post-independence smallholder cotton production and marketing at a time when LSC sector is diversifying into greenhouse production of horticultural and floricultural crops for export market requires close scrutiny. Zimbabwe's cotton production has historically been concentrated in the Natural regions[25] III, and IV although new varieties suitable for cultivation in higher elevations more than 1200m above sea level have recently been developed (Zimbabwe Cotton Handbook (ZCH), 1998).

Zimbabwe's first post-independence cotton revolution occurred between 1980 and 1985. During this period smallholder cultivated area increased dramatically by 120% (Figure 4.1). The return to peaceful conditions in the rural areas after a protracted war of liberation, and the lifting up of international sanctions provided a favorable environment for the dramatic growth in cultivated area (Chimedza-Mabeza, 1999; Rorhbach, 1989; Mlambo, 1997). Further, key factors responsible for the dramatic increase in smallholder cotton cultivation in the early 1980s are the upsurge in the number of rural cotton depots and the clearance of tsetse flies from Gokwe, a high potential cotton area (Govereh, 1999; Rukuni, 1994). As a result, the numbers of officially registered cotton growers increased rapidly from about 80,000 farmers to more than 300,000 between 1983 and 1992 (Blackie, 1983; Jowa, 1996).

The smallholder acreage growth momentum slowed down between 1985 and 1995, and it's generally attributed to two major droughts in 1986/87 and 1991/92. The slow implementation pace of the resettlement program due to government budgetary constraints could be a critical factor given that previous efforts to resettle the landless have concentrated in Natural Regions III, IV and V where cotton is the most dependable crop Mariga (1994). Kupfuma (1998) cites a severe reduction in support services ear-marked for smallholders between 1986 and 1994; with Agricultural Finance Corporation (AFC) credit loans allocated mostly to farmers in high rainfall areas leaving the bulk without access to essential credit.

However, a major recovery (i.e. the second revolution) occurred after 1995 as the area cultivated increased by about 60% between 1995 and 1999 (Figure 4.1). Perhaps a crucial factor explaining the second revolution is the end of the civil war in Mozambique and the signing of the peace accord[26] in 1992 (Arndt et al., 2000). The end of hostilities stimulated massive cotton expansion in the South East Lowveld that borders the Central Region of Mozambique. Further, the region's unique Vertisols[27] enabled smallholders to grow cotton without fertilizer, allowing significant savings in input costs.

A different pattern seems to characterize the LSC cotton acreage trends. Before 1980, LSC growers dominated cotton production with an insignificant amount coming from the smallholders. By 1985/86, LSC farmers contributed 60% of the national share of cotton output, down from about 90% in 1980. More significant contraction in LSC cotton

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[25] Agro-ecological zones demarcated on the basis of rainfall pattern, soil type and agricultural production potential. Zimbabwe has 5 such regions, and the risk of crop failure due to drought increases as one moves from natural region I to V.
[26] Following negotiations in 1991, peace was agreed on in 1992, and it was accompanied in October 1994 by free and democratic elections whereby Joachim Chissano was elected President (Arndt et al., 2000).
[27] Vertisols constitute about 5 percent of the land area or 1.2 million ha in Zimbabwe. The largest area is found in the South East Lowveld in natural region IV. These soils are mainly derived from basalt and are

occurred when cultivated area reached an average of 64,000 hectares in the 1990s compared to an average of 80,000 hectares in the 1980s (Figure 1). As a result, LSC average annual output dropped to 77,000 tons in the 1990s compared to 150,000 tons in the 1980s. In addition to the poor farm-gate prices and rising production costs, other causes for the major decline in LSC cotton production includes adverse weather conditions, emergence of *verticillium* wilt as a serious disease in some areas, poor quality planting seed in 1989, and loss of confidence in the Cotton Marketing Board (CMB) (Gillham, 1993). Further, the introduction of minimum wage legislation and stringent labor regulations may have contributed to stagnation in LSC cotton acreage (Billing, 1985; Mlambo, 1997; ZCH, 1995).

During the past two decades, the structure of cotton production in Zimbabwe has changed radically. In the late 1980s, LSC farmers diversified into unregulated crops such as tobacco and horticulture while smallholders now provide the bulk of national output (67% in 1998) thus making cotton the most important cash crop in the communal areas.

4.1.3 Adoption of Structural Adjustment Programs (SAPs) In Zimbabwe

Zimbabwe adopted the World Bank/IMF-inspired SAPs in 1990, in response to severe external shocks and emerging macroeconomic imbalances. The SAP package consisted of:(1) flexible exchange rate policy, (2) state-owned enterprise restructuring and reform, (3) marketing and pricing policy liberalization and (4) export promotion and diversification (Sithole, 1996). Zimbabwe's reform program resembles similar programs in many other African countries.

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highly fertile due to their strong nutrient and water holding properties Nyamudeza et al. (undated).

In cotton, the CMB had a GOZ-mandated monopoly in terms of seed cotton purchases and distribution of cottonseed. Throughout the 1980s, extensive controls existed on cotton prices and marketing. Pan-territorial (i.e. no geographic price differential) and pan-seasonal (i.e. no seasonal price differential) pricing policy operated for most controlled crops including cotton, and producer prices were set pre-harvest (Takavarasha, 1992). Nonetheless, CMB began to face financial problems as a pattern set in of high budget deficits, weak management and motivation, delayed payment for farmers and high interest rates. The next major challenge was to sustain the CMB by making it more efficient, transparent and internally accountable.

The introduction of SAPs led to the subsequent demise of the CMB monopoly in 1993/94 and it gave birth to COTTCO, a privately owned company quoted on the Zimbabwe Stock Exchange (ZSE) in Harare. The transformed company has as its shareholders, farmers, workers and government. The adoption of SAPs allowed an era of competition and eliminated a financial burden for the GOZ after having subsidized the losses of the CMB for more than a decade. Liberalization enabled the entry of COTPRO and CARGILL Inc.(a large US based agro-business company) as new players in the cotton industry in 1994/95 and 1995/96 respectively. Sheltered for decades from competition, CMB has lost some market share to the emerging competitors although it still operates as a regional monopoly in some geographic locations, a factor attributed to the limited ginning capacity of rival firms. This study recognizes that reviving and sustaining the "white revolution" in Zimbabwe requires compelling evidence on the implications of SAPs on the performance of both LSC and smallholder cotton growers. It draws lessons for other SSA countries along with some concluding remarks for further research.

4.2 Methodology and Data

4.2.1 Theoretical Model for Cotton Supply Response

Assume the goal of Zimbabwe cotton farmers is profit maximization and let the concave cotton profit function be $\pi(p, r_1..r_n)=py(x)-\sum r_i x_i-TFC$ for $i=1...n$ and the resulting indirect expected profit function is given by $\pi^*=\pi^*(p, r_1..r_n, B)$. Using Hotelling's lemma, the first derivative of profit function gives us the cotton supply function $\partial\pi/\partial p=y^*(p, r_1,..r_n)$ where p is the product price, and $r_1..r_n$ are the prices of variable inputs used in producing cotton output y and TFC is total fixed cost associated with a vector of fixed inputs B. Nerlove's naïve functional form of acreage response to prices states that desired acreage is a linear function of expected prices:

$$(1)\ A_t^*=a_0+a_1P_t^*+a_2Z_t+u_t$$

where A_t^* is the expected cotton cultivated area in period t, P_t^* is the expected price in period t, The vector P_t^* comprises prices expected by the farmer in future periods. If farmers rely on past information of the series when planning production to maximize profits, then the expected prices are functions of past prices $P_t^*=\lambda(P_t, P_{t-1}, P_{t-2},...)$ (Sarmiento and Allen, 2000, Martin, 1992). Additional supply shifters Z_t in period t include prices of substitute and complementary crops, government policy, technological change and weather, and u_t is the stochastic error term. Desired acreage behavior is hypothesized as:

$$(1)\ A_t-A_{t-1}=\delta(A_t^*-A_{t-1})$$

where LHS represents actual change in acreage between two periods, $A_t^* - A_{t-1}$ is the desired change between two periods, and δ is known as the coefficient of adjustment with range $0 < \delta < 1$. Therefore, rearranging equation *(2)* we have:

$$(3)\ A_t = \delta A_t^* + (1-\delta)A_{t-1}$$

Substituting the desired acreage *(1)* above and the Nerlove price expectations $P_t^* = P_{t-1}$ into *(3)* gives us the acreage response model:

$$(4)\qquad A_t = \delta_0 + \delta_1 A_{t-1} + \delta_2 P_{t-1} + \delta_3 Z_t + u_t$$

Estimates of price responses have also been obtained from functional forms based on actual yield equations presented below:

$$(5)\qquad Y_t = \beta_0 + \beta_1 Y^p + \beta_2 P_{t-1} + \beta_3 Z_t + e_t$$

where Y_t is actual yield at time t and Y^p is potential yield at time t given by $Y^p = \sum \alpha_i A_{t-i}$ for $i=1...k$ where $k=1$ for annual crops (Bond, 1983). Past studies have demonstrated the role of farm sizes in supply response analysis (Adelaja, 1991; Sedjo and Lyon, 1996). As already noted, the dichotomy in Zimbabwe's cotton production in terms of external input use, scale of operation, yields, and property rights allows us to model cotton supply response as two separate functions. Also, the recommended long-staple irrigated LSC cotton varieties differ considerably from the rain-fed medium staple varieties grown mostly by smallholders, which further justify our disaggregation approach (ZCH, 1998). The basic differences between these varieties create grade differences that fetch distinct prices leading to different price responses. Further, because LSC farmers tend to have irrigation, drought has differential impacts across the two sectors. In addition to the risk management ability attributed to variations in capital intensity and economic status of the growers, the adjustment process is influenced by factors like differential access to productive land, and to credit and product markets.

Although the GOZ traditionally announces post planting or pre-harvest prices during the month of March or April, at planting time in October farmers must anticipate the future government-determined cotton price. Given the GOZ's policy of annual review of agricultural prices, we assume that cotton growers' price expectations are systematically formed in a forward-looking manner, suggesting that Zimbabwe's cotton farmers have rational rather than naïve price expectations[28]. After SAPs, the Zimbabwe Maize Commodity Exchange (ZIMACE) and COTTCO have offered more opportunities for forward fixed price contracts to growers further justifies the rational expectations argument (COTTCO, 1996). The formation of price expectations has been reviewed extensively in the literature (Askari and Cummings, 1976). We expect that cotton acreage will be positively and inversely correlated with its own price and price of substitute crops respectively.

In SSA, weather plays an important role, as most agricultural production is rain-fed. It is estimated that at least 60% of SSA is vulnerable to drought and up to 30% is highly vulnerable (Benson and Clay, 1998). The role of risk in supply response has been noted (Antonovitz and Green, 1990). Other work has used residuals from yield trend model as a proxy for quantifying climatic risks (Jaeger, 1992). In addition to the negative effect due to climatic risks, a number of African countries have been coping with conflicts and civil strife which have devastating effects on their agriculture (Lele, 1990;

[28] We assume that expectations are formed in a rational or forward-looking manner rather than an adaptive (backward-looking or naïve) manner. Rational expectations assume economic agents use current and relevant information in forming expectations and do not solely rely on the past (Gujarati, 1995; Soludo, 1998).

Messer et al 1998). Civil war is linked to destruction of physical, human, and social capital including disruption of markets and other forms of social and economic order (World Bank, 2001). External factors like trade deficits and the debt burden have also been hostile to growth and development in Africa (Ajayi, 1994). In addition to addressing the structural imbalances, SAPs have serious social and economic consequences. In Zimbabwe's case, we expect exogenous shocks like ***ESAP*** and peace in Mozambique ***MOZPEACE*** to have positive supply response effect among the cotton growers.

Some SSA countries such as Malawi, Tanzania and Mozambique have had a history of forced cotton acreage although this has not been the experience of Zimbabwe (Isaacman, 1996; Kydd, 1982; Shapiro, 1974). In the absence of forced cotton acreage, we assume independent cotton acreage decisions are a good proxy for the aggregate cotton supply in the respective subsectors (Ogbu and Gbetibouo, 1990; Bond 1983). Also, area planted is under the control of the farmer to a much greater degree than output, which is subject to drought, pests and other exogenous shocks (Townsend and Thirtle, 1997). As in conventional supply analysis, current period acreage is highly correlated with acreage in previous years (Martin, 1998, Parhusip, 1976). Considering this, the dependent variable is lagged one time period as an independent variable. The lagged acreage for the LSC ***LLSAREA*** and smallholder farmers ***LCAREA*** respectively are expected to have a positive effect on acreage response.

Agricultural output prices, input costs, exchange rates, wages, interest rates, market imperfections and information are central to most discussions on responsiveness of agriculture to policy and should be taken into account (Jaeger, 1992; Townsend and Thirtle, 1998). The annual government guaranteed prices are used as output and input price expectations. The prices are assessed in nominal terms as this represents what the farmers use in their land allocation decisions. Since tobacco has not been a controlled commodity, we used the average annual price at the Zimbabwe Tobacco Auction Sales Floors. Maize and sorghum are the two major crops that compete with cotton for land and labor in the smallholder sector while tobacco is considered the leading competitor in LSC agriculture. The input price used in the model is ammonium nitrate fertilizer prices ***ANFPRICE***. We assume that a rise in fertilizer price induces a reduction in cotton acreage.

Macroeconomic variables that form part of our analysis are nominal exchange rates ***EXCHRATE*** and interest rates ***INTEREST***. The exchange rate is a measure of agricultural competitiveness (Dibley et al., 1996). It also captures the financial risk induced by international price distortions in both factor and product markets. Zimbabwe exports about 70% of her hand picked cotton to niche markets in Europe, the Far East, South Africa and South America. Also, exchange rate devaluation[29] is a critical determinant of the distribution of income in a country as it influences the returns to producers or consumers of tradable goods. Devaluation has a dual effect on the profitability equation. On the revenue side, it raises the dollar price of internationally tradable export commodities like cotton relative to non-tradable but on the cost side it increases the price of imported machinery, and it spurs domestic inflation which can "undo" its potential benefits (Dibley, et al., 1996; Poulton, 1998). Smith[a] (1989) also notes that devaluation timing, export taxes, and unequal market bargaining power may

[29] Exchange rate devaluation is a reduction in the nominal value of the local currency relative to another currency or group of currencies and it represents an *increase* in the cost of foreign exchange when paid for in local currency (Dibley et al., 1996).

"cream off" potential producer price increase from devaluation. Its effect on acreage response cannot be determined a priori.

Access to capital is critical in any supply response model and interest rates are a proxy for LSC growers' access to productive capital in support of cotton cultivation. We also expect the level of legislated minimum wage ***MIWAGE*** to affect cotton acreage response. It is reasonable given that cotton cultivators use hired labor especially during labor–peak periods like weeding and harvesting. The price of labor used in the final model is the official minimum wage in Zimbabwe. We expect a rise in wages to increase production costs and hence lower the cotton acreage. Higher wages increase the attractiveness of off-farm employment and thus offer disincentives to smallholder cotton acreage expansion (Kydd, 1992). However, the negative effects are easily diluted by the practice of voluntary labor exchange among the rural households.

Key non-price factors such as physical infrastructure, credit, extension and research also play a major role (Lele, 1989; Savadogo et al., 1995). Change in technology are a dominant factor in explaining supply response although there is no direct measure of "changes in technology" hence the use of a proxy such as time which assumes a smooth change in technology of equal amounts each period (Townsend and Thirtle, 1997). Cornia et al., (1987) observes that supply capacity in Africa is severely constrained by technical training. This study uses the annual number of graduates at the Cotton Training Center as a proxy for technology development and transfer. We expect the trained graduates to make more informed choices about land allocation, and to implement innovative ideas in choosing cotton varieties, pest scouting, soil and water management, and record keeping. The training variable is expected to positively influence both smallholder and LSC cotton acreage. Other important non-price supply shifters analyzed include size of the smallholder cattle herd that represents access to draft power, a form of rural capital (Eicher and Baker, 1982; Savadogo et al., 1995). Draft power variable was excluded in the final model, as it was statistically insignificant.

Due to limited data range, we could not estimate models with a rich lag structure, as it would have reduced both the degrees of freedom and the measurement power of the estimated model (Sarmiento and Allen, 2000). Given that the range for our data is 17 years, we decided to adopt a more parsimonius model. Variables included in the final model are grouped into four categories; farm size, product and factor prices, macroeconomic and institutional variables, and exogenous factors.

The LSC and smallholder supply models differ in terms of Z_t values and relative prices. Macroeconomic variables such as ***EXCHRATE*** and ***INTEREST*** are deliberately excluded from the smallholder model. Exchange rate movements are more likely to affect acreage decisions and hence export revenue for LSC farmers who face competing needs for land for diverse export crops such as tobacco, flowers, paprika and soybeans. More importantly, changes in the exchange rate affect the rental price of imported machinery and machinery parts. We expect the exchange rate to influence the LSC cotton growers' diversification strategies more than smallholders who use hoe-cultivation. The latter's acreage decisions are more likely to be influenced by household consumption decisions suggesting that land allocation between food and cash crops is a paramount factor which is captured by the inclusion of the relative price of the substitute crops. Further, the information gap makes it highly unlikely for them to use the exchange rate in their acreage decisions.

Nearly all LSC cotton growers have collateral and hence ready access to financial credit. It is therefore reasonable to assume that fluctuations in interest rates affects LSC farmer's access to capital, and is a critical ingredient for their acreage decisions. Since LSC cotton grower's operations are highly mechanized, we consider the variable cattle as irrelevant in the specification of their acreage response model. Instead, cattle is considered a proxy for capital in smallholder agriculture but was eventually dropped from the final model as it turned out insignificant. Supply response model specification requires a clear understanding of the farming system. As already highlighted, food crops compete with cotton for land and labor in Zimbabwe's smallholder agriculture while in the same vein tobacco competes with cotton on LSC farms. This explains why the relative prices are different in the two models. It is also important to note that autoregressive supply response models are subject to specification errors and diagnostic tests are needed to correct any such problems (Greene, 1997; Ferris 1998).

4.2.2 Empirical Econometric Model

From the fore-going considerations, we present the general structure of the auto-regressive cotton acreage response model estimated:

(5)(LSC cotton acreage)$_t$ = f(lagged acreage, product prices, input prices, macroeconomic factors, institutional factors, exogenous shocks)

The smallholder acreage supply model is similar, except that macroeconomic variables are excluded as largely irrelevant.

(6)(Smallholder cotton acreage)$_t$= f(lagged acreage, product prices, input prices, institutional factors, exogenous shocks)

The empirical models are specified mathematically as follows:

$$(7)\ LSAREA = \lambda\ (LLSAREA, COTTONP, TOBACCOP, ANFPRICE, WAGE, TRAINING, EXCHRATE, INTEREST, LDROUGHT, MOZPEACE, ESAP) + e_t$$

$$(8)\ CAREA = \phi\ (LCAREA, COTTONP, MAIZEP, SOGHUMP, ANFPRICE, WAGE, TRAINING, LDROUGHT, MOZPEACE, ESAP) + u_t$$

4.2.3. Data Considerations

The data used in the analysis were obtained from various publications (Table 4.1) including the Zimbabwe Ministry of Agriculture (ZMOA, 1999), Central Statistical Office (CSO) (1989), Reserve Bank of Zimbabwe (RBZ), (RBZ, 1995), Cotton Training Center (Jarachara, personal communication), and the National Employment Council (NEC). These sources provided quantitative data on annual cultivated cotton area, yields, crop producer prices, fertilizer prices, interest rates, wages, exchange rates and training levels at CTC. Most of the data covers the period from independence in 1980 to 1997. Our analysis focuses on this period first, because of the extensive controls that existed in cotton pricing and marketing policy before 1990. Second, because we are interested in analyzing the impact of SAPs implemented in1990 by the GOZ. Third, because of the reliability of aggregate level data collected after the war period, such data offers the background for understanding cotton's acreage historical transformation and its growth potential.

4.3. Empirical Results

Several diagnostic tests[30] were conducted to address the problem of model misspecification. Both the LSC and smallholder cotton acreage series were stationary and

[30] Inspection of corellograms and preliminary unit root tests were made on all variables included in the final model. Both the Dickey Fuller (DF) unit root tests and corellograms showed no evidence of non-stationarity in the variables. The reported standard errors were corrected for a general form of

did not show any trends or random walk components. Since degrees of freedom were a premium, we estimated a structural model with parsimonious set of parameters. The supply response models use data in levels rather than logarithms based on results of MWD and RESET tests. Supply response modeled as differenced equations were rejected due to theoretical consistency problems. Secondly, potential loss of long-term relationships between cotton acreage and relevant economic variables resulting from use of differenced model enabled us to work with the levels model [Gujarati, 1995]. The explanatory power of the models is high as both regressions are highly significant. The coefficients of acreage adjustment for LSC and smallholders are respectively 0.78 and 0.61 although the former is insignificant. Based on the evidence, we infer that 61% of the discrepancy between the desired and actual smallholder cotton acreage is eliminated in a year.

4.3.1 Large Scale Commercial Cotton Supply Response Results

Results show that contrary to policy makers' expectations, the implementation of SAPs has contributed to a significant reduction in LSC cotton acreage in Zimbabwe (Table 4.2). The coefficient for SAP is negative and significant at 5% level. The result suggests evidence of structural change in LSC cotton cultivation due to SAPs. Expected SAP-induced cotton acreage expansion may have been undone by rising inflation rates, electricity prices, railway tariffs and the high cost of manufactured inputs resulting in a

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heteroscedasticity using the Huber-White method. Based on CRDW test for co-integration, neither model exhibits spurious regressions, as all the explanatory variables included in the respective models were cointegated with acreage at 5% and higher, a positive sign for stable long run relationship (Gujarati, 1995). The RESET test for functional form misspecification yields a value of 6.25 (LSC) and 0.45 (smallholder) less than the respective critical values of 7.71 and 5.99, indicating failure to reject the hypotheses of correct functional form. The MWD test identifies the levels model as suitable functional forms for both farmer groups.

negative impact on LSC cotton acreage. SAPs may also have added momentum for LSC growers to diversify out of cotton production as illustrated by a major downturn in cotton acreage after 1989. Given that SAPs are still ongoing under the Zimbabwe Program for Economic and Social Transformation[31] (ZIMPREST), their full impact can only be felt at the end of this program.

Among LSC farmers, there is evidence of negative acreage response to the Mozambique peace process although it barely achieves statistical significance. We postulate that the peace settlement which saw the repatriation of Mozambican refugees back to their country may have resulted in the disappearance of previously available cheap labor making it more difficult for LSC farmers to find cotton pickers (Magadela, 1997). Further, the development of machine pickable varieties by the Cotton Research Institute is in response to decreasing hand picking labor supply following the departure of Mozambique refugees (ZCH, 1995).

As expected, the coefficient for minimum wage ***MIWAGE*** has a negative significant impact on acreage. The negative sign provides evidence of economic hardship facing LSC growers following the legislation of minimum wages in agriculture soon after independence. As labor costs escalated, it became increasing difficult for LSC growers to hire contract laborers for harvesting cotton leading to a contraction in cotton acreage. The official minimum wage rose annually by about 32 % during the first decade of independence and it rose further by 21% per annum between 1990 and 1995.

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[31] The main objectives of ZIMPREST are synonymous with the GOZ's 1981 "Growth With Equity Policy" which are to: restore macroeconomic stability (low inflation and interest rates, stable exchange rates), facilitate public and private sector savings and investment, promote economic empowerment and poverty alleviation through employment creation and to strengthen safety nets for the disadvantaged groups (ZIMPREST, 1998).

Ammonium nitrate fertilizer price ***ANFPRICE*** has an unexpected positive and significant effect on cotton acreage. A number of explanations can give rise to this scenario. Lack of viable alternative fertilizers to Ammonium Nitrate could be a factor. A possible explanation also, is that a positive coefficient suggests the presence of substitution effects between fertilizer and land in Zimbabwe's commercial cotton production.

The cotton price coefficient for LSC acreage model is positive and significant at 5% level. The result indicates that prices do matter and can be powerful engines of transformation (Berg, 1995). This highlights LSC growers responsiveness to economic incentives brought about by higher cotton prices. The coefficient for tobacco prices ***TOBACCOP*** is significant and has the expected negative sign. The relative price effect is theoretically consistent as we expect tobacco to compete for land and labor inputs with cotton.

Among the macroeconomic variables, the coefficient for interest rate ***INTEREST*** is significant while that for exchange rate ***EXCHRATE*** is insignificant. The coefficient for interest rate ***INTEREST*** has a statistically significant negative effect on LSC cotton supply response. Interest rates negatively affect the financial position of growers as well as the level of capital deployment. Zimbabwe's nominal interest rates increased from 7.5% to 35.5% between 1980 and 1995 choking off potential investment in productive assets in support of cotton cultivation. High interest rates also exacerbate the level of farm indebtedness. The insignificance of the exchange rate variable should be put into context. Prior to SAPs, Zimbabwe had rigid controls in foreign exchange and the exchange rate was subjected to erratic depreciation in 1982, 1983,1988 and 1989. The over-valued exchange rates in the 1980s meant that cotton growers were explicitly taxed as they were paid less than the farm-gate export parity prices. More systematic exchange rate devaluation only started after liberalization when the Z$ fell from U$1.00: Z$2.64, in 1990 down to U$1.00:Z$38.00 in 1999. Whether the devaluations brought the exchange rate to equilibrium is debatable. However, realignment of the exchange rate is expected to generate positive incentives to expand cotton acreage. Nonetheless, the evidence clearly shows that LSC farmers are highly responsive to agricultural output prices.

4.3.2 Smallholder Cotton Supply Response Results

The smallholder model results shows that institutional factors such as resolving land constraints and improved knowledge through access to training matters most in efforts to stimulate cotton acreage expansion in Zimbabwe. However, the coefficient for SAP displays a statistically insignificant negative sign for smallholders.

A key result is that the coefficient for Mozambique peace ***MOZPEACE*** is positive and statistically significant at the 1% level. The result suggests that the peaceful conditions prevailing in the South East Lowveld after a protracted civil war in Mozambique enabled previously displaced farmers to return to their old farms in the villages and produce cotton. Cotton expansion in the South East Lowveld accelerated in the 1990s and is attributed to the "peace dividend". The cotton boom in the Lowveld has benefited from the huge belt of fertile vertisols that make it easier for farmers to grow cotton without any fertilizer applications. The non-use of fertilizer presents a major comparative cost advantage to Lowveld cotton growers at a time when the post-liberalization upsurge in fertilizer prices and the tightening of credit supply has caused a severe decline in the aggregate use of external inputs throughout SSA (Kelly, 2000;

Poulton et al., 1998; World Bank, 1994). In addition, the peace process in Mozambique resulted not only in the cotton boom in the Lowveld, but it also helped eliminate costly transport diversions and improve the flow of exports from land-locked Zimbabwe to the port of Beira, the country's shortest and most vital link to the ocean. Similar evidence of the Mozambique civil war raising external transportation costs, displacing thousands of refugees and drastically changing the economic situation in neighboring countries has been cited (Kydd, 1986;Lele, 1990, Cromwell, 1992).

It is striking to note that the coefficients for input and output prices including that of cotton ***COTTONP*** are statistically insignificant. This suggests that agricultural pricing policy did not provide sufficient incentives for smallholder cotton acreage expansion. To speed up price response, there is need to raise farmer awareness and understanding of seed cotton pricing and payment options through the provision of rural market infrastructure such as market information system that disseminate price news and lower entry barriers in all major cotton growing areas to eliminate regional monpsony and thus encourage greater competition and efficiency (Masters, 1993; Poulton, 1998). Lele, (1989) argues that effectiveness of price policies in ensuring a supply response is itself heavily conditioned by the quality of the institutions that conduct cotton research, extension, input supply and commercialization.

An important question is whether the seed cotton grading process allows farmers to obtain the highly priced grades. A major complaint from Zimbabwe smallholders is that they receive low grades and prices for their cotton. Analysis of marketed cotton output in Sanyati and Chipinge indicates that less than 50% of the farmers' output achieve first grade (A) in both districts while second grade (B) seems to dominate most of the output in Chipinge. Further, Zimbabwe's cotton farmers have historically faced late payment problems and that has major disincentive effects. Lack of trust in the marketing system increases marketing costs, restricts use of markets, and thus limits opportunities (Shaffer et al., 1985). The positive and significant lagged cotton acreage ***LCAREA*** response suggests a cob-web supply relationship, implying that smallholder's planting decisions are influenced by previous year's acreage.

The positive coefficient for training is statistically significant at 5% level. This indicates a profound relationship between smallholder cotton expansion and CTC training of growers. The result highlights the pivotal role CTC has played in the transfer of technology among smallholders. A total of 16, 014 trainees (i.e. comprising mostly farmers and extension workers) attended various cotton courses offered by CTC in the 1980s compared to 12,023 in the 1990s. The smallholder model results shows that institutional factors are the centerpiece in efforts to stimulate cotton acreage expansion in Zimbabwe.

4.4 Conclusion

The clearest pattern emerging from our study is that economic reforms generate unintended negative effects for both LSC and smallholder farmers. It seems fair to conclude that, in the short run, SAPs generate negative impacts among Zimbabwe cotton growers. The rapid upfront costs of the deflationary policies are working against cotton acreage expansion. The depressing effect on cotton growers is particularly worrisome given that cotton is the second leading cash crop in terms of foreign exchange generation after tobacco. The negative effect of the SAP coefficient on LSC cotton growers suggests that compensatory measures are needed to limit their vulnerability to adverse effects of

SAPs and the resulting diversification out of cotton production. The results present unexpected challenges to addressing the equity objective through adjustment process, as it appears that SAPs have negatively affected the wealthier LSC farmers. The real challenge is to craft policies that improve smallholders' access to SAP-induced benefits without hurting the LSC growers. The basic argument is that such pro-poor policies have a public good impact.

An important lesson supported by our findings is that liberalization does not result in automatic production incentives (Putterman, 1995). A growing number of independent researchers have come to the same conclusion that in the African context, SAPs have resulted in modest or disappointing supply responses (Ajayi, 1994;Bigsten and Ndung'u, 1992). Additionally, SAPs are being blamed for their deleterious effects on human and physical infrastructure in Africa (Browne, 1992). Consequently, the appropriateness of liberalization as an agricultural development strategy in a situation of missing and imperfect markets, and poor infrastructure is now being questioned (United Nations, 1999). Moreover, there is a convergence of ideas on the fact that poverty worsened in Africa in the 1980s following the adoption of SAPs (Berg, 1995; Cornia et al., 1988). Other work cites not only increased incidence of poverty but also the creation of "new" poverty following adjustment, which threaten the productive capacity of poor farmers (Stewart, 1995).

A striking result from our analysis is that the end of the Mozambique civil war and the signing of the peace accord had positive spillover benefits for smallholders in neighboring Zimbabwe. In other words, after accounting for SAP and drought, a net gain occurred in land area cultivated to cotton highlighting the economic benefit of investments in peace. The policy implication is that resolving hostilities is critical for agricultural growth in Africa. Our results also show that price incentives play a significant role in determining cotton acreage response for LSC growers. However, the insignificant coefficients for both product and factor prices suggests that there is no evidence of the expected rapid switching of acreage into cotton production due to agricultural price liberalization among the smallholder growers. Structural rigidities are inferred by smallholder's limited capacity to respond to price incentives without assured relevant production inputs and credit support. The evidence underlines the fact that smallholder supply response is strongly influenced by non-price factors such as access to land, investment in training and peace, but not economic incentives.

Future work should investigate more specific elements of the reform agenda such as 1) the move from monopsonistic to oligopolistic marketing in cotton purchases 2) credit disbursement under market liberalization, 3) implications of reforms in cotton research and development, especially the recent elimination of the cotton varietal purity policy (one variety in one region), and 4) liberalization of cotton seed sector and the potential impact of the introduction of cotton biotechnology. Further research effort should be devoted to diagnosing the implications of land reforms for commercial cottonseed production and seed cotton supply response in Zimbabwe in general. The results obtained here provide ample evidence that scale of operation influence Zimbabwe cotton growers' response to the generally improving incentive environment brought about by SAPs. Although it seems reasonable to argue that smallholders are relatively more vulnerable to the dire effects of SAPs due to their low income and inability to save and accumulate assets, the bottom-line is that so far, Zimbabwe LSC cotton growers have benefited specifically from cotton price liberalization while smallholder's response to the economic incentives offered by SAPs has been muted in the short run.

Future gains from SAPs depend upon the cotton growers' capacity to obtain marketing and other services on more favorable terms than those originally offered by the state. In Zimbabwe's case, it could be that new opportunities offered by liberalized markets are still in their formative stages or are concentrated in regions with better infrastructure. The missing or imperfect market argument seems plausible given the initial limited geographical presence of rival firms in the cotton industry, inaccessible roads in the new cotton zones, and the vacuum in credit service provision created by the gradual retreat of the GOZ. Signs of overall negative initial effects of SAPs on Zimbabwe's cotton growers suggest that its future benefits are uncertain.

The immediate challenge for the GOZ is to redesign and administer SAPs that do not create new resource gaps but rather reduce the flaws depicted by the early generation of reforms. Compensatory measures to reduce, mitigate and cope with the unintended negative short-run impacts of SAPs are needed if the elusive goal of eradicating income poverty through broad-based expansion of cotton production is to be realized. Key features of a future strategy for cotton expansion are; targeted training of smallholders, secure access to land, job creation schemes to re-deploy retrenched workers and improvements in smallholders' access to markets and information. Increasing training and market opportunities must be complemented by investment in rural infrastructure to eradicate barriers due to geographic remoteness of the smallholder cotton growers. A clear lesson is that getting prices right in an institutional vacuum will not generate the needed positive supply response from Zimbabwe's smallholder cotton growers.

Table 4.1 Description of variables used in Zimbabwe's Cotton Supple Response Models, 1980-1997

Variable Name	Units	Data Source	Mean	Standard Deviation
Dependent variable(s)				
Communal area acreage (CAREA)	Hectares	ZMOA	153,926.50	71,446.19
Large-scale commercial acreage (LSAREA)	Hectares	ZMOA	65,068.95	21,144.77
Scale of operation (Farm Size)				
Lagged communal acreage (LCAREA)	Hectares	ZMOA	153,926.50	71,446.19
Lagged LSC acreage (LLSAREA)	Hectares	ZMOA	65,068.95	21,144.77
Product and factor prices				
Maize producer price (MAIZEP)	Z$/ton	ZMOA	540.28	711.71
Sorghum producer price (SOGHUMP)	Z$/ton	ZMOA	405.56	481.30
Ammonium nitrate price (ANFPRICE)	Z$/ton	ZMOA	1043.28	1,206.25
Cotton producer price (COTTONP)	Z$/ton	ZMOA	1,914.47	2,014.45
Tobacco average price (TOBACCOP)	Z$/ton	ZMOA	15,288.91	18,496.90
Minimum wage (MIWAGE)	Z$/month	NECZ	363.23	437.63
Macroeconomic and institutional variables				
Exchange rate (EXCHRATE)	Z$/U$	ZMOA	9.84	14.25
Interest rate (INTEREST)	(%)	RBZ	19.75	12.17
Cotton Training Center (TRAINING)	Number	CTC	1,465.68	385.35
Exogenous shocks				
Lagged drought (LDROGHT)	(0,1)	ZMOA	0.25	0.44
Mozambique peace (MOZPEACE)	(0,1)	Arndt, C et al.	0.43	0.51
Structural Adjustment Program (SAP)	(0,1)	Mlambo, A.S.	0.52	0.51

Table 4.2: Zimbabwe Cotton Acreage Response Model Results, 1980-1997

Dependent variable: cultivated cotton acreage (ha)

	Large Scale Commercial Model		Smallholder Model	
Parameter	**Estimate**	**z-value**	**Estimate**	**z-value**
Scale of operation (farm size)				
LAGGED AREA	2.10	0.06	*0.39	1.87
Product and factor prices				
COTTONP	**230.00	2.08	35.00	0.23
TOBACCOP	**-4.10	-2.01	-	-
ANFPRICE	*120.00	1.66	-120.00	-1.21
MIWAGE	*-1400.00	-1.72	430.00	0.89
MAIZEP	-	-	-91.00	-0.32
SOGHUMP	-	-	170.00	0.47
Macroeconomic and institutional				
EXCHRATE	38,000.00	1.34	-	-
INTEREST	**-6,200.00	-2.41	-	-
TRAINING	-2,100.00	-1.07	**34.00	2.09
Exogenous Shocks				
LDROUGHT	9,600.00	1.55	12,000.00	1.25
MOZPEACE	-94,000.00	-1.39	***33,000.00	2.42
SAP	**-380,000.00	-2.02	-32,000	-0.27
N	17		17	
Log likelihood chi-square	**-162.82**		**-184.72**	
χ^2-p value	**0.0000**		**0.0000**	

***=significance at 1% level, **=significance at 5% level,*=significance at 10% level

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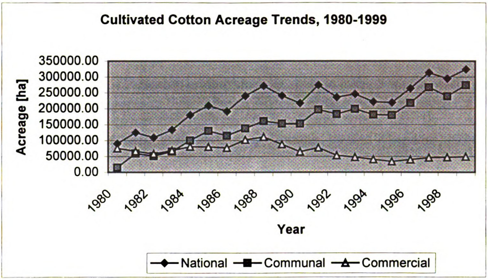

Figure 4.1: Zimbabwe Trends in Cotton Area Cultivated, 1980-2000

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Appendices

TableA4.1: Results of Diagnostic Tests on the Cotton Acreage Response Models

Test	Test Statistic Value(s): Smallholder Model	Test Statistic Value(s): Large Scale Commercial	Critical Value @ 5% significance
Heteroscedasticity			
White test	10.75	14.75	$\chi^2(9)=16.91$; $\chi^2(11)=19.68$
Park test	0.406	-2.35	1.746
Glejser test	-0.185	0.254	1.753
Arch effects	3.10	13.50	$\chi^2(6)=18.54$
Functional Form			
RESET test	0.48	0.37	5.32; 5.99
MWD test	-5.15	-4.28	1.75
Autocorrelation			
Ljung-Box:8 lags	52.19	87.88	$\chi^2(16)=7.96$
Q statistic[32] :8 lags	21.98	24.41	$\chi^2(16)=7.96$
Breusch-Godfrey (BG) test	12.46	11.25	5.99
Berenblutt-Webb g-test[33]	-	1.09	$(d_L, d_U)=(0.11; 3.44)$
Berenblutt-Webb test	1.16	-	$(d_L,d_U)=(0.22;3.09)$
Cointegration			
CRDW test	1.51-1.78	1.53-2.00	0.386

[32] The Q-statistic is given by $Q=n\Sigma\rho_k^2$ **(for k=1....m)** where n= sample size, m=lag length and ρ_k = autocorrelation function (ACF]. The Ljung-Box (LB) statistic is defined as $LB=n(n+2)\ \Sigma(\rho_k^2/n-k)\sim\chi^2_m$ **(for k=1....m)** (Gujarati, 1995]. The computed Q and LB statistics exceed the critical chi-square values and we reject the null hypothesis that all $\rho_k=0$; at least some are none zero.

[33] The g statistic is used to test for the presence of perfect positive serial correlation and is computed as follows: $g=\Sigma^n_{t=2}e_t^2/\Sigma^n_{t=1}u_t^2$ where u_t and e_t are OLS residuals from the original and first differenced models respectively. Since observed $g>d_L$, reject null hypothesis that true $\rho=1$ i.e. no perfect positive serial correlation of first order in both models.

Table A4.2: Zimbabwe Cotton Yield Response Model Results, 1980-1997

Dependent variable: Natural log of cotton yield (kg/ha)

	Large Scale Commercial Model		Smallholder Model	
Parameter	**Estimate**	**z-value**	**Estimate**	**z-value**
Scale of operation (farm size)				
LAGGED AREA	***-0.01	-4.51	-0.01	-1.06
Product and factor prices				
COTTONP	***0.29	3.77	0.02	0.34
TOBACCOP	***-0.34	-5.21	-	-
ANFPRICE	0.38	0.71	**-0.33	-1.94
MIWAGE	*3.40	1.76	***1.92	2.06
MAIZEP	-	-	0.03	0.96
Macroeconomic and institutional				
INTEREST	***-48.00	-3.82	-	-
TRAINING	0.06	1.00	*0.10	1.79
Exogenous Shocks				
DROUGHT	***-190.00	-2.93	***-290.00	-9.78
ESAP	***-440.00	-3.25	***-200.00	-4.27
N	**16**		**17**	
Log likelihood chi-square	**-95.04**		**-90.61**	
χ^2-p value	**0.0000**		**0.0000**	

***=significance at 1% level, **=significance at 5% level,*=significance at 10% level

Table A4.3 Agricultural Policy Changes in Zimbabwe, 1980- 2000

Year	Policy Change	Effects of Policy
Prior to 1980	Cotton marketing controlled by Cotton Marketing Board; Growth With Equity policy unveiled at independence.	GOZ regulated annual cotton producer-prices. Large-scale commercial sector dominate seed cotton supply. Promote more equitable ownership of natural resources especially land; achieve sustained economic growth.
1982-1985	Transitional National Development Plan.	Aimed at increasing exports, investments and employment Formation of SFCS under AFC; targeted lending to smallholders; Formation of the Resettlement Farm Sector (RFS); smallholders assume leading role as seed cotton producers in the country.
1986-1990	First Five-Year National Development Plan.	Establishment of several rural cotton depots. Target growth 5.1% and 28,000 new jobs per annum.
1990-1995	Economic Structural Adjustment Program (ESAP); export diversification & promotion strategy; parastatal reform; privatization and commercialization. Land Acquisition Act passed.	Use of flexible exchange rate. Restructuring parastatals CMB, CSC DMB etc. Formation of COTTCO Private Limited. Liberalization of agricultural pricing policy. ZIMACE commodity clearing house formed. Oligopolistic cotton marketing e.g., CARGILL Inc. COTPRO and CHIPANGAYI.
1996-1999	Second phase of adjustment. Further market reforms under ZIMPREST adopted in 1995. Parastatal, financial & civil service reforms. Economic downturn; Fast track land reform. Millenium Recovery Plan.	Foreign currency shortages. Interest rate liberalization. Fuel shortages; Slow growth in agriculture sector. Cyclone in cotton zones S.E. Lowveld

Table A4.4: Zimbabwe Data for Cotton Supply Response Analysis, 1980-1997

YEAR	LSC ACREAGE (HA)	SMALL-HOLDER ACREAGE (HA)	TRAINING	EXCHANGE RATE (Z$/US$)	INTEREST RATE (%)	WAGES (Z$)
1979/80	74,921	15,000	1,056	0.631	7.50	32.00
1980/81	66,054	59,000	966	0.717	9.10	44.00
1981/82	58,014	51,000	1,205	0.920	10.25	50.00
1982/83	67,976	65,000	1,269	1.106	13.00	60.00
1983/84	80,155	100,000	1,992	1.502	13.00	65.00
1984/85	79,658	130,000	2,182	1.641	13.00	75.00
1985/86	76,617	115,000	2,331	1.678	13.00	85.00
1986/87	102,086	138,000	1,838	1.663	13.00	100.00
1987/88	110,787	161,000	1,675	1.943	13.00	120.00
1988/89	87,571	153,000	1,495	2.270	13.00	133.40
1989/90	64,486	153,000	1,273	2.636	12.25	157.41
1990/91	77,222	197,000	1,376	5.051	11.75	185.00
1991/92	52,777	183,000	1,019	5.482	14.63	210.00
1992/93	47,300	199,000	1,450	6.935	34.63	241.00
1993/94	40,150	181,150	1,210	8.387	37.90	289.80
1994/95	33,800	179,760	1,406	9.311	36.39	359.35
1995/96	40,000	217,620	1,435	10.839	35.50	503.09
1996/97	45,755	267,500	1,532	18.608	44.00	654.08
SOURCE	ZMOA	ZMOA	CTC	RBZ	RBZ	NEC

Table A4.5: Zimbabwe Data for Cotton Supply Response Analysis Continued, 1980-1997

YEAR	COTTON PRICE (Z$)	TOBACCO PRICE (Z$)	MAIZE PRICE (Z$)	SORGHUM PRICE (Z$)	FERTILIZER PRICE (AN)
1979/80	37.00	970.78	85.00	105.00	168.20
1980/81	40.00	1,800.00	120.00	115.00	187.20
1981/82	51.00	2,536.00	120.00	115.00	207.00
1982/83	52.00	2,951.00	120.00	120.00	207.00
1983/84	57.00	3,426.00	140.00	140.00	306.00
1984/85	67.00	4,200.00	180.00	180.00	406.00
1985/86	80.00	4,957.00	180.00	180.00	406.00
1986/87	80.00	4,915.00	180.00	180.00	406.00
1987/88	85.00	5,492.00	195.00	195.00	415.00
1988/89	93.00	8,272.00	215.00	215.00	433.00
1989/90	117.00	14,300.00	225.00	225.00	433.00
1990/91	141.00	18,141.00	270.00	250.00	613.00
1991/92	301.00	14,976.00	550.00	350.00	981.00
1992/93	320.00	15,402.00	900.00	520.00	1,222.00
1993/94	370.00	28,977.00	900.00	520.00	1,222.00
1994/95	420.00	60,021.00	1,050.00	650.00	1,795.00
1995/96	600.00	62,836.00	1,200.00	920.00	2,490.00
1996/97	720.00	21,027.66	3,000.00	2,100.00	3,495.00
SOURCE	ZMOA	ZMOA & RBZ	ZMOA	ZMOA	ZMOA

Table A4.6 Dick

Variable
Smallholder c
Large-scale a
Nominal cott
Nominal ma
Nominal tob
Nominal sor
Nominal AN
Nominal ex
Nominal int
Nominal m
Cotton Trai

Note: Indeper

Table A4.7:

Prices
Nominal c
Nominal r
Nominal s
Nominal
Nominal r
Interest ra
Exchange
Annual ir

Table A4.6 Dickey Fuller (DF) unit root test (constant without trend)

Variable	Calculated t-value	Critical Value @5% Level	Unit Root Status
Smallholder cotton acreage (ha)	10.61	-2.90	REJECT
Large-scale acreage (ha)	5.74	-2.90	REJECT
Nominal cotton price (Z$/ton)	18.96	-2.90	REJECT
Nominal maize price (Z$/ton)	7.35	-2.90	REJECT
Nominal tobacco price (Z$/ton)	4.27	-2.90	REJECT
Nominal sorghum price (Z$/ton)	10.36	-2.90	REJECT
Nominal AN fertilizer prices (Z$/ton)	32.60	-2.90	REJECT
Nominal exchange rate (Z$/US$)	14.63	-2.90	REJECT
Nominal interest rates (%)	7.65	-2.90	REJECT
Nominal minimum wages (Z$)	39.15	-2.90	REJECT
Cotton Training Center graduates	3.77	-2.90	REJECT

Note: Independent variables are stationary (or stable) so the series do not exhibit unit root problem

Table A4.7: Zimbabwe average annual growth rates of official prices, 1980-1995

Prices	Pre-ESAP	Pre-ESAP	Post-ESAP	Post-ESAP
	Nominal (%)	Real (%)	Nominal (%)	Real (%)
Nominal cotton price (Z$/ton)	13.28	-2.16	30.22	3.34
Nominal maize price (Z$/ton)	7.92	-4.25	61.11	4.91
Nominal sorghum price (Z$/ton)	10.48	-3.43	31.48	-3.28
Nominal AN fertilizer prices (Z$/ton)	15.74	8.07	52.42	42.95
Nominal minimum wages (Z$)	31.68	4.04	21.38	-5.31
Interest rates	6.33	-4.51	33.69	-1.66
Exchange rates	25.97	31.36	50.64	3.47
Annual inflation rate	2.21		15.19	

APPENDICES

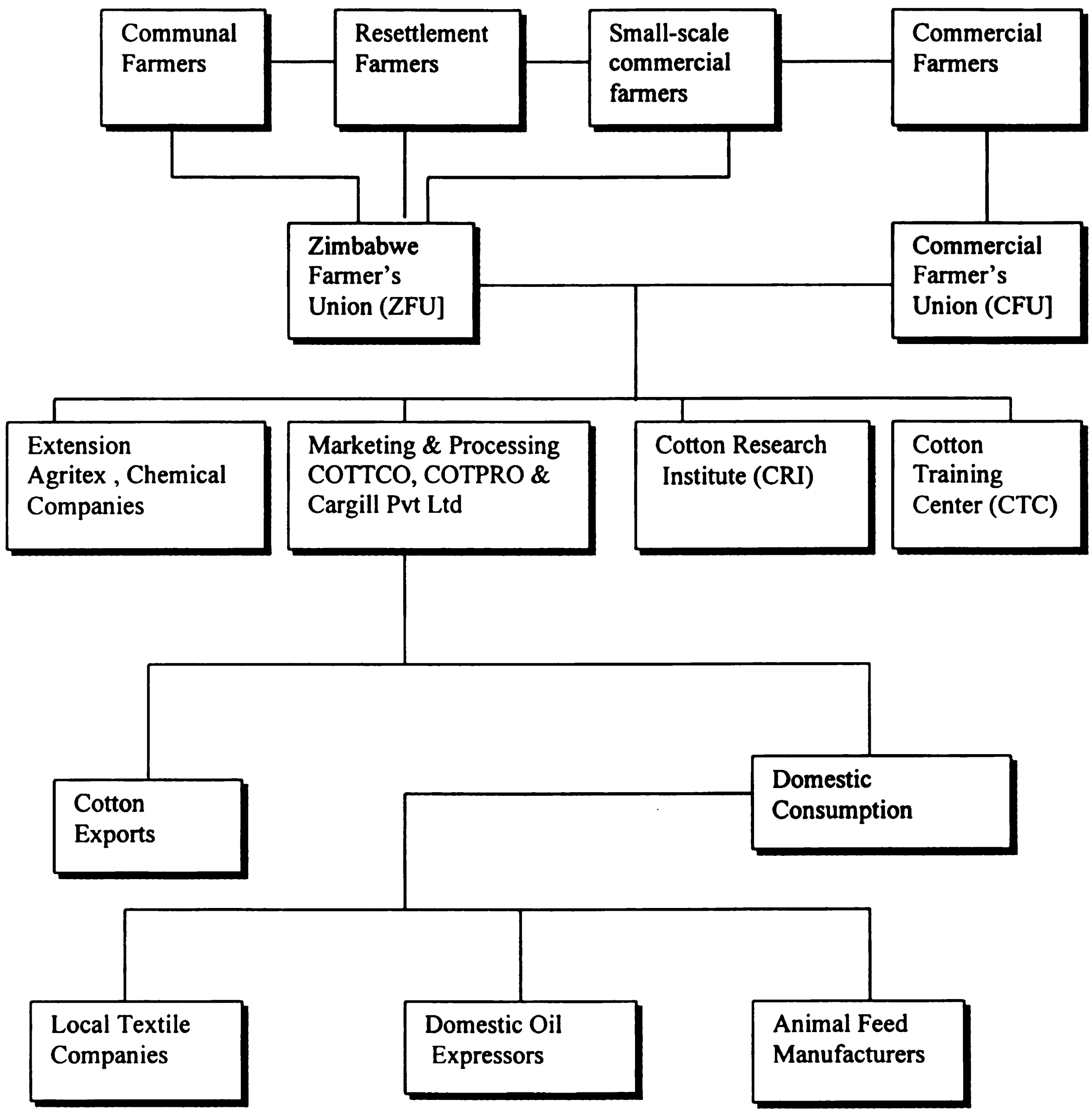

Figure A4.1. Structure of the Cotton Industry in Zimbabwe

Source: Adapted from "Impact Assessment of Cotton Research and Enabling Environment in Zimbabwe, 1970-1995"

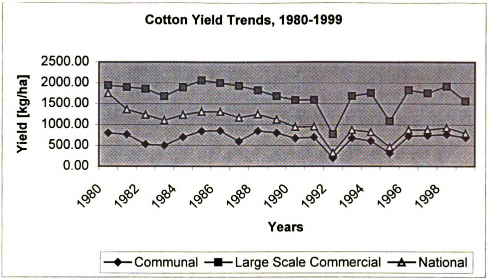

Figure A 4.2: Zimbabwe Cotton Yield Trends, 1980-1999

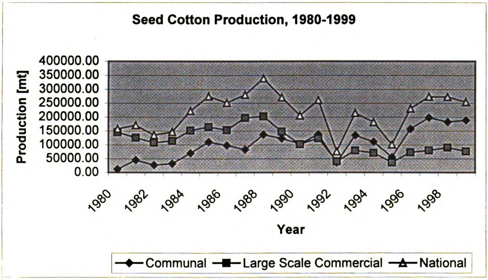

Figure A4.3: Zimbabwe Seed Cotton Production Trends, 1980-199

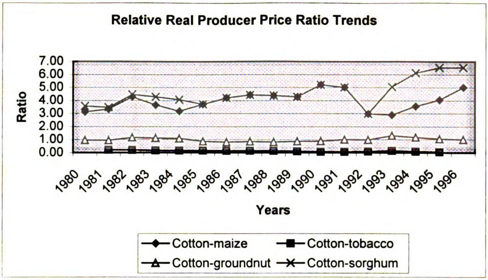

Figure A4.4: Zimbabwe Trends in Relative Real Agricultural Producer Prices, 1980-1996

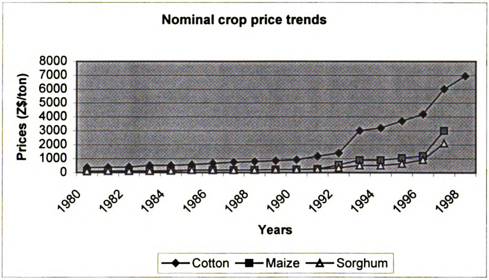

Figure A4.5: Zimbabwe Nominal Crop Producer Prices, 1980-1998

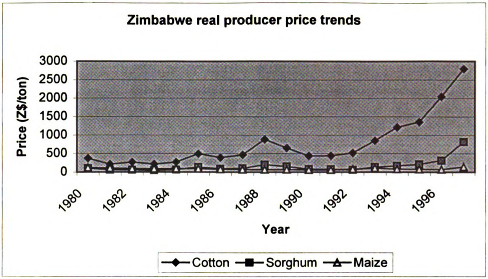

Figure A4.6: Zimbabwe Real Crop Producer Prices, 1980-1998

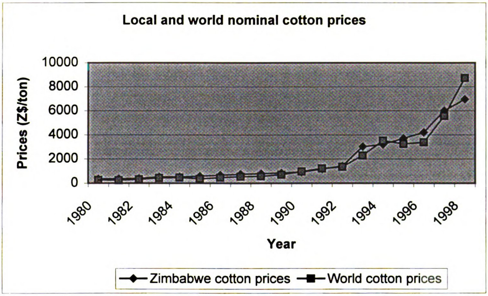

Figure A4.7: Comparison of local and world cotton prices, 1980-1997

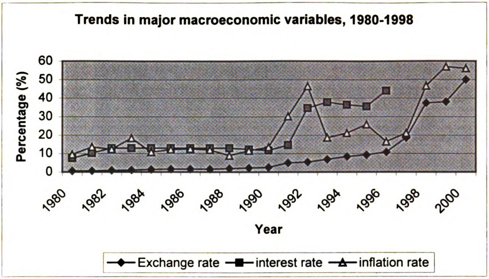

Figure A4.8: Zimbabwe macroeconomic trends, 1980-1998

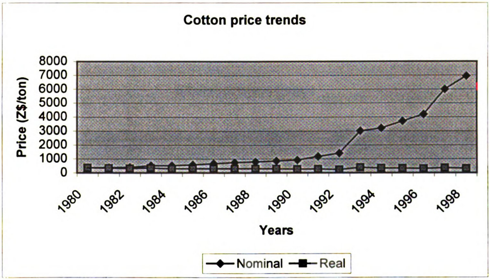

Figure A4.9: Zimbabwe Cotton Producer Price Trends, 1980-1997

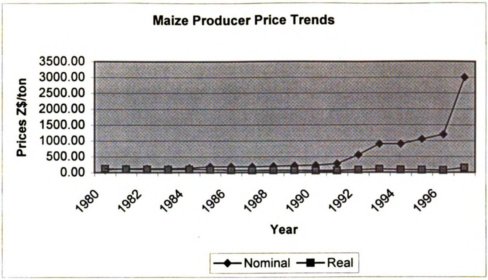

Figure A4.10: Zimbabwe Maize Producer Price Trends, 1980-1998

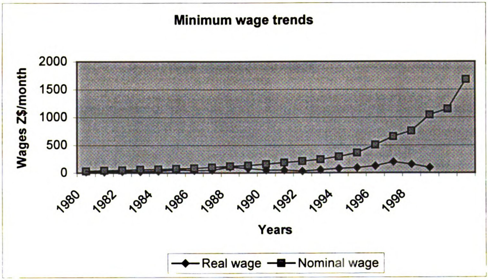

Figure A4.11: Zimbabwe minimum wage trends, 1980-1999

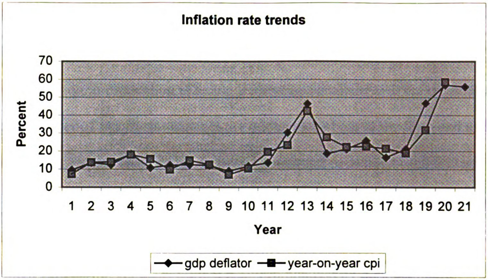

Figure A4.12: Zimbabwe inflation rate trends, 1980-2000

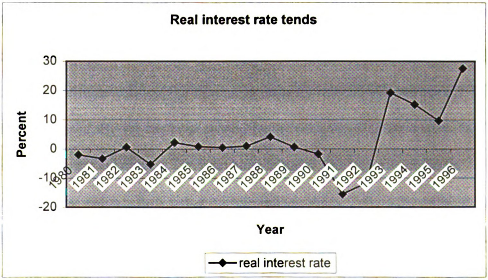

Figure A4.13: Zimbabwe real interest rate (nominal-inflation) 1980-1997

CHAPTER 5

SUMMARY AND CONCLUSION

Africa's cotton production is facing tremendous challenges at the dawn of the new century. A number of significant changes are taking place both at the farm and national policy levels that require close attention from agricultural economists and farmers alike. Cotton is a strategic export crop throughout Sub-Saharan Africa (SSA) and its successful cultivation is critical for foreign exchange earnings, income diversification and employment generation. As the continent has been plagued by poor economic performance, it is in Africa's best interest to expand cotton production and restore the buoyancy of its export crop sector. Above all, most of the SSA countries face the major problem of poverty; the sustained development of cotton production has an important contribution towards the solution of this dilemma.

The study analyzed both the farm and policy level constraints to expanding cotton production in Zimbabwe. In Africa, indiscriminate use of pesticides is threatening the health of poor farmers. Unless efforts are directed at resolving health risk of exposure to pesticides, long-term investments in the cotton industry in SSA will not payoff. In addition, cotton productivity has been eroded by the use of ineffective traditional calendar based spray techniques. The relevance of using fixed spray schedules irrespective of pest status is now being questioned in Africa. Part of the problem is that pesticide dependency and misuse has created pest resistance and secondary pest outbreak, especially the red spider mite in Zimbabwe despite the implementation of the acaricide rotation scheme.

The United Nation's Food and Agriculture Organization (FAO) in collaboration with the government of Zimbabwe (GOZ) has embarked on Farmer Field School (FFS)-based Integrated Pest and Production Management (IPPM) extension efforts as a means to tackle the "pesticide treadmill" dilemma crippling cotton production in Africa. Little is known about conditions under which integrated pest management (IPM) innovations can be diffused in Africa. This study is a leading effort to understand the motivational factors required to provide the adoption stimulus for cotton IPM. In addition, structural adjustment programs (SAPs) implemented in the 1990s have raised new questions about whether or not the reforms are beneficial to Zimbabwe's cotton farmers. In particular, the distributional impact of SAPs has not received serious attention in Africa. Despite heavy reliance on pesticides, declining cotton yields (Figure A4.2), coupled with inadequate knowledge about the distributional impact of SAPs on large and small-scale farmers who cultivate one of Africa's strategic export crop is detrimental to the long term sustainability of productivity and rural poverty alleviation. This chapter summarizes the main findings and suggests policy implications to revive cotton production in Africa.

To address the pesticide-induced farmer health risks, pest management and policy constraints confronting cotton production in Africa, a field research was conducted between June and December 1999 to collect primary data in Zimbabwe's two leading cotton producing districts namely Sanyati and Chipinge. Supporting secondary data was obtained from the Zimbabwe Ministry of Agriculture (ZMOA) publications, the Cotton Training Center (CTC) and the Reserve Bank of Zimbabwe (RBZ). The challenges facing sustainable cotton production in Zimbabwe provides lessons for other African countries going through the same cycle of pest management and structural adjustment reforms.

Chapter 2 presented an analysis of the acute health risks attributed to pesticides use among smallholder cotton growers in Zimbabwe. Using primary data from Sanyati and Chipinge district, our study demonstrates that pesticide use in smallholder cotton production has significant adverse effects on farmer health. Pesticide-related acute health symptoms impose opportunity costs in the form of lost sick days and increased expenditure on treating health problems which average Z$180 and Z$316 per household head in 1998/99 in Sanyati and Chipinge respectively (1998/99 exchange rate: Z$38 = 1 US$). For every Zimbabwe dollar spent on pesticides, a minimum of 0.45 and 0.83 dollars is incurred in the form of health costs in Sanyati and Chipinge respectively.

The main result from the cost of illness models is that farmer-reported acute health symptoms is the key factor in predicting health costs among cotton growers. The results from the Poisson acute symptom incidence models show that acute health effects are associated with the use of toxic chemicals, leaking sprayers, label illiteracy, personal habits like smoking and alcohol intake, and taking meals in the fields after spraying. Exposure averting and mitigating strategies that significantly reduce the incidence of acute symptoms are protective clothing and knowledge of first aid, respectively. Contrary to our expectation, exposure to FFS-based IPM training does not significantly reduce acute symptom incidences. Surprisingly, farmers who favor reforming calendar-based spraying are less likely to suffer acute pesticide symptoms.

In terms of policy, we recommend that the key to successful improvement of farmers' health in the short-term is limited use of hazardous pesticides by smallholders in order to minimize their negative side effects. Emphasis should be placed on substituting the most toxic pesticides with ones with greater selectivity and high safety for human health and the environment. Secondly, evidence of adverse health effects among the cotton growers suggests the need for government policy intervention in farm worker safety. Reinforcing farmer use of both relevant protective clothing and equipment, and safe pesticide storage and disposal practices is a critical intervention strategy to preserve farmer health in the short-run. Thirdly, labeling policy reform is needed to help label-illiterate farmers understand better the health hazards of toxic cotton pesticides. Educating illiterate cotton growers about the negative health impacts of toxic pesticides will help minimize occupational exposure to pesticides. Fourth, improving farmer health services should entail changing the current mode of health delivery. Existing agricultural extension services should help disseminate pesticide-related health information, given that there is minimal contact between farmers and the formal health care system in Zimbabwe. Increased efforts should also focus on public policies designed to change perceptions that view chemical interventions as panacea for all pest problems.

Future research effort should focus on cotton farmers for longer time periods to establish the true adverse effects of the observed acute and chronic health effects. Our results suggest that spurring pest management innovations should not be emphasized at the expense of endangering farmer health. The findings from this study provide a basis for discussions on the merits of policy reforms in pesticide use in smallholder agriculture and health care delivery in rural Zimbabwe. Future pest management policy design should be cast in a much broader context to include both agricultural policies and farmer health issues.

In Chapter 3, factors affecting cotton IPM adoption are analyzed. The results show that awareness of technical practices resulting from participation in FFS extension training is significantly associated with the adoption of IPM practices. In addition, scale of production is positively related to IPM practice adoption. Scale provides a relative measure of potential economic gain from adoption. This suggests scale economies in cotton IPM use. Pesticide-related health risks however had no significant influence on the adoption of IPM technology. This evidence implies that the GOZ should expand its use of FFS and other farmer-to-farmer approaches that diffuse IPPM awareness. Further, the findings underline the fact that investment in pest management information and knowledge is important for successful cotton production in Zimbabwe.

An important conclusion from Chapter 4 is that SAPs have led to negative short-run impacts on LSC cotton growers in Zimbabwe. The results suggest that positive effects of liberalization are yet to be demonstrated. The initial evidence of the negative impact of SAPs on LSC cotton growers so far highlight the importance for policy makers to pay closer attention to crafting compensatory mechanism to alleviate the vulnerability of the growers. This requires targeted policies to ease the burdens that reforms impose on the farmers. Realizing that SAPs are multifaceted process, further studies ought to break down and analyze the impact of specific elements of adjustment packages on supply response for individual food and cash crops. Such an approach would help policy makers eliminate any cross contamination from different policy instruments. Moreover, our study is conducted in aggregate terms but analysis of responses to economic decline at the household level would further illuminate SAP impacts.

The second key result is that the signing of the Mozambique peace accord appears to have stimulated smallholder cotton acreage in Zimbabwe. The evidence underlines the vital importance of investment in peace and the spillover benefits in agricultural production and marketing in Africa. The results also suggest that much of the positive response in Zimbabwe's smallholder cotton production is attributed to shifts in geographic location of production rather than the intensification of existing farming systems. From policy standpoint, the evidence highlights the fact that peace can be a major ingredient for progress in agricultural production expansion in Africa.

Finally, the overall research results indicate that there are good reasons to refine the current reforms in Africa to engender a more vigorous positive supply response. Key strategies to stimulate cotton production and diminish the risk of crop failure in the short term requires a major focus on institutional factors such as Farmer Field School-based IPM training, investment in regional peace efforts, and rural infrastructure development to lower market access barriers. This is particularly important as opportunities for expanding production through extending the land frontier become limiting in Africa. Crafting policies that ameliorate SAP-induced negative effects among the vulnerable farmers is central for generating a positive cotton supply response in future.

Although our study did not specifically address the benefits and costs of IPM use under smallholder conditions, future research ought to focus closely on this subject. Demonstrable IPM benefits could provide incentives for the future uptake of IPM by the farmers.

The insignificance of pesticide-related health risks in IPM adoption should not be excuses for policy inaction, but rather a challenge for extension re-design. Serious thought must be given by policy makers to farmer health risks associated with cotton cultivation practices in Africa. Short term solutions to pesticide-induced acute illnesses demand raising farmer awareness about health risks and improving on-farm safety as a precautionary measure when using chemicals. Alternative pest management approaches that emphasize less use of toxic pesticides should provide the basis for a future pest management strategy that does not compromise farmer health and the sustainability of cotton production. Despite the several challenges confronting the continent, SSA remains a key supplier of world cotton and peace will provide a vital foundation for agricultural growth in the twenty-first century.

QUESTIONNAIRES

SERIAL NUMBER__________

SMALLHOLDER COTTON PRODUCTION AND PEST MANAGEMENT IN ZIMBABWE: LOWVELD AND MIDDLEVELD SURVEY 1999-2000

APPENDIX A1: HOUSEHOLD LEVEL QUESTIONNAIRE

Date of Interview________________________ Name of Enumerator________________

Name of District____________________ **DISTRICT**_______

Name of Ward______________________ **NWARD**_________

Name of Village_____________________ **VILNAME**_______

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SECTION 1: HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS

1. Demographic characteristics of HOUSEHOLD HEAD and SPOUSE (S)

FAMILY MEMBER	AGE (YEARS)	GENDER (M/F)	EDUCATIONAL LEVEL (YEARS)	HIGHEST LEVEL EDUCATION
HEAD OF HOUSEHOLD				
FIRST WIFE				
SECOND WIFE				
THIRD WIFE				
WIDOWER				
WIDOW				

FAMILY MEMBER CODES

1= HEAD OF HOUSEHOLD
2= FIRST WIFE
3= SECOND WIFE
4= THIRD WIFE
5=WIDOWER
6= WIDOW
7=OTHER (SPECIFY)

EDUCATIONAL LEVEL CODES

1=NO EDUCATION
2=PRIMARY EDUCATION
3=COMPLETED ZIMBABWE JUNIOR CERTIFICATE
4=COMPLETED O-LEVEL
5=COMPLETED A-LEVEL
6=COLLEGE DIPLOMA TRAINING
7=UNIVERSITY DEGREE
8=POST GRADUATE DEGREE
9=OTHER (SPECIFY)

2.How many people are above the age of 14 years in your household? **BVADULTS**__________

3.How many people are below the age of 14 years in your household? **BLWCHDN**__________

4. Have you received any training related to cotton production in the past 5 years?

1=YES 0=NO

5. If YES, please name the source, nature of training and year of training?

SOURCE OF TRAINING	NATURE OF TRAINING	YEAR OF TRAINING
AGRITEX		
COTTON TRAINING CENTER (CTC)		
COTTON COMPANY OF ZIMBABWE (COTTCO)		
LOCAL FARMER CLUBS		
CARGILL PVT LTD		
COTPRO		

CODES FOR TRAINING IN COTTON AGRONOMIC PRACTICES

1=COTTON PEST SCOUTING
2=PESTICICE SPRAYING
3=RECORD KEEPING/CREDIT MANAGEMENT
4=COTTON PICKING
5=SOIL CONSERVATION

CODES FOR SOURCE OF TRAINING

1=AGRITEX
2=COTTON TRAINING CENTER [CTC]
3=COTTON COMPANY OF ZIMBABWE
4.CARGILL
5.COTPRO
6.LOCAL FARMER CLUBS
7.OTHER (SPECIFY)

SECTION 2: OFF-FARM INCOME EARNING ACTIVITIES IN THE HOUSEHOLD

1.Is the head of household formally employed elsewhere? **FORMEMPL**__________
1=YES 0=NO (If NO please GO TO QUESTION 5)

2. If YES, state your primary occupation **OCCUPTN**____________

3.What is your annual gross income from your primary occupation? **OCCUPINC**____________

1. LESS THAN Z$10 000
2. BETWEEN Z$10 001 AND Z$20 000
3. BETWEEN Z$20 001 AND Z$30 000
4. BETWEEN Z$30 001 AND Z$40 000
5. BETWEEN Z$40 001 AND Z$50 000
6. BETWEEN Z$50 001 AND Z60 000
7. MORE THAN Z$60 000

4. Household income from off-farm activities from Sept 1st, 1998 to August 31st, 1999

<-------1998----→←----------------1999----------------------------→

HOUSEHOLD MEMBER	OFF-FARM ACTIVITY	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTAL INCOME (Z$)
1 Head of Household														
2 First Wife														
3 Second Wife														
4 Third Wife														
5. Widow														
6. Widower														
7. Adult Child														
8. Relative														
9.														
10.														

OFF-FARM ACTIVITIES CODES

1=BASKET WEAVING	11=ROOF THATCHING
2=BEER BREWING	12=TAILORING
3=BICYCLE REPAIRER	13=SHOE MAKING
4=BRICK MAKING	14= STONE CARVING
5=BUILDING ACTIVITIES	15=TRADING STORE
6=BUTCHER	16=TRADITIONAL HEALING
7=CARPENTRY	17= WOOD CARVING
8=KNITTING	18=COTTON PICKING
9=MIDWIFE	19=TEA PICKING
10=NEIGHBOURING FARM	20=OTHER (SPECIFY)

5. Do you own the following assets?

ASSET DESCRIPTION	QUANTITY	VALUE [Z$]
1. Bicycle		
2. Bore-hole		
3. Lorry		
4. Passenger Vehicle		
5. Radio		
6. Television		
7. Trading store		
8. Tractor		
9. Trailer		
10. Van		
11. Water cart		
12. Planter		
13. Cultivator		
14. Mould-board Plough		
15. Wheel burrow		

6. Do you receive remittances in CASH or in KIND from employed relatives and children?
1=YES 0=NO **REMTANCE________**

<u>NOTE TO THE ENUMERATOR</u>: PLEASE CALCULATE THE DOLLAR AMOUNT IF FARMER RECEIVEDANY REMITTANCES IN KIND IN THE PAST YEAR.

7. Estimate amount received in the past year from Sept 1st 1998 to August 31st 1999 [in Z$]
TOTREM__________

←--------1998--------------------→←--------------------------------1999-----------------------------------→

SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG

SECTION 3: ON-FARM MANAGEMENT OF COTTON PRODUCTION

1.Who makes the major decisions about cotton production in this household? **HDECISN**_________

1=HEAD OF HOUSEHOLD
2= SPOUSE
3=ADULT CHILD
4=OTHER (SPECIFY)

2. Indicate your cropping program for the past three years?

COTTON FIELD	1998/99	1997/98	1996/97
1. Homestead field			
2. Cotton field 1			
3. Cotton field 2			
4. Cotton field 3			

CODES FOR CROP ROTATIONS
1=MAIZE-COTTON
2=SORGHUM-COTTON
3=GROUNDNUTS-COTTON
4=MAIZE-COTTON-SORGUM
5=MAIZE-COTTON-SUNFLOWER
6=MAIZE-COTTON-GROUNDNUTS
7=FALLOW
8= OTHER (SPECIFY)

3. Did you cultivate all your fields in 1998/99? **FARMCULT**_____
1=YES 0=NO

4.If NO, did you leave any land lying fallow in 1998/99? **FFALLOW**_______
1= YES 0=NO

5. When did you plant your cotton crop in 1998/99? **DATEPLNT**______

1. SECOND WEEK OF OCTOBER
2. THIRD WEEK OF OCTOBER
3. LAST WEEK OF OCTOBER
4. FIRST WEEK OF NOVEMBER
5. SECOND WEEK OF NOVEMBER
6. THIRD WEEK OF NOVEMBER
7. FOURTH WEEK OF NOVEMBER
8. OTHER (SPECIFY)

6. Did you use any hired labor in 1998/99? **HIREDLAB**______
1=YES 0=NO

7. If YES, specify your source of hired labor in 1998/99 **HLABSORC_____**

1.SCHOOL CHILDREN
2. LABORERS FROM NEIGHBOURING VILLAGES
3. FORMER "REFUGEES" FROM MOZAMBIQUE
4. LOCAL NON-COTTON FARMERS
5. OTHER (SPECIFY).

8. How would you characterize the availability of hired labor in your community? **LABAVAIL______**

1 ABUNDANT LABOUR FORCE
2.SCARCE LABOUR FORCE
3.NOT AVAILABLE
4.OTHER (SPECIFY)

9. Did you use chemicals to control cotton pests in 1998/99? **CHEMUSE______**
1=YES 0=NO

10. If NO, what are the reasons for NOT using chemicals? **RNOCHEM______**

1. LACK OF MONEY TO BUY CHEMICALS
2. CHEMICALS ARE DANGEROUS TO FAMILY HEALTH
3. DISCOURAGED IN IPPM TRAINING
4. DON'T BELIEVE IN CHEMICAL USE
5. OTHER (SPECIFY)

11. Have you used chemicals in the past two years to control pests? **PASTCHEM_____**
1=YES 0=NO

12. Number of years you have grown cotton? **COTYEARS_____**

SECTION 3: SOIL CONSERVATION AND TILLAGE PRACTICES IN COTTON PRODUCTION

1. Do you own any livestock? **LIVESTOK**___________
1= YES 0=NO

2. What type of animals and how many did you own at the end of the past season, 1998/99?

ANIMAL CLASS	NUMBER
1.Beef Cattle	
2.Donkeys	
3.Goats	
4.Pigs	
3. Sheep	
4. Chickens	
5. Rabbits	
6. Ducks	

3. What was your source of draft power in 1998/99? **DRAFTPSO**______

1. OWN DRAFT ANIMALS
2. OWN TRACTOR
3. HIRED "TRACTOR" SERVICES
4. HIRED DRAFT ANIMALS
5. BORROWED DRAFT ANIMALS
6. OTHER (SPECIFY)

NOTE TO THE ENUMERATOR: IF FARMER HIRED DRAFT ANIMALS OR TRACTOR PLEASE COMPLETE QUESTION 4 BELOW, IF NOT GO TO QUESTION 5.

4. Indicate the source of HIRED DRAFT POWER, number of animal/tractor days and the cost?

DRAFT POWER SOURCE	DRAFT ANIMAL/ TRACTOR DAYS	COST OF HIRE Z$/ACRE
1.HIRED TRACTOR		
2.HIRED DRAFT ANIMALS		
3.OTHER (SPECIFY)		

5. Among the following TILLAGE PRACTICES, please indicate below the ones you used on your cotton crop in 1998/99? **TILPRAC________**

TILLAGE PRACTICE	**PRACTICE ADOPTION 1=YES 0=NO**
1. MINIMUM/ZERO TILLAGE	
2. CONTOUR RIDGES	
3. TIED RIDGES	
4. WINTER PLOUGH	
5.CONVENTIONAL PLOUGHING	
6. MULCHING	
7.OTHER (SPECIFY)	

6. Did you burn cotton stover in 1998/99? **BURNSTOV________**

1=YES 0=NO

7. If YES, please indicate date of slashing and destruction of cotton stover

COTTON FIELD	**SLASHING DATE**	**DESTRUCTION DATE**
HOMESTEAD FIELD		
COTTON FIELD 1		
COTTON FIELD 2		
COTTON FIELD 3		
OTHER (SPECIFY)		

SECTION 4. PEST MANAGEMENT PRACTICES

1. Do you have a master farmer certificate? **FARMCERT______**
   1=YES 0=NO (IF NO, GO TO QUESTION 3)

2.State the year you received this certificate? **YEARCERT______**

3.How many COTTON EXTENSION MEETINGS did you attend in 1998/99? **COTEXMTG______**

4. Number of direct contacts with the COTTON EXTENSION WORKER in 1998/99? **CONTACTS________**

5. Who provides you with COTTON EXTENSION ADVICE in this area? **SOPEXT___________**

   1.AGRITEX
   2.COTTON TRAINING CENTER (CTC)
   3.COTTON COMPANY OF ZIMBABWE (COTTCO)
   4. CARGILL
   5. COTPRO
   6.LOCAL FARMERS
   7. NON-GOVERNMENTAL ORGANIZATION (NGO)
   4.OTHER (SPECIFY)

6. What year did you FIRST receive pest management advice? **FRSTPMGT________**

7. Who do you consider as your main source of PEST MANAGEMENT INFORMATION? **PESTINFO_________**

   1.AGRITEX
   2.COTTON TRAINING CENTER (CTC)
   3.COTTON COMPANY OF ZIMBABWE (COTTCO)
   4. CARGILL
   5. COTPRO
   6.LOCAL FARMERS
   7. NON-GOVERNMENTAL ORGANIZATION (NGO)
   8.AGRICURA
   9.RADIO AND TELEVISION (MEDIA)
   10.OTHER (SPECIFY)

8. Did you practice professional pest scouting in cotton in 1998/99? **PROSCOUT_________**
   1=YES 0=NO

9. If YES, describe who scouted, the pest pressure in 1998/99 and your experience scouting for the same pest.

PEST TYPE	SCOUTING (1=YES 0=NO)	WHO SCOUTS	PEST PRESSURE	NUMBER OF YEARS OF SCOUTING
INSECTS				
1.Heliothis Boll Worm				
2.Red-Boll Worm				
3.Pink Boll Worm				
4.Spiny Boll Worm				
5.Stainers				
6.Aphids				
DISEASE				
7. Bacterial Blight				
8. Damping Off				
9. Boll rot				
10. WEEDS				
11.RODENTS				
MITES				
12.Red Spider mite				
13.Termites				

COTTON SCOUTING CODES

1=HOUSEHOLD HEAD 2=SPOUSE 3=OTHER FAMILY MEMBER
4=INPUT SUPPLIER EXPERT 5=EXTENSION WORKER 6=OTHER (SPECIFY)

CODES FOR PEST PRESSURE

1.SEVERE 3. LIGHT
2.MEDIUM 4. OTHER (SPECIFY)

10. How many times did you SCOUT your cotton crop for INSECTS in 1998/99?

INSCOUT__________

11. How often did you SCOUT your cotton crop for DISEASES in 1998/99?

DISCOUT__________

12. Do you believe scouting for pests is beneficial to you? **SCOUTBFT__________**
1= YES 0=NO

ENUMERATOR INSTRUCTION: IF RESPONSE IS YES, GO TO QUESTION 13 AND IF NO, GO TO QUESTION 14 BELOW.

13. What do you consider the main ADVANTAGE in pest scouting? **SCOUTADV________**

1. MINIMIZES PEST DAMAGE
2. MINIMIZES AMOUNT OF CHEMICALS USED
3. MAXIMIZES NET FARM INCOME
4. REDUCES LABOR COSTS
5. OTHER (SPECIFY)

14. What is the main DISADVANTAGE with pest scouting? **SCOUTDIS_______**

1. LABOR INTENSIVE
2. NO SIGNIFICANT YIELD GAIN
3.TOO MANY PESTS TO SCOUT
4. DO NOT UNDERSTAND IT
5. NO DISADVANTAGE
6. OTHER (SPECIFY)

15. How do you determine when to apply INSECTICIDES (strategy for pest management)?
CHEMTIMG_______

1.WEEKLY
2. EVERY TWO WEEKS
3. ONLY AFTER SCOUTING FOR PESTS
4. SPECIFIC GROWTH STAGES OF THE PLANT
5. BASED ON PREVAILING PEST PROBLEMS
6. BASED ON RECOMMENDATION FROM INPUT SUPPLIERS
7. ABITRARILY
8. OTHER (SPECIFY)

16. What is your main source of water for cotton spraying? **WATPRO______**

1. OWN WELL
2. OWN BOREHOLE
3. COMMUNAL BOREHOLE
4. WATER HARVESTING
5. NEARBY RIVER
6. DAMS
7. OTHER (SPECIFY)

17. How far is your water source from your main cotton field (meters)? **WATERDST____**

18. State how you transport water to the cotton fields. **WATRANSP____**

1.OWN WATER CART
2. HIRE WATER CART
3. WHEEL BARROW
4. OTHER (SPECIFY)

19. Who made chemical application most of he time in 1998/99? **APLCATOR_____**

1. HEAD OF HOUSEHOLD (FARMER).
2. SPOUSE
3. ADULT FAMILY MEMBER
4. HIRED LABOR
5. OTHER [SPECIFY]

20. Do you OWN any sprayers? **OSPRAYER_____**

1=YES 0=NO (IF NO, GO TO QUESTION 24)

21. Describe the type of sprayer, number in each category owned and cost of purchase.

TYPE OF SPRAYER	QUANTITY	YEAR OF PURCHASE	PRICE OF SPRAYER (Z$)	TOTAL COST (Z$)
1=Knap-sack				
2=Ultra-Low Volume (ULV)				
3=Other (specify)				

22 Did you RENT any sprayers from other farmers in 1998/99? **SPRYRENT______**
1=YES 0=NO

23. If YE

TYPE SPRA HIREI
1.Knap
2.Ultra Volum
3. Othe
TOTA

24. What

WE
1=
2=
3=
4=

25. Do y
disease)
1=YES

23. If YES, indicate below the type of sprayers, number hired and the hiring cost in 1998/99.

TYPE OF SPRAYER HIRED	NUMBER OF SPRAYERS HIRED (1)	NUMBER OF DAYS HIRED (2)	RATE PAID [Z$/ DAY] (3)	TOTAL COST [Z$] (4) (1)*(2)*(3)
1.Knap-sack				
2.Ultra-Low Volume				
3. Other				
TOTAL COST				

24. What methods did you use to control WEEDS in your cotton crop last year?

WEED CONTROL METHOD	METHOD USE (YES=1/NO=0)
1= Hand hoe	
2= Ox-drawn cultivator	
3=Pre-emergence herbicides	
4=Post-emergence herbicides	

25. Do you know any TRADITIONAL METHODS that are used to control cotton pests (weeds, insects or disease). **IKNOW__________**
1=YES 0=NO

26. Indigenous control methods used to suppress pests, diseases and weeds

PEST TYPE	DESCRIBE TRADITIONAL/ INDIGENOUS CONTROL METHOD
1. Weed type	
2. Insects type	
3. Disease type	
4. Rodents type	
5. Nematodes type	
6. Other [specify]	

SECTION 5: ACCESS TO, AND USE OF CREDIT AND FERTILIZER IN COTTON PRODUCTION

1. Did you apply for agricultural credit in 1998/99? **CREDTAPP**______
1=YES 0=N0

2. Did you receive agricultural credit in 1998/99? **CREDTRCV**______
1=YES 0=NO *(GO TO QUESTION 6)*

3. Who provided you with credit and describe the type of credit received in 1998/99?

CREDIT SOURCE	CREDIT RECEIVED 1=CASH 2=KIND 3=BOTH	CREDIT VALUE (Z$)
1=Agricultural Finance Corporation (AFC)		
2=Cotton Company of Zimbabwe (COTTCO)		
3=Agricura		
4=Cargill Zimbabwe Pvt. Ltd.		
5=Savings club		
6=Cotpro		
7=Cooperative		
8=Relatives		
9=Local Rural Traders		
10=Other (specify)		

4. State the specific type of credit received in 1998/99 **CREDITWHY**_____

1. SEASONAL INPUTS (FERTILIZER, CHEMICALS AND SEEDS)
2. MACHINERY AND IMPLEMENTS (TRACTORS, PLOUGH, SPRAYERS ETC)
3. WATER DEVELOPMENT (BOREHOLE, WATER CART ETC)
4. FARM DEVELOPMENT (FENCING MATERIAL ETC)

5. Did you receive your SEASONAL INPUTS on time in 1998/99? **SEASOINP**________

1. ALWAYS ON TIME
2. SOME INPUTS RECEIVED ON TIME
3. LATE DELIVERY
4. NEVER DELIVERED
5. OTHER (SPECIFY)

6. Indicate other years that you have received cotton credit in the past 5 years?

YEAR	CREDIT RECEIVED 1=YES 0=NO	CREDIT SOURCE
1997/98		
1996/97		
1995/96		
1994/95		
1992/93		

CODES FOR CREDIT SOURCES

1=AGRICULTURAL FINANCE CORPORATION
2=COTTON COMPANY OF ZIMBABWE (COTTCO)
3=AGRICURA
4=CARGILL ZIMBABWE PVT. LTD.
5=SAVINGS CLUB
6=COTPRO
7=COOPERATIVE
8=RELATIVES
9=LOCAL RURAL TRADERS
10=OTHER (SPECIFY)

7. State for which additional crop(s) you obtained credit in 1998/99? **CREDTUSE**_______

CROP ENTERPRISE	CREDIT OBTAINED 1=YES 0=NO	VALUE OF CREDIT OBTAINED [Z$]
1. MAIZE		
2. SORGHUM		
3. SUNFLOWER		
4. GROUNDNUT		
5.		
6.		

8. Do you have any problems with your current input contract (credit) scheme?
Explain____
____
____
____

SECTION 6:SMALLHOLDER COTTON AND FOOD CROP-INTERACTIONS

1.Describe other crops grown on the farm and the estimated area planted to each crop in 1998/99.

CROP ENTERPRISE	ESTIMATED AREA PLANTED (HA)
1=Groundnuts	
2=Maize	
3=Sorghum	
4=Sunflower	
5=Tobacco	
6=Other (Specify)	

2. If you had additional land, what crop would you plant? **PLTADD**______________

1.COTTON
2.MAIZE
3.SORGHUM
4.GROUNDNUTS
5.SUNFLOWER

3.Estimate the distance of your home to the nearest cotton depot [km]? **CMKTDIST**____________

4. How did you transport your cotton crop to the market in 1998/99? **COTRANSP**____________

1. OWN TRANSPORT
2. HIRED PRIVATE TRANSPORT
3. COTTON COMPANY OF ZIMBABWE (COTTCO)
4. CARGILL
5. COTPRO
6. OTHER (SPECIFY)

5. What was the average cost of transporting cotton to the market per bale in 1998/99 (Z$)?

COTCOST_______

6. What is the amount of income obtained from other cropping activities?

CROP SALES	QUANTITY HARVESTED (KG)(BAGS)	QUANTITY SOLD (KG) (BAGS)	AVERAGE PRICE RECEIVED (Z$/BAG)	TOTAL REVENUE (Z$)
1. Maize				
2. Sorghum				
3. Groundnut				
4. Sunflower				
5. Tobacco				
6. Other				

7. Did you have storage problems with your COTTON in 1998/99? **STOPROB______**
1=YES 0=NO

8. Describe the nature of the storage problem. **STOPROB______**

1. STORAGE PESTS PROBLEMS
2. LACK OF ADEQUATE ON-FARM STORAGE SPACE
3. LACK OF STORAGE CONTAINERS (BAGS, BALES ETC?)
4. THEFT
5. COTTON ACCIDENTALLY BURNT IN STORE-ROOM
6. OTHER (SPECIFY).

SECTION 7: FUTURE STRATEGIES IN COTTON PRODUCTION

1.Identify what you consider as TWO LEADING future strategies in cotton production from list below?

FUTURE STRATEGY	LEADING STRATEGY (1=YES 0=NO)
1.Increase cultivated area under cotton	
2.Receive training on IPPM techniques	
3.Hire more labor for cotton production	
4.Reduce use of pesticides in cotton production	
5. Build own well/bore-hole	
6. Acquire own transport	
7. Acquire own draft power	
8. Use more credit in future	
9. Use more fertilizer on cotton	
10. Adopt land conservation practices in cotton	
11. Invest in cotton storage shed	
12. Adopt/abandon crop rotations	
13. Expand cultivated area under food crops eg maize and or sorghum	
14. Abandon cotton production	

2. What do you consider as the main problem you face in cotton production today?

COTPROB_____

1. PESTS MANAGEMENT
2. LACK OF CREDIT
3. DROUGHT
4. POOR VARIETIES
5. POOR MARKET PRICES
6. EXPLOITATION BY CONTRACTORS
7. OTHER (SPECIFY)

3. What are your views regarding the improvement of pest management strategies in smallholder cotton production? **PMGTVIEW____**

1. MAINTAIN CURRENT STRATEGIES
2. NEED NEW AND BETTER METHODS
3. MORE PEST MANAGEMENT TRAINING FOR FARMERS
4. NO IDEA
5. OTHER (SPECIFY)

4.Would you be willing to grow a new variety of cotton [Bt] that does not require the use of pesticides? **BTCOTTON_____**

1. WOULD TRY IT IMMEDIATELY
2. NOT SURE
3. CURRENT VARIETIES ARE SATISFACTORY
4. PESTICIDES CONTROL MORE EFFECTIVE

5. If farmer wants to try Bt cotton, does farmer consider any of the following a major deterrent. **BTPROBLM_____**

1. PLANTING Bt COTTON & CONVENTIONAL COTTON SIDE BY SIDE
2. LONG TERM EFFECT OF RED BOLL WORM ON Bt COTTON UNKNOWN
3. OTHER [SPECIFY]

THANK YOU VERY MUCH

===END OF HOUSEHOLD QUESTIONNAIRE===

APPENDIX A2: HOUSEHOLD MEMBER HEALTH QUESTIONNAIRE

SERIAL NUMBER _______

SMALLHOLDER COTTON PRODUCTION AND PEST MANAGEMENT IN ZIMBABWE: SANYATI AND CHIPINGE DISTRICT SURVEY 1999-2000

Date of Interview__________________________________

Name of Enumerator_______________________________

Name of Farmer________________________________

Name of District_____________________ **DISTRICT_______**

Name of Ward______________________ **NWARD_________**

Name of Village_____________________ **VILNAME_______**

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SECTION 1: HEALTH EFFECTS OF PESTICIDE USE IN SMALLHOLDER COTTON PRODUCTION

1. Has any one in your family ever experienced the following SYMPTOMS after spraying pesticides. **SPRAYSYM________**

   1. NAUSEA
   2. VOMITING
   3. ABDOMINAL PAINS
   4. DIARRHEA
   5. BLURRED VISION
   6. DIZZINESS
   7. NASAL BLEEDING
   8. NONE

2. Has anyone in your family ever had PESTICIDE STOMACH POISONING problem in the past year? **PPOISON________**

   0=NO 1=YES 2=DON'T RECALL

3. If YES, indicate in table below the individual in your family who has been affected by PESTICIDE STOMACH POISONING in the past year?

HOUSEHOLD MEMBER AFFECTED	STOMACH POISONING SEVERITY	NUMBER OF INCIDENCES IN 1998/99
TOTAL		

HOUSEHOLD MEMBER CODES

1= HEAD OF HOUSEHOLD
2= SPOUSE
3= CHILDREN
4= RELATIVE
5= OTHER (SPECIFY)

CODES FOR SEVERITY OF PESTICIDE POISONING

1=DEADLY
2=VERY SEVERE
3=MILD TO MODERATE
4=DO NOT KNOW
5=OTHER (SPECIFY)

4. Has anyone in your household ever had SKIN IRRITATIONS in the past year after using chemicals?
1=YES 0=NO **SKINIRRIT**______

5. If YES please indicate in table below the individual in your household who has been affected by SKIN IRRITATIONS in the past year as well as the severity and number of incidences of this condition.

HOUSEHOLD MEMBER	SKIN IRRITATIONS SEVERITY	NUMBER OF INCIDENCES
TOTAL		

HOUSEHOLD MEMBER CODES	CODES FOR SEVERITY OF SKIN IRRITATIONS
1= HEAD OF HOUSEHOLD	1=DEADLY
2= SPOUSE	2=VERY SEVERE
3= CHILDREN	3=MILD TO MODERATE
4= RELATIVE	4=DO NOT KNOW
5= OTHER (SPECIFY)	5=OTHER (SPECIFY)

6. Have you had EYE IRRITATIONS in the past year after using pesticides?

1=YES 0=N0 **EYEIRRIT______**

7. If YES, please indicate in table below the individual in your household who has been affected by EYE IRRITATIONS in the past year as well as the severity and number of incidences of this condition.

HOUSEHOLD MEMBER	EYE IRRITATION SEVERITY	NUMBER OF INCIDENCES

HOUSEHOLD MEMBER CODES	CODES FOR SEVERITY OF SKIN IRRITATIONS
1= HEAD OF HOUSEHOLD	1=DEADLY
2= SPOUSE	2=VERY SEVERE
3= CHILDREN	3=MILD TO MODERATE
4= RELATIVE	4=DO NOT KNOW
5= OTHER (SPECIFY)	5=OTHER (SPECIFY)

<u>NOTE TO ENUMERATOR</u>: Please complete the following table if household member was sick for a number of days and or received treatment from nearby health center or hospital for above reported symptoms.

8. Indicate the symptoms, number of days sick, treatment received and number of visits and cost of treatment in the past year.

HOUSEHOLD MEMBER	PESTICIDE AILMENT	NO OF DAYS SICK	TREATED 1=YES 0=NO	NO. OF CLINIC VISITS	COST/VISIT (Z$)	TOTAL COST (Z$)

<u>NOTE TO ENUMERATOR</u>: Request farmer to check one's medical record cards if available to verify information on treatment costs..

<u>HOUSEHOLD MEMBER CODES</u>

1= HEAD OF HOUSEHOLD
2= SPOUSE
3= CHILDREN
4= RELATIVE

<u>CODES FOR PESTICIDE AILMENTS</u>.

1=SKIN IRRITATION
2=EYE IRRITATION
3=STOMACH POISONING
4=BACK PROBLEMS (CARRYING KNAPSACK FOR PROLONGED PERIODS, WATER)

9.Does any one in your family have the following medical condition (long term medical effects)

HOUSEHOLD MEMBER	LONG TERM MEDICAL CONDITION	DURATION OF ILLNESS

HOUSEHOLD MEMBER CODES

1= HEAD OF HOUSEHOLD
2= SPOUSE
3= CHILDREN
4= RELATIVE

CODES FOR LONG TERM PESTICIDE RELATED ILLNESS.

1= CANCER
2= BLINDNESS
3= BACK PROBLEMS
4=LUNG DAMAGE
5= OTHER SPECIFY

10. Do your sprayers LEAK on your back when you apply chemicals? **SPLEAK**______
1=YES 0=NO

11. What is your main source of HEALTH OR SAFETY INFORMATION on pesticides use?

HSINFO______

SOURCE OF SAFETY INFORMATION	1=YES 0=NO

CODES FOR SOURCES OF SAFETY INFORMATION

1. AGRICURA
2. AGRITEX
3. COTTCO
4. CARGILL
5. OTHER FARMERS
6. LOCAL NEWSPAPERS
7. VILLAGE HEALTH WORKER
8. NATIONAL RADIO
9. LOCAL TELEVISION
10. CIBA-GEIGY
11. OTHER (SPECIFY)

12. Does anyone in your household consume alcohol? **ALCOHOL**__________
1=YES 0=NO

13. If YES, please indicate below the individual, amounts consumed as well as duration of alcohol consumption.

HOUSEHOLD MEMBER	ALCOHOL CONSUMPTION	ALCOHOL CONSUMED PER WEEK [LITRES]	DURATION OF ALCOHOL CONSUMPTION [YEARS]

HOUSEHOLD MEMBER CODES

1= HEAD OF HOUSEHOLD
2= SPOUSE
3= CHILDREN
4= RELATIVE

CODES FOR ALCOHOL CONSUMPTION

1=LARGER (CASTLE, PILSNER, LION, BLACK LABEL)
2=SPIRITS (WHISKY, KACHASU)
3=TRADITIONAL BREW (CHIBUKU OR SCUDS)
4=OTHER

14. Does anyone in this household smoke? **HHSMOKE**____________

1=YES 0=NO

15. Please provide information regarding SMOKING by household members.

HOUSEHOLD MEMBER	TYPE OF CIGARETTES SMOKED	CIGARETTES/WEEK NUMBER	SMOKING DURATION [YEARS]

HOUSEHOLD MEMBER CODES

1= HEAD OF HOUSEHOLD
2= SPOUSE
3= CHILDREN
4= RELATIVE

CODES FOR CIGARETTERS

1=MADISON
2=KINGSGATE
3=EVEREST
4=BERKELY
5=SHAMROCK

15. Indicate below any member of the household who used to drink alcohol in the past **PDRINK**_______

1= HEAD OF HOUSEHOLD
2= SPOUSE
3= CHILDREN
4= RELATIVE

16. Identify any member of the household who used to smoke in the past. **PSMOKE**_______

1= HEAD OF HOUSEHOLD
2= SPOUSE
3= CHILDREN
4= RELATIVE

SECTION 2: PESTICIDE SAFETY AND HANDLING

17. Where do you normally store your agricultural chemicals **CHEMGT**_______

1.STOREROOM FOR CHEMICALS ONLY
2.STOREROOM FOR FOOD CROPS
3.KITCHEN
4.BEDROOM
5.OTHER (SPECIFY)

18. Do you own any of the following protective clothing?

PROTECTIVE CLOTHES	**OWNERSHIP (1=YES 0=NO)**
1.Long Sleeved Overall	
2.Rubber Gloves	
3.Rubber Boots	
4.Face Shield/Mask	
5.Respirator	
6.Goggles	

NOTE TO ENUMERATOR: You may ask the farmer to show you some of these protective clothes in order to prove beyond any doubt that the farmer has the required protective gear.

19. Please rank on the basis of color of the triangle which is the MOST DANGEROUS and LEAST DANGEROUS pesticide used in cotton pest management.

COLOR OF TRIANGLE (WARNING SIGNS)	MEANING OF COLORED TRIANGLE
1.Purple Triangle	
2.Red Triangle	
3.Amber Triangle	
4. Green Triangle	

CODES FOR COLOR CATEGORIZATION OF PESTICIDES
1.VERY DANGEROUS PESTICIDE
2.DANGEROUS PESTICIDE
3.AVERAGELY DANGEROUS PESTICIDE
4. LEAST DANGEROUS PESTICIDE

20. Do you sometimes have meals in the fields on the same day that you spray chemicals in your cotton fields? **EATSPRY**_______

1=YES 0=NO

21. Do you sometimes smoke in the fields while you spray your cotton crop? **SMOKSPRY**_____

1=YES 0=NO

22. What do you do to the pesticide containers after use? **PESTDSPO**________

1.DESTROY OR BURN
2.USE AS CONTAINERS FOR DRINKING WATER
3.RETURN TO CHEMICAL DEALERS
4.USED FOR FOOD STORAGE
5.NOTHING
6.OTHER (SPECIFY)

23. Do you understand **FIRST AID**? **FAID**_________

1=YES 0=NO

24. Do you have a **FIRST AID KIT** in your household? **FKTAID**_______

1=YES 0=NO

25. How far are you from the nearest health center **DISTHCTR**______

THANK YOU VERY MUCH

====END OF HEALTH QUESTIONNAIRE====

APPENDIX A3: FIELD LEVEL QUESTIONNAIRE

SERIAL NUMBER ______

SMALLHOLDER COTTON PRODUCTION AND PEST MANAGEMENT IN ZIMBABWE: CHIPINGE AND SANYATI DISTRICT SURVEY 1999-2000

Name of Enumerator____

Date of Interview____

Name of Farmer____

Name of District______________________ **DISTRICT_______**

Name of Ward_______________________ **NWARD_________**

Name of Village_____________________ **VILNAME_______**

PROJECT SPONSORSHIP
JOINTLY SPONSORED BY ROCKEFELLER FOUNDATION AND WK KELLOGG FOUNDATION

SECTION 1: FIELD LEVEL MANAGEMENT OF COTTON PRODUCTION

1. Indicate the cotton variety grown and area planted to cotton in 1998/99 in each field?

COTTON FIELD	COTTON VARIETY	ESTIMATE AREA(HA) PLANTED	ESTIMATE AREA (HA) FALLOW	REPLANTED COTTON ? YES=1/NO=0	DRY PLANTED COTTON? 1=YES/0=NO
1=HOMESTEAD					
2=FIELD # 1					
3=FIELD # 2					
4=FIELD # 3					

CODES FOR COTTON VARIETIES GROWN IN ZIMBABWE

1=ALBAR G502
2=ALBAR K603
3=DELMAC
4=ALBAR G501
5=ALBAR K602
6=ALBAR BB8714
7=ALBAR AG4869
8=ALBAR BC853
9=ALBAR EU883G502
10. CY 889
11. ALBAR EU8910
12. ALBAR DF 885
13. ALBAR FQ902
14. ALBAR FQ904
15. LONG STAPLE 797
16. ALBAR SZ 93-14
17. AF (88)4

2. Describe the planting densities for each cotton field

COTTON FIELDS	COTTON IN - ROW SPACING (CM)	COTTON BETWEEN ROW SPACING (CM)	QUANTITY COTTON SEEDS APPLIED (KG)	COST OF COTTON SEED (Z$)
1.HOMESTAED				
2.FIELD # 1				
3.FIELD # 2				
4.FIELD #3				

3. Did you use any hired labor in 1998/99? **HIREDLAB______**
1=YES **0=NO**

4. Did you practice LABOR SHARING in cotton production in 1998/99? **LABSHARE______**
1=YES **0=NO**

NOTE TO THE NUMERATOR:
1.PLEASE COMPLETE SHEET NUMBER 1, 2, 3 AND 4 FOR LABOUR USE IN COTTON FIELDS.

2.IF LABOR IS REWARDED IN KIND CALCULATE THE EQUIVALENT DOLLAR VALUE OF OUTPUT PAID AS WAGE FOR WORK RENDERED USING 1998/99-PRODUCER PRICE FOR THE PARTICULAR CROP.

5. Indicate the amount of family and any hired labor used in cotton production as well as the TOTAL wage paid to hired labor for the listed field operations in 1998/99?

HOMESTAED FIELD: 1998/99 OPERATIONS **SHEET #1**

TASK	TIME (DAYS)	FAMILY LABOUR NUMBER	HIRED LABOUR NUMBER	HIRED LABOUR TOTAL WAGE (Z$)	SHARED LABOUR NUMBER?
1= Land preparation					
2=Planting cotton					
3=Basal fertilizer application					
4=Top dressing fertilizer					
5=Scouting for pests					
6=Mechanical weeding					
7=Pre-emergence herbicides					
8=Post emergence herbicides					
9=Insecticides application					
10=Rodenticides application					
11=Cotton Picking					
12=Burning Stover					

COTTON FIELD # 1: 1998/99 OPERATIONS **SHEET #2**

TASK	TIME (DAYS)	FAMILY LABOUR NUMBER	HIRED LABOUR NUMBER	HIRED LABOUR TOTAL WAGE (Z$)	SHARED LABOUR NUMBER?
1= Land preparation					
2=Planting cotton					
3=Basal fertilizer application					
4=Top dressing fertilizer					
5=Scouting for pests					
6=Mechanical weeding					
7=Pre-emergence herbicides					
8=Post emergence herbicides					
9=Insecticides application					
10=Rodenticides application					
11=Cotton Picking					
12=Burning Stover					

COTTON FIELD # 2: 1998/99 OPERATIONS **SHEET #3**

TASK	TIME (DAYS)	FAMILY LABOUR NUMBER	HIRED LABOUR NUMBER	HIRED LABOUR TOTAL WAGE (Z$)	SHARED LABOUR NUMBER?
1= Land preparation					
2=Planting cotton					
3=Basal fertilizer application					
4=Top dressing fertilizer					
5=Scouting for pests					
6=Mechanical weeding					
7=Pre-emergence herbicides					
8=Post emergence herbicides					
9=Insecticides application					
10=Rodenticides application					
11=Cotton Picking					
12=Burning Stover					

COTTON FIELD # 3: 1998/99 OPERATIONS **SHEET #4**

TASK	TIME (DAYS)	FAMILY LABOUR NUMBER	HIRED LABOUR NUMBER	HIRED LABOUR TOTAL WAGE (Z$)	SHARED LABOUR NUMBER?
1= Land preparation					
2=Planting cotton					
3=Basal fertilizer application					
4=Top dressing fertilizer					
5=Scouting for pests					
6=Mechanical weeding					
7=Pre-emergence herbicides					
8=Post emergence herbicides					
9=Insecticides application					
10=Rodenticides application					
11=Cotton Picking					
12=Burning Stover					

6. Did you use fertilizer on your cotton crop in 1998/99? **COTFERT_______**
1=YES 0=NO

7.Describe fertilizer use on your cotton crop in 1998/99?

HOMESTAED FIELD: 1998/99 FERTILIZER APPLICATION BY FIELD

TYPE OF FERTILIZER APPLIED	AREA APPLIED (HA)	NUMBER OF FERTILIZER BAGS APPLIED	PRICE (Z$/BAG)	TOTAL COST (Z$)
1=Ammonium Nitrate (AN)				
2=Compound K				
3=Compound L				
4= Lime				
5= Urea				
6				
7.				

COTTON FIELD #1: 1998/99 FERTILIZER APPLICATION BY FIELD

TYPE OF FERTILIZER APPLIED	AREA APPLIED (HA)	NUMBER OF FERTILIZER BAGS APPLIED	PRICE (Z$/BAG)	TOTAL COST (Z$)
1=Ammonium Nitrate (AN)				
2=Compound K				
3=Compound L				
4= Lime				
5= Urea				
6.				
7				

COTTON FIELD #2: 1998/99 FERTILIZER APPLICATION BY FIELD

TYPE OF FERTILIZER APPLIED	AREA APPLIED (HA)	NUMBER OF FERTILIZER BAGS APPLIED	PRICE (Z$/BAG)	TOTAL COST (Z$)
1=Ammonium Nitrate (AN)				
2=Compound K				
3=Compound L				
4= Lime				
5= Urea				
6.				
7				

COTTON FIELD #3: 1998/99 FERTILIZER APPLICATION BY FIELD

TYPE OF FERTILIZER APPLIED	AREA APPLIED (HA)	NUMBER OF FERTILIZER BAGS APPLIED	PRICE (Z$/BAG)	TOTAL COST (Z$)
1=Ammonium Nitrate (AN)				
2=Compound K				
3=Compound L				
4= Lime				
5= Urea				
6.				
7				

8. Did you apply organic manure to your cotton crop in 1998/99 season? **OGMANURE____**
1=YES 0=NO

9. If YES, please indicate the field and amount of organic manure applied in 1998/99?

COTTON FIELD	**ORGANIC MANURE APPLIED [1=YES/ 0=NO]**	**QUANTITY APPLIED**
1=HOMESTEAD FIELD		
2=FIELD #1		
3=FIELD #2		
4=FIELD #3		

10. What are the types of chemicals that you applied on your cotton crop in 1998/99?

HOMESTEAD: AGRO-CHEMICAL USE IN 1998/99 SHEET # 1

CHEMICAL NAME	TARGET PEST	NUMBER OF APPLICATIONS	QUANTITY OF CONCENTRATE	UNIT SIZE (KG/ML)	COST PER UNIT (Z$)
1. Carbaryl					
2. Thiodan					
3. Larvin					
4. Fenvalerate					
5. Agrithrin super					
6. Karate					
7. Dimethoate					
8. Rogor					
9. Marshall					
10. Pfumo					
11. Monocrotophos					
HERBICIDES					

CODES FOR PESTICIDES

Herbicides	**Acaricides**	**Fungicides**
12. Trif	13. Cucacron	14. Calirus
15 Stomp	16. Hosthion	17. Tecto
18 Bladex	19. Azodrin/Nuvacron	20. Brassicol
21 Gesagard	22. Tedion/Tetradifon	23. Rizolex
24 Dual	25. Mitac	26. Monceren combi
27 Planavin	28. Secure	29. Vitavax
30 Cotoran	31. Kelthane	32 Quintozene
33 Cotogard	34. Omite	
35 Gesapax		
36 Diuron		
37 Igran		

COTTON FIELD #1: AGRO-CHEMICAL USE IN 1998/99 SHEET # 2

CHEMICAL NAME	TARGET PEST	NUMBER OF APPLICATIONS	QUANTITY OF CONCENTRATE	UNIT SIZE (KG/ML)	COST PER UNIT (Z$)
1. Carbaryl					
2. Thiodan					
3. Larvin					
4. Fenvalerate					
5. Agrithrin super					
6. Karate					
7. Dimethoate					
8. Rogor					
9. Marshall					
10. Pfumo					
11. Monocrotophos					
HERBICIDES					

CODES FOR PESTICIDES

Herbicides	**Acaricides**	**Fungicides**
12. Trif	13. Cucacron	14. Calirus
16 Stomp	16. Hosthion	17. Tecto
18 Bladex	19. Azodrin/Nuvacron	20. Brassicol
21 Gesagard	22. Tedion/Tetradifon	23. Rizolex
24 Dual	25. Mitac	26. Monceren combi
27 Planavin	28. Secure	29. Vitavax
30 Cotoran	31. Kelthane	32 Quintozene
33 Cotogard	34. Omite	
35 Gesapax		
36 Diuron		
37 Igran		

COTTON FIELD #2: AGRO-CHEMICAL USE IN 1998/99 SHEET # 3

CHEMICAL NAME	TARGET PEST	NUMBER OF APPLICATIONS	QUANTITY OF CONCENTRATE	UNIT SIZE (KG/ML)	COST PER UNIT (Z$)
1. Carbaryl					
2. Thiodan					
3. Larvin					
4. Fenvalerate					
5. Agrithrin super					
6. Karate					
7. Dimethoate					
8. Rogor					
9. Marshall					
10. Pfumo					
11. Monocrotophos					
HERBICIDES					

CODES FOR PESTICIDES

Herbicides	**Acaricides**	**Fungicides**
12. Trif	13. Cucacron	14. Calirus
17 Stomp	16. Hosthion	17. Tecto
18 Bladex	19. Azodrin/Nuvacron	20. Brassicol
21 Gesagard	22. Tedion/Tetradifon	23. Rizolex
24 Dual	25. Mitac	26. Monceren combi
27 Planavin	28. Secure	29. Vitavax
30 Cotoran	31. Kelthane	32 Quintozene
33 Cotogard	34. Omite	
35 Gesapax		
36 Diuron		
37 Igran		

COTTON FIELD #3: AGRO-CHEMICAL USE IN 1998/99 SHEET # 4

CHEMICAL NAME	TARGET PEST	NUMBER OF APPLICATIONS	QUANTITY OF CONCENTRATE	UNIT SIZE (KG/ML)	COST PER UNIT (Z$)
1. Carbaryl					
2. Thiodan					
3. Larvin					
4. Fenvalerate					
5. Agrithrin super					
6. Karate					
7. Dimethoate					
8. Rogor					
9. Marshall					
10. Pfumo					
11. Monocrotophos					
HERBICIDES					

CODES FOR PESTICIDES

Herbicides	**Acaricides**	**Fungicides**
12. Trif	13. Cucacron	14. Calirus
18 Stomp	16. Hosthion	17. Tecto
18 Bladex	19. Azodrin/Nuvacron	20. Brassicol
21 Gesagard	22. Tedion/Tetradifon	23. Rizolex
24 Dual	25. Mitac	26. Monceren combi
27 Planavin	28. Secure	29. Vitavax
30 Cotoran	31. Kelthane	32 Quintozene
33 Cotogard	34. Omite	
36 Gesapax		
36 Diuron		
37 Igran		

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12. H

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<u>**NOT**</u>

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13.

11 Imagine a poor, average and good season, how much yield would expect to get on your farm

SEASON	EXPECTED YIELD (KG/HA)
Poor	
Average	
Good	

NOW WE WANT TO ASK YOU QUESTIONS ABOUT PEST MANAGEMENT PRACTICES YOU MAY HAVE USED ON YOUR COTTON CROP IN 1998/99.

12. Have you ever received training on IPPM?

1=YES 0=NO

<u>NOTE TO ENUMERATOR</u>**: Provide definition of IPPM if farmer is not clear about its meaning:**

IPPM is the control of pests using multiple management tactics, which include cultural, biological, strategic and chemical control. IPPM knowledge is disseminated through Farmer Field Schools.

13. Where did you receive your training? **IPMEDUC_______**

1. AGRITEX
2. COTTON TRAINING CENTER (CTC)
3. IPPM TRAINED FARMERS
4. MASTER FARMERS
5. OTHER (SPECIFY)

14. Indicate which pest management practices you used on your farm to control cotton **INSECTS** in 1998/99 season?

PEST MANAGEMENT PRACTICE FOR COTTON INSECTS	**ADOPTION STATUS 1=YES 0=NO**
1=Use of pest resistant cotton varieties	
2=Pest scouting and use of economic thresholds in making pesticide treatment.	
3=Burning cotton stover (Field Sanitation)	
4=Crop rotations	
5=Mulching	
6=Soil testing for pests	
7=Use of less toxic and safer chemicals	
8=Alternating pesticides to slow development of pest resistance to pesticides.	
9= Adjusting planting dates to lessen pest problems	
10=Use of beneficial organisms that prey on pests (e.g. predator insects or mites).	
11= Adjusting application rates, timing and frequency of pesticide use to protect beneficial organisms	
12= Use of pheromones such as ants or moths that excrete poisonous chemicals externally for trapping .	

15. What do you think about IPPM? **IPMFPP**_______

1. LABOR INTENSIVE
2. IPPM IS EFFECTIVE PEST CONTROL METHODS
3. IPPM METHODS ARE INEFFECTIVE
4. NOT SUPERIOR TO CONVENTIONAL CHEMICAL USE
5. OTHER (SPECIFY)

16. How many bales did you harvest from the different cotton fields in 1998/99?

COTTON FIELD	NO OF BALES
1=HOMESTAED FIELD	
2=FIELD 1	
3=FIELD 2	
4=FIELD 3	

17. Indicate how many bales where sold to the following markets in 1998/99

MARKETING OUTLET	NUMBER OF BALES
1.COTTCO	
2.CARGILL	
3.COTPRO	
4.LOCAL RURAL TRADER	
5.NEIGHBORS	
6.RELATIVE	

18. Please indicate the grade distribution of cotton harvested in 1998/99?

GRADE CATEGORY	NUMBER OF BALES	PRICE PER KG	TOTAL REVENUE
A			
B			
C			
D			
REJECT			

SOIL CONSERVATION AND TILLAGE PRACTICES IN COTTON FIELDS

20.Predominant soil texture in the village **SOILTXT**___________

1=SANDY LOAM SOIL
2=BLACK CLAY SOIL (VERTISOLS)
3=RED CLAY SOIL
4= OTHER (SPECIFY)

21. Cotton field characteristics

COTTON FIELD CHARACTERISTICS	**HOMESTEAD FIELD**	**FIELD # 1**	**FIELD # 2**	**FIELD # 3**
Dominant soil texture				
Walking time from homestead (hours/minutes)				
Type of conservation practice				
Soil Test Conducted? (1=YES/0=NO)				

CODES FOR SOIL TEXTURE

1=SANDY SOIL
2=BLACK SOIL (VERTISOL)
3=RED SOIL
4=CLAY SOIL
5=OTHER (SPECIFY)

CODES FOR CONSERVATION PRACTICES

1=TIED RIDGES
2=CONTOURS
3=WINDBREAKS
4=MULCHING
5=MINIMUM TILLAGE

22. COTTON FIELD NUMBER________________ :FIELD AREA MEASUREMENTS

SIDE NUMBER	ANGLE (DEGREES)	LENGTH (METERS)

23. COTTON FIELD NUMBER______________ :FIELD AREA MEASUREMENTS

SIDE NUMBER	ANGLE (DEGREES)	LENGTH (METERS)